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E-GROCERY BEHAVIOURAL ANALYSIS FOR SUSTAINABLE URBAN LOGISTICS IN MOROCCO

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ABSTRACT · Evaluating people behaviours towards online grocery channels is of great importance in sustainable urban mobility planning. This study uses stated preference methods to assess both Moroccans' habits to buy groceries and potential behaviour change. A multinomial logit model is used to estimate parameters influencing consumers when purchasing goods in grocery stores or online (either via home delivery or click&pick). Results demonstrate that product price, product range, lead time and service cost for the two options are the main choice determinants. Market shares, travelled distances generated by groceries shopping, and CO/NOx emissions are calculated for different scenarios. The paper provides valuable insights for private and public stakeholders to develop their sustainable policies and reduce negative externalities on the environment at an urban scale.

KEYWORDS · E-Groceries, Stated Preferences, Urban Logistics, Home Delivery, Click & Pick, Environment.

1. INTRODUCTION

In an almost post COVID-19 era, everything has been turned upside down. Important sectors are becoming the least important ones and vice versa. The fear of being infected by the virus pushes people to work remotely and order everything they need from e-commerce platforms. Basic goods as groceries and medicines were the most requested during the pandemic (Whitten 2020). This trend of buying groceries online is favored by the growth of internet users. In Morocco, there was an annual growth rate of 13% between 2019 and 2020, with more than 70% Moroccans being internet users (*Digital 2020: Morocco* 2020). People developed this habit of buying everything online even after the worst period of the pandemic. "Consumer shifts around online, value, and lifestyle agendas are creating an attrac-

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tive opportunity for grocery retailers to capture market shares over the next two to three years" as reported by Mckinsey&Company (Mckinsey&Company 2021). Providing analytical tools and models, analyzing the impact on the environment (Figliozzi 2020) or assessing changes in behavior, studies are multiplying efforts to better understand and develop the e-grocery market. However, a methodology based on experimental design and choice modelling is practically nonexistent in e-groceries research (Martín *et al.* 2019). This paper adopts such a methodology to analyze behavior change and assess environmental impacts. Furthermore, to the best of authors' knowledge, this is the first research paper addressing the impact of travelled distances, due to grocery shopping trips, on environment in Morocco while providing a tool for policy makers to foster sustainable urban planning.

This research addresses two major issues to grocery channel choice in Morocco to complement studies already undertaken on the e-grocery field.

First, the study is part of the "detailed diagnosis of delivery habits" launched by the AMDL in 2020 (The Moroccan Agency of Logistics Development) in its Urban Logistics Guide (AMDL 2020). In fact, the paper provides estimates of consumers' behavior change toward grocery shopping using the three different existing channels, namely Grocery Store (GS), Home Delivery (HD) and Click&Pick (CP). Our expectations in a country context are to have a greater in-store customers share compared to online ones due to sociability of Moroccans. Based on survey results, the paper also estimates vehicle kilometers travelled due to dedicated trips to markets when buying groceries, considering public transport, walking and car as transport modes.[1] This is of crucial importance to Sustainable Urban Mobility Plans for better designing, organizing and implementing city logistics solutions.[2] Passengers and freight mobility is one of the key issues in integrated planning in urban areas.[3] The growth of e-commerce and home deliveries is likely to affect the structure and performance of the urban freight chain (Bj *et al.* 2019).

Second, the paper shows the impact on the environment related to grocery shopping. Indeed, the Kingdom of Morocco has voluntarily committed itself in recent years to a process of environmental rehabilitation and integration of sustainable development in all its policies (Le matin 2021). The transport sector, which plays a major role in boosting the country's socio-economic activity, contributing to 6% of GDP and absorbing around 25% of national energy consumption (BR 2016), should be more involved in all aspects of sustainable development. In line with guidelines of the ministry of Equipment, Transport, Logistics and Water (AMDL 2020), this study calculates the impact of generated trips, km driven, and environmentally noxious emissions. We are expecting a high emissions volume in line with our hypoth-

[1] It is important to note that the mode-specific impact also depends upon the characteristics of the vehicles used. In fact in urban freight there is a trend towards the use of greener vehicles (Patella *et al.* 2021).

[2] It is important to note that digital twin based models are attracting research attention due to their possible role in fostering policy-making and planning (Marcucci *et al.* 2020).

[3] Under this respect, it is important to note that a new and fast-rising phenomenon is picking up in urban freight transport: crowdshipping. Notwithstanding the fact that crowdshipping services can be performed in different ways, one should note that there has been a growing attention paid to its environmental performance (Simoni *et al.* 2020).

esis of having a greater share of GS users. The analysis based on alternative scenarios with different shares of online/offline purchases represents a powerful tool for decision makers whose aim is to offer an adequate mobility planning, accounting for urban logistics in an environmentally friendly fashion. In fact, decision makers while developing their urban policies could encourage/discourage e-groceries depending on the resulting impact on the environment.

In an almost post pandemic era, omni channel strategies have developed significantly. A recent report by Mckinsey&Company (2021) stated that 50% of CEOs that were part of a survey conducted in 2021 put the scaling of e-grocery business in their top priority, hence adopting an omni channel strategy to cope with recent changes caused by Covid-19. We underline that market share information and change in consumers' behavior could be of valuable use to e-grocery platforms to evaluate the actual market and develop their marketing strategies.

Stated differently, this paper answers the following research questions: What are the factors influencing consumers' channel choice behavior when shopping for grocery? How does the channel choice affect the travelled distances at an urban scale? What is the resulting impact on the environment due to the changing behavior of consumers?

The next section reports a literature review of papers focusing on grocery shopping, especially those dealing with e-groceries. The third section describes the methodology used. The fourth illustrates the case study while its results are reported in Section 5. Study limitations, conclusions and future research endeavors are in Section 6.

2. Literature review

Studies on electronic grocery are multiplying. Electronic platforms offering grocery products are increasing and becoming more known to the public. Hence, more data is available to researchers to explore the field. New models can estimate consumers' behavior, market shares, travelled distances and be included in a decision-support tool to either assist supply chain managers decisions or policy makers choices (Harris *et al.* 2017). This could help the former redirect their marketing efforts toward the people who are willing to change from store to online shopping. We investigate large purchases using a car for their trip to the market (Suel and Polak 2017), as small baskets consumers walk in supermarkets to get their groceries and are less attracted by online shopping. For the same purpose, online grocery platforms could also concentrate their efforts to develop their e-service quality (Shahrulliza *et al.* 2016). Others concentrate on CP option to assess people behaviors (Pernot 2021), or on the efficiency of smart lockers.

2. 1. *Factors affecting consumers e-grocery behavior*

The literature discusses and analyzes various factors that could affect consumer choice when it comes to e-grocery. In the present study, a deep search in previous works was conducted to select attributes that play a role in consumer selection of a channel when shopping for everyday goods. The first investigated attribute is product price, and it is defined as total price of a group of grocery products (basket) dur-

ing a typical purchase using one of the different channels (HD, CP or GS). Research considers consumer perception of this attribute differently. A qualitative study from Blitstein, Frentz and Jilcott Pitts (2020) revealed that product price is perceived by consumers as one of the most important e-grocery benefits. Contradictory, Cervellon, Sylvie and Ngobo (2015) demonstrated that money savers tend to be attracted by conventional stores, because of discounts. From a retailer perspective, pushing customers to spend more while buying their usual goods online could be enhanced by delivery subscription models *(Wagner et al.* 2021). Moreover, fees incurred by HD or CP channels could impact negatively consumer adoption of online channels and require additional investigations. Indeed, offering customers a low price or free delivery service could encourage them to shop online (Magalhães 2021). This low service cost strategy could even increase orders by half in some cases (Fikar *et al.* 2019). A third factor is lead time or as considered in this study, the time between placing the order and getting it delivered (time between order placement and order being ready to pick in the relay point). Offering same day delivery enables the provider to increase orders by about 10% (Fikar *et al.* 2019). People are even willing to pay up to 0.96€ to have a reduction of 1 hour in lead time, according to a recent study conducted in Italy (Maltese *et al.* 2021).

Expected delivery time interval of the online order is commonly called time window. In general, customers seek very short time windows so not to wait for a long time at home for their deliveries. For retailers, to meet such conditions or either to violate them induce important costs (Hsu *et al.* 2007). In fact, consumers attach a high value to their preferred time window (Hirogaki 2015). The latter is even a determining parameter to predict demand in an e-grocery context (Aktas *et al.* 2020). However, this strategy reduces transport efficiency from a consolidation point of view (Marcucci *et al.* 2021). Thus, it is worth to analyze whether providing a shorter time window will enhance consumers' e-grocery choices, especially when reducing consolidation efficiency impacts negatively on emissions generated by delivery vans. Another attribute worth analysing is product range. In fact, assortment can play an important role in consumers' online store choice decisions (Melis *et al.* 2015). Price-oriented shoppers, in particular, consider important the range of products offered by e-grocery platforms (Frank and Peschel 2020). One should also note that travel time is the round trip either from home to supermarket or home to the pickup point. Indeed, a study conducted in England (Huang and Oppewal 2006) confirmed that fifteen minutes difference in travel time to the GS has a greater impact on shopping online or offline compared to £5 delivery fee. Discomfort related to travel time when shopping for grocery has an even greater value for those using public transportation (Suel and Polak 2017) especially considering that the value of travel time also depend on how it is spent when using public transportation (Kaufmann 2002).

2. 2. *Sustainable mobility and e-grocery*

Sustainability concerns are important in different research fields. Sustainable mobility is also the goal of many policy planners (Van Den Berg *et al.* 2020) who can

encourage HD for groceries when it reduces trips to the market and restrict private car use (Bj *et al.* 2019). Both goals are key to a successful sustainable mobility planning. Planners could, in principle, also support these initiatives by encouraging use of electric vehicles either by consumers, when going to the supermarket, or by e-grocery platforms when delivering goods to homes. Use of electric vehicles could reduce emissions compared to internal combustion engines especially when using energy produced from renewable resources (Ehrler *et al.* 2019). Moreover, air and ground autonomous delivery robots have the potential to reduce energy consumption and CO_2 emissions (Figliozzi 2020). According to the same study, autonomous delivery vehicles are even more efficient than E-vans.

As a household's price sensitivity is inversely related to its distance from the closest physical store (Cebollada *et al.* 2019), this distance could be used to estimate the impact that a purchase of groceries from physical stores has on the environment. Knowing the distance per shopping trip and average distance covered by delivery vehicles, one can calculate carbon dioxide emissions (Hardi and Wagner 2019). Following this approach and based on stated preference results, this paper calculates the impact on the environment that a grocery shopping trip might produce.

Studies using experimental design and choice modelling on e-grocery are scarce (Martín *et al.* 2019). In fact, a correct understanding of the e-customers' preferences in terms of services and channels choice could be key to discovering new market segments and understanding their environmental and economic sustainability requirements (Gatta *et al.* 2020; Lagorio and Pinto 2021). This paper closes a methodological research gap by using stated preferences methods to estimate consumer grocery channels choices and estimating their transport and environmental impacts. Moreover, research addressing groceries from a consumer perspective are rare in Morocco. In fact, only two papers exist, with Amine and Lazzaoui (2011) studying shoppers' reaction to modern food retailing systems, and Yassine Jadil, P. Rana and K. Dwivedi (2022) investigating drivers of online trust and intention to buy on a website. None of them focus on the grocery sector nor do they estimate order delivery on the environment. Hence, the second research gap the paper fills relates to the study of an emerging market and its sustainable mobility implications in Morocco where this was never investigated before. Fundamentally, the most important motivation at the basis of this paper is providing a scientifically sound answer to the call from governmental agencies asking for support those policy makers faced with the daunting tasks of planning for sustainable mobility (AMDL 2020). Indeed, local government is lacking scientific support when developing urban mobility plans in Morocco and the current paper represents a valuable example of a decision-making support tool for urban planners.

This paper adopts a research framework already used in a study conducted in Norway (Marcucci *et al.* 2021) applying it to a different country and with a specific focus on the environment. In particular, investigating this issue in Morocco is important due to its specific economic maturity and, possibly, substantially different contextual and sociological characteristics (i.e., African continent/culture). Morocco is the fifth economy in the African continent and committed to the development of sustainable strategies complying with international recognized standards.

3. Methods and data

3.1. *Theoretical background*

Choosing between buying groceries in a GS or buying them online while choosing HD or CP seems a simple task. However, understanding the underline process behind this decision (Koppelman and Bhat 2006) and the role each characteristic play for the alternatives considered is not trivial. Stated preference methods are designed to investigate this behavior.

According to random utility maximization theory (Louviere *et al.* 2000), interviewees select the alternative with the highest utility. The researcher assumes the decision process agents adopt relies on the trade-offs among the attributes characterizing the alternatives (Koppelman and Bhat 2006). The paper adopts an efficient experimental design (Gatta and Marcucci 2016) to define the choice-sets. Multinomial Logit (MNL) model results illustrate the role attributes play in the choice decision and allow calculating willingness to pay measures. Scenario simulations permit estimating market shares, kms driven, and environmental impacts. The following section describes the case study and provides detailed information on the sample.

3.2. *Empirical context*

Experimental design helps defining choice tasks so to study the relative influence of independent variables (attributes) on a given observed phenomenon (choice) (Marcucci *et al.* 2013). Using well-designed experiments, the analyst can determine the choice tasks and, after acquiring data, can use MNL to estimate choice probabilities which is tantamount to determining the influence on the observed choice made by the sampled individuals (agents). In our case, the convenience sample of 246 respondents includes individuals that do grocery shopping or have a deep knowledge of the process made by one of their family members. Due to COVID-19 restrictions, most answers were collected using online platforms or via virtual face to face interviews. Around 60 interviews were performed either in public places (e.g., schools, universities, or grocery markets). The administration of the survey took place between April and May 2021. In our case, we investigate three different ways of buying groceries, namely: GS, CP, and HD. Based on a literature review, we concentrated on 6 attributes: Product Price (PP); Service Cost (SC); Lead Time (LT); Time window (TW); Product Range (PR); Travel Time (TT). Subsequently, these attributes were tested and confirmed via a focus group with 20 people and also by performing in depth interviews. Focus group participants included e-grocery professionals and people from different social categories and ages. In our case, the focus group was carried out to confirm the attributes that were included in the stated preference survey. The next step was defining attribute levels. This was performed considering the actual market situation but also future possible fluctuations. Table 1 shows attributes and levels for the three alternatives considered.

Table 1. Attribute and levels of the three alternatives.

	Levels					
	PP	TT	PR	SC	TW	LT
Grocery store	Stated	Stated	100%	-	-	-
Home delivery	90%, 100%, 110%	-	50%, 100%, 150%	0 MAD, 20 MAD, 40 MAD	30min, 60min, 120min	1 H, 6H, 12H
Click&Pick	90%, 100%, 110%	50%, 100%, 150%	50%, 100%, 150%	0 MAD, 10 MAD	-	1 H, 6H, 12H

Note: MAD = Moroccan Dirham is the currency of Morocco. Exchange rate on July 2021 is approximately about 1 MAD = 0,09 Euro.

The questionnaire was tested in two pilot surveys. A first group of 30 people responded to the questionnaire allowing us to make some important changes both in the way the questions were presented and in the survey description. A second group, also composed of 30 people, tested the questionnaire and allowed confirming the good quality of the revised version that was subsequently administered to the general public. Table 2, presents an example of the choice task used.

Table 2. Choice task example.

	Home Delivery	**Click &Pick**	**Grocery Store**
Purchase Cost [MAD]	250	250	250
Service Cost [MAD]	40	0	
Lead Time [Hour]	6	1	
Time Window [Hour]	1		
Product Range [%]	50	100	100
Travel Time [Minutes]		2,5	5
Which one will you choose?			

Table 3. Socio-demographic characteristics of the sample.

Family members		**Groceries budget (MAD)**		**Age**	
0	6,1%	> 1000	17,89%	16-24	17,9%
1	9,3%	1000-2000	35,77%	25-34	41,9%
2	15,4%	2000-3000	20,33%	35-44	19,1%
3	32,5%	3000-4000	17,48%	45-54	12,2%
		4000-6000	5,69%		

The overall sample is not balanced in terms of gender. Females represent 62% of the respondents compared to only 38% males. This is mainly due to the interest females have shown with respect to the survey on groceries. This might also be due to the low value of their time due to their unemployment status, as confirmed by (Saphores and Xu 2020). The predominant age category of our sample (Table 3) is 25-34 years with a percentage of 41,9% followed by 35-44 and 16-24. This age distribution is in line with High Commission for Planning report on Moroccan demography (HCP 2012). The top of the age pyramid represents a low proportion of respondents. They are characterized by higher willingness to walk (Ariza-Álvarez *et al.* 2021) and interest in physical stores. The prevailing family types are those with more than 4 members, representing more than one third of the families in our sample. Concerning monthly grocery budget, the distribution is unbalanced towards wealthy people who can spend more than 10000 MAD. Most respondents allocate a budget between 1000 and 2000 MAD to groceries, representing one third of the interviewed sample. Two third of the respondents have already purchased goods online. Among them, 75 persons have already bought groceries online. A notable result is that Moroccans frequently buy groceries with an average of 6 times per week.

4. Results

4. 1. *Model results*

The results obtained are reported below. The MNL model was estimated using NLOGIT software. The utility functions used are presented here after:

$$U_{GS} = V_{GS} + \varepsilon_{GS}; \qquad U_{HD} = V_{HD} + \varepsilon_{HD}; \qquad U_{CP} = V_{CP} + \varepsilon_{CP}$$

Where:

- U_{PS}, U_{HD}, U_{CP} are respectively the utility functions for GS, HD and CP.
- V_{GS}, V_{HD}, V_{CP} are respectively the deterministic part of the utility functions for GS, HD and CP.
- ε_{PS}, ε_{HD}, ε_{CP} are error terms for these alternatives.

The deterministic parts of the utility functions of the three alternatives are presented below:

$$V_{GS} = ASC_{GS} + \beta_{PP}\, PP_{GS} + \beta_{TT}\, TT_{GS} \tag{1}$$

$$V_{HD} = \beta_{PP}\, PP_{HD} + \beta_{SC\_HD}\, SC\_HD + \beta_{TW}\, TW_{HD} + \beta_{PR}\, PR_{HD} + \beta_{LT}\, LT_{HD} \tag{2}$$

$$V_{CP} = ASC_{CP} + \beta_{PP}\, PP_{CP} + \beta_{TT}\, TT_{CP} + \beta_{SC\_CP}\, SC\_CP + \beta_{PR}\, PR_{CP} + \beta_{LT}\, LT_{CP} \tag{3}$$

Table 4. MNL model.

Variables	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
PP	-.00688***	.00185	-3.72	.0002	-.01050	-.00325
SC_HD	-.03303***	.00570	-5.79	.0000	-.04420	-.02185
TW	-.17882	.14173	-1.26	.2071	-.45661	.09897
PR	.01042***	.00147	7.07	.0000	.00753	.01331
LT	-.10040***	.01367	-7.35	.0000	-.12719	-.07361
ASC_CP	-.70314***	.19064	-3.69	.0002	-1.07678	-.32949
TT	-.00844**	.00415	-2.04	.0418	-.01656	-.00031
SC_CP	-.04609***	.01423	-3.24	.0012	-.07397	-.01821
ASC_GS	.20722	.28162	.74	.4618	-.34475	.75919

***, **, * ==> Significance at 1%, 5%, 10% level.

HD is set as the reference alternative in the overall model (Table 5). The pseudo-R^2 is 0.23 which reflects a good fit to data. In this model, we expected the alternative specific constant of GS to be significant and positive reflecting the attitude of Moroccans toward stores in general. This can be explained by statistics about purchase frequency (PFreq) in stores (Table 5). However, the results show an indifferent attitude towards buying groceries in-store compared to the benchmark which is buying them online with HD. This is reflected by the insignificance of the alternative-specific constant of the GS alternative. Table 5 reports a balanced behavior between GS and HD when it comes to purchase frequency per week per channel. In the other hand, the alternative specific constant for CP is negative confirming shoppers' preference for HD. Most attributes (PP, SC either for HD or CP, and LT) are significant at a 1% level, while TT at 5% level. A plausible explanation is that most people (more than 51%) perform their shopping in convenient stores with an average travel time of about 14min (Table 6). Even if the mean TT for the overall sample is 19,34 min, the mode is still 10min, confirming its overall non-significance. TW is not significant. This can be explained by the average stated TW of 85min which is approximately similar to the maximum level tested 120 min (Table 7). In addition, 97 respondents stated a preference for TW equal or greater than 120 min.

Table 5. Purchase frequency before and after SP.

	Mean	SD	Min	Max
GS frequenct before SP	5,08	4,47	0	30
HD frequency before SP	0,23	0,59	0	4
CP frequency before SP	0,26	0,94	0	7
GS frequency after SP	2,73	3,82	0	30
HD frequency after SP	1,73	1,93	0	15
CP frequency after SP	0,53	0,96	0	4

Table 7 reports willingness to pay (WTP) measures. They indicate how much money people are willing to spend to get a better service quality. Results show that an individual is willing to pay up to 14,59 MAD to have a 1 hour decrease in LT. PR also matters to respondents. This is confirmed by a willingness to pay 1,52 MAD for every 1% increase in PR. People are willing to pay 3,04 MAD in SC_HD to have a 1 hour decrease in LT relative to HD, and 2,18 MAD in SC_CP to have a 1 hour decrease in LT_CP. The interest of respondents with respect to PR is confirmed by their WTP respectively of 0,32 MAD and 0,23 MAD in SC for HD and CP for every 1% increase in PR. A 95% confidence intervals are calculated for these WTP measures using the delta method (Gatta *et al.* 2015).

Table 6. Stated values overall statistics of TT, TW and PP.

Variable	Mean	SDev	Mode	Min	Max
TT Overall sample (Min)	19,3	16,7	10	1	120
TT Convenient store (Min)	13,9	8,2	10	2	30
TW (Hours)	1,4	0,8	1	0	6
PP (MAD)	212	294,3	100	20	2000

Table 7. Willingness to pay measures.

		WTP in MAD
PP	LT 1 H decrease	14,59
	PR 1% increase	1,52
SC HD	LT 1 H decrease	3,04
	PR 1% increase	0,32
SC CP	LT 1 H decrease	2,18
	PR 1% increase	0,23

4. 2. *Market shares*

One of the most important matters for a company is market share calculation. Here, we calculate market shares variations via scenarios analysis. The adopted approach is to change attributes levels with respect to the base scenario and to identify the changes for the various purchasing channels.

The base scenario is constructed from actual market data reported by Managers of the leaders of online and offline groceries in Morocco which are Marjane and Carrefour. Base case definition also relies on acquired data from the survey for TT and PP. Table 7, shows the average TT and PP used in scenarios analysis, which are respectively 19min and 200 MAD. The base scenario for GS alternative is constituted by these two attribute values. Regarding the base case scenario for HD, the attribute values are taken from the actual market except for the PP, which is a generic attribute for all three alternatives. The values are: SC_HD is set to be 25 MAD, TW is 2H, PR is 50% and LT is 6H. Concerning CP, we set the value of TT at 19min similar to the base scenario for In-Store alternative. SC_CP is set to 10MAD representing the actual value in the Moroccan market. PR and LT are similar to HD and are respectively 50% and 6H. The objective is to assess the best scenario modifying attribute levels in comparison to the base scenario. Eight scenarios were tested: Scenario 1 offers free delivery service by including service cost in the total price, while scenario 2 reduce lead time from 6 hours to 1. The third scenario increases lead time from 6 hours to 12 hours and the fourth one increases product range by 50%. The fifth and sixth consecutively increase product range by 20% and decrease travel time for CP option by half. Scenario 7 offers a decrease in time window by half while the last one is a mix of scenarios 1, 2 and 4 for HD only. Offering free service cost while reducing LT to 1 hour and increasing product range 50% was offered by scenario8.

The results of the analysis are shown in Table 8. The objective is not only to determine which scenario provides the best share for online channel but also to test the relative efficiency of given attributes changes in terms of market share variations. For instance, scenario 7 proves that even by reducing TW by 50% of its actual value, this will slightly improve the share for HD and will worsen the one of CP. These model results suggest that in Morocco, TW does not influence customers' choices much. Identically, improving customers TT with respect to CP does not have a big impact on share. This is due to the small travel time Moroccans spent to get to the store. Hence, reducing a travel time from 6 to 3 min will not impact the consumer choice and will not be a good strategy to increase market share. A decisive action to make HD grow by more than 50% compared to the base scenario is to offer free delivery by including the service cost in products prices. These results should be confirmed by a larger sample investigation.

5. Impact on environment

The survey conducted in this study was administered in different types of cities. From big cities with more than 3.5 million inhabitants to medium and small ones. We choose the congested city model, Casablanca, for our evaluation of kilometers

travelled using different purchase channels and their impact on the environment. The approach can be duplicated in similar big cities that are facing congestion problem like Tangier, Marrakech and Salé. For other medium to small cities, we can just adjust the assumptions used in this study. The environmental impact evaluation is based on the calculation of distance travelled and CO/NOx emissions for all the eight scenarios in comparison to the base one.

Table 8. Market shares.

	Grocery store		Home Delivery					Click&Pick					P(i)		
	PP (MAD)	TT (Min)	PP (MAD)	SC_HD (MAD)	TW (h)	PR (%)	LT (h)	PP (MAD)	SC_CP (MAD)	TT (min)	PR (%)	LT (h)	GS	HD	CP
Base	200	19	200	25	2	50	6	200	10	19	50	6	66,52%	17,92%	15,56%
Scenario 1	200	19	225	0	2	50	6	210	0	19	50	6	**53,64%**	**27,78%**	**18,57%**
Scenario 2	200	19	200	25	2	50	1	200	10	19	50	1	**54,60%**	**24,30%**	**21,10%**
Scenario 3	200	19	200	25	2	50	12	200	10	19	50	12	78,40%	11,56%	10,04%
Scenario 4	200	19	200	25	2	100	6	200	10	19	100	6	54,13%	24,55%	21,32%
Scenario 5	200	19	200	25	2	70	6	200	10	19	70	6	61,73%	20,48%	17,79%
Scenario 6	200	19	200	25	2	50	6	200	10	9,5	50	6	65,67%	17,69%	16,64%
Scenario 7	200	19	200	25	1	50	6	200	10	19	50	6	64,26%	20,70%	15,03%
Scenario 8	200	19	225	0	2	100	1	200	10	19	50	6	**37,39%**	**53,86%**	**8,75%**

Table 9. Assumed CO and NOx emissions.

			Euro 4		Euro 6	
			NOx (mg/vkm)	CO (mg/vkm)	NOx (mg/vkm)	CO (mg/vkm)
Standard threshold	Cars	New vehicles	250	500	80	500
	Delivery vans less than 1350kg		250	500	80	500
Measured	Cars	Aged vehicles	610	1152		
		New vehicles	450	900	180	900
	Delivery vans less than 1350kg		450	900	180	900

The equation to evaluate the travelled distance (Marcucci *et al.* 2021) is presented below:

$$dji[km/week]=Users\_car*Frequency*A\_distance*Pji*\%consol$$

Where:

- Users_car: number of car users making dedicated trips to purchase groceries.
- Frequency: Average shopping frequency per week.
- A_distance: Average distance to the GS.
- Pji: Probability of choosing alternative j in scenario i.
- %consol: reduction in travelled distance due to freight consolidation.

Car users performing dedicated trips are estimated to be 1094646 based on the percentage of car users in Casablanca city. According to the relevant statistics from the whole sample about the shopping frequency, we assumed that an individual buys its groceries on average 6 time per week. The average distance was calculated assuming an average speed in dense urban areas of 30km/hour and a mean of 21 min to get to the usual store for car users. This implies an average travelled distance of 10,5 km. We assume the least consolidation percentage of 40% that could be achieved for HD cases. Figure 2 shows the variation in travelled distance for each scenario.

Scenario 1 produces the best reduction in travelled distance when choosing GS alternative to CP one, while providing a decrease in travelled distance by freight vehicles assuming a consolidation percentage of 40%.

Scenario 6 even by offering a decrease in travel time for CP it increases the travelled distance slightly compared to the base scenario

Scenario 4 is one of the best scenarios that decreases substantially the travelled distance. This confirms the importance of having a high percentage of product range that is similar to the one in brick-and-mortar stores.

Impact on environment is of high importance to Morocco. In fact, Moroccan Ministry of Equipment, Transport, Logistics and Water is very concerned with vehicles emissions and is adopting progressively European standards on vehicles emissions. In fact, the transition to the Euro VI standard will take place in 2023 (Le matin 2021). However, the obsolescence of the Moroccan vehicle fleet partially slows

down this progress. Indeed, 73% of vehicles in Morocco are more than 10 years old since their commissioning and only 7% of vehicles are less than 5 years (HCP 2006). The ageing of the fleet is mainly due both to the large number of second-hand vehicles purchased abroad in the past few years and financial constraints hindering vehicle replacement. In fact, there is a close relationship between the age of a vehicle and its emissions (Zachariadis *et al.* 2001).

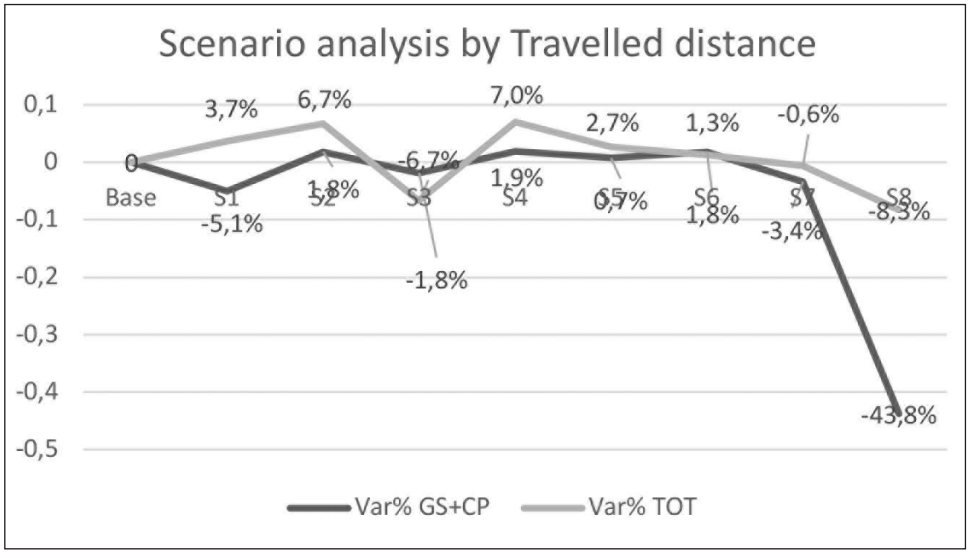

Figure 1. Variation in Travelled Distance.

The government is contrasting used car imports via import tax increase and offering scrapping/renewal grants for companies that aim to renew their freight vehicles fleet (Ministère de l'Équipement 2019). Financial support is increasing, and this initiative has reduced CO emissions by almost 3 M Tons from 2007 to 2015. This approach proved efficient in other countries, such as, for instance, China where annual emissions in Beijing were cut by 22,600 tons CO and 1330.2 tons NOx (Xiao *et al.* 2019).

This study is part of the same perspective and offers the ministry and the policy makers interested in fostering sustainable urban mobility plans a clear vision of the positive impact e-groceries might have on the environment. The simulation of emissions applies only for NOx and CO in the city of Casablanca and is based on a comparative analysis of the previous eight scenarios. One of the main motivations behind this choice is that, in early 2021, the city of Casablanca was witnessing a strong increase in with PM2.5 emissions going up to 31.2 $\mu g/m^3$. The figure would place it into the higher end of the 'moderate' pollution bracket according to the air quality report (https://www.iqair.com/ 2021). Moreover, according to the same article, much of the pollution in Morocco would be closely related to NOx emissions.

Since more than 90% of cars in Morocco are diesel-powered vehicles, the whole

calculation will consider standard emissions for these types of vehicles (*Finances News Hebdo* 2017).

Here, we conduct a sensitivity analysis to evaluate the effect of vehicle age and standards evolution on vehicles emissions in the context of groceries. In the first part, we consider that all vehicles considered in this study comply with the Euro IV standard (The one adopted in the country since 2011) and NOx and CO emissions ratios per vkm are those dictated by this standard.

In the second part, considering the ageing car fleet in Morocco but also the increase of new cars in circulation by 18% in 2017, we make several assumptions for the calculation of the emissions. Aged vehicles emit more harmful gases than new ones. We consider that aged vehicles are under the EURO III emissions threshold standard as the one enforced back in 2001. This concerns only private cars. In fact, all delivery vehicles for grocery strictly respect standards and are new generation vans. Food cooling is not included in this paper. However, recent studies shows that total CO2 emissions are much higher when food cooling is included as refrigerator units increase fuel consumption and, thus, freight transport emissions increase by factor two to five as compared to regular driving (Heldt *et al.* 2021). For this part, we assume 45% of private vehicles are old.

Since the strengthening of the technical inspection of vehicles (Ministère de l'Équipement 2019), which has led to an improvement in the mechanical condition of vehicles, average emissions will be those dictated by EURO IV standard using a variation observed in the actual state for the remaining 30%. Officially reported CO2 values do not reflect the actual performance of the vehicles on the road (Georgios *et al.* 2017), 30 to 40% difference between official values and real-world estimates was found. We assume 450 mg/vkm for real use measure of NOx (ADEME 2014) and 900 mg/vkm for CO (1,8 time higher than the 500 mg/vkm threshold limited by the standard for both light commercial vehicles under 1305kg and passenger cars (Euro standards 2021). Table 9 is a summary of the values used for the analysis.

The third part will provide policy makers with the impact of the adoption of EURO VI standard for vehicles dedicated to groceries deliveries. In fact, Morocco plans to adopt this EURO standard by 2023. Thus, we assume that all vehicles in this scenario will comply with EURO VI emissions standard.

Figure 3 and Figure 4 report the results of the three situations where the objective is to measure the influence of changing CO and NOx emissions threshold for cars and light vans with respect to each of the 8 scenarios. The most important result to highlight is the emission reduction when adopting a mixed of improvements as in scenario 8. Not only emissions by GS and CP trips are reduced, but also overall emissions, including HD. This is important for both e-grocery operators and public decision-makers whose aim is decreasing the overall impact on the environment. A second important fact emerging from the analysis is the counterintuitive result of greater emissions in scenarios where EURO standard thresholds are imposed with respect to partitioning vehicle fleet between aged and new vehicles. While scenario 3 produces the worst impact on travelled distance, it is also characterized by one of the lowest level of emissions. In fact, as Kagawa *et al.* (2013) demonstrate, scrapping aged cars does not necessarily maximize environmental benefits.

Switching to HD and planning for sustainable urban mobility or encouraging commercial vehicles renewal constitute important strategies that need to be supported by scientific studies.

6. Policy implications

Public stakeholders are encountering stern problems to insure a safer and uncongested mobility for all city residents. The challenge is even harder in big cities where freight, passenger, and environmental issues are intermingled and should be jointly addressed in policy interventions. Urban planners in Casablanca city focus on low emission zones and shared public transport to promote sustainable mobility (Casa Transport SA 2018). Including freight transport stakeholders within the planning process, as recommended by government (AMDL 2020), city council members need appropriate stakeholder participation tools supporting the process since this is definitively not a trivial task. Under this respect, it is important to note that Gatta and Marcucci (2016) when comparing various data acquisition approaches with the intent of evaluating alternative policy options stress the reliability and robustness of using stated preference methods to this end.

An important result useful for mobility planning is the reduction in the overall travelled distances by 6.7% in the third scenario and more than 8% in the last one. From an environmental point of view, scenario 8 produces the best impact on the environment reducing both NOx and CO emissions by more than 8%. These results will likely induce public planners to encourage e-groceries adoption in large cities. While e-grocery platforms should propose high-quality services offering free delivery along with wide PR and short LT.

An important issue that was stressed in the Sustainable Development Action Plan (Ministère de l'Équipement 2019) is the reinforcement of the technical control of vehicles and their repair, especially those owned by private individuals. Government can support low-income people in buying new vehicles thanks to some financial aids or providing financial relief. The result this study produces is of great value in supporting private companies' strategy definition to promote a greater e-grocery penetration in Morocco. In fact, scenario analysis suggests that it is not worthwhile reducing the current TW width. In fact, also reducing TW by half (Table 9), will only increase HD share by approximately 2.5% while concurrently decreasing CP share by less than 1%. On the contrary, increasing PR by 50%, reducing LT, and most important offering free delivery are the most effective marketing levers. This integrated intervention might produce a market share increase of almost 10% for HD as scenario 1 shows (Table 9). A better option is combining the three policies as in scenario 8.

Sustainability is not only a public stakeholders concern. Private companies should align with environmental regulations but should also do it for customers as they are more aware of their importance. Pressure on delivery companies is also increasing due to two contrasting forces. On one side, end customers are becoming more and more sophisticated while demanding low-cost and fast deliveries. On the other hand, infrastructural interventions are promoting walking, cycling, and

public transport thus reducing curbside accessibility for last-mile operations (Allen *et al.* 2017).

This paper also produces valuable information for e-grocery platforms. In fact, they can use the results as guidelines for defining policy interventions capable of minimizing the negative impacts their delivery services produce on the environment. Other influencing factors for reducing emissions are proximity to regional warehouses and roadway density (Wygonik and Goodchild 2018). Leveraging network of existing physical stores is proven to be a sustainable option (Mkansi and Luntala 2021) which is already applied in Morocco by Marjane Holding.

7. Conclusions

This paper uses stated preferences methods to study Moroccans' preferences toward online grocery shopping. Interviews were conducted in several cities, including big and medium sized ones, gathering 246 respondents. MNL model results highlight an indifference in grocery purchasing channel when comparing GS and HD. Comparing CP and HD, MNL estimates indicate people prefer HD.

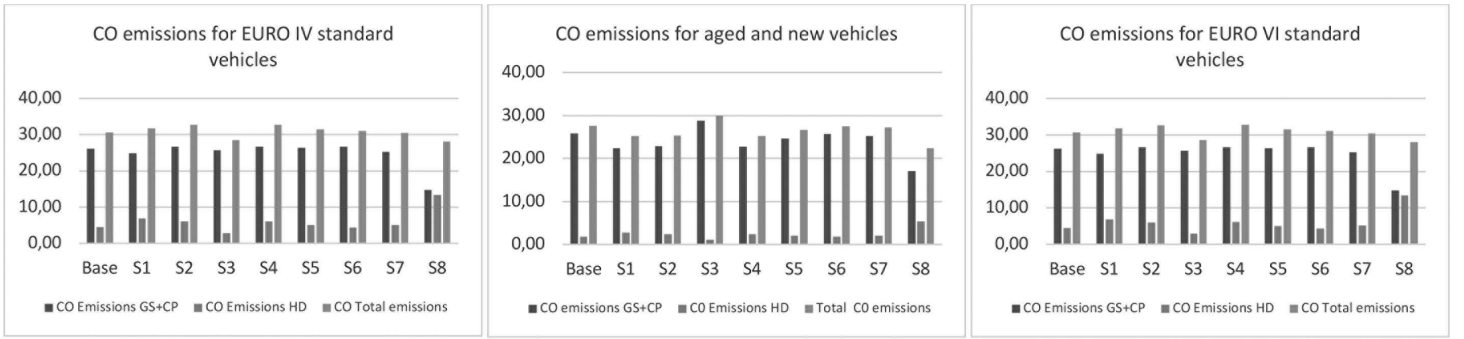

FIGURE 2. CO emissions for different scenarios.

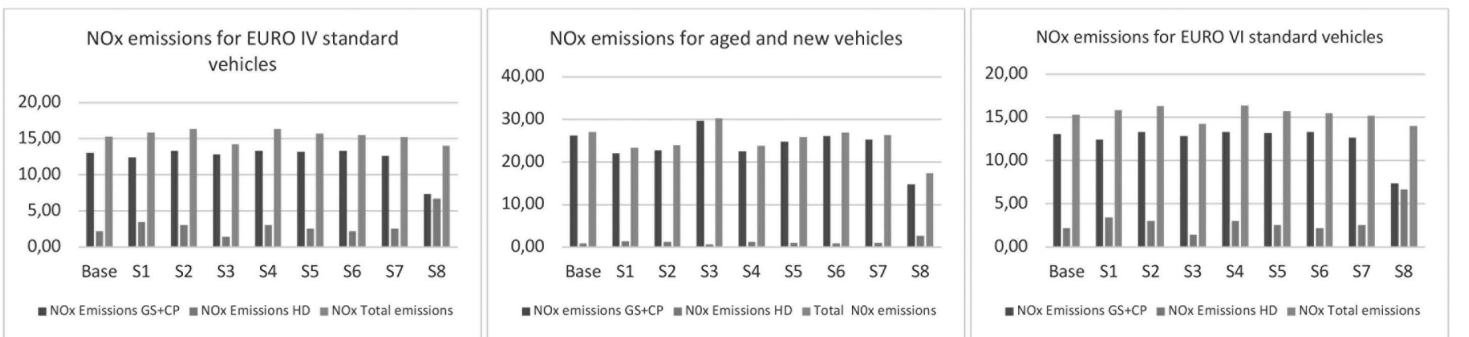

FIGURE 3. NOx emissions for different scenarios.

This study provides valuable information for both public and private operators. In fact, online grocery sales can be doubled by combining three strategic improvements, namely: extending online PR, reducing LT to 1 hour, and including SC in PP and offering free HDs. The same improvements will allow private managers to reduce overall noxious emissions. The results obtained can also contribute to develop appropriate sustainable urban mobility plans in line with governmental agencies requirements.

Some limitations characterize the current study. First, the sample size should be bigger if the aim is obtaining representative results. One should also underline that the results produced are sufficient to gain some preliminary insights. Second, fleet vehicle data and their emissions can be updated. Under this respect, we suggest that future research should focus on estimating emissions for different vehicle types. Third, one could, in principle, also investigate more flexible models including non-linearity (see e.g. Rotaris *et al.* 2012; Gatta and Marcucci 2016), heterogeneity (see e.g. Marcucci and Gatta 2012), and interation effects (see e.g. Marcucci *et al.* 2017). All these factors might potentially influence the accuracy of the estimated environmental impacts e-groceries might produce. Additionally, one could consider performing the same study in a post pandemic context so to pick up the COVID-19 induced changes. In fact, it would be interesting assessing whether the COVID-19 induced changes in grocery purchasing habits are temporary or permanent Future research should also provide a more balanced dataset with respect to gender mix and we foresee this as a relatively easy task once social distancing constraints will be removed. Futhermore, in order to keep stated preference studies costs low, one could consider adopting a research strategy based on the investigation of what e-grocery professionals believe their customers' preferences are. Should this suggestion prove reliable one could both reduce adminsitration costs while being reassured of the quality of the knowledge acquired. For an example of the implementation of this technique please refer to Marcucci and Gatta 2016.

The most important contribution this article has produced is the definition of a research framework that, once appropriately deployed, can produce all the relevant knowledge private and public agents might want so to define sustainable development strategies aligned with both end consumers preferences as well as high livability standards. While the proposed framework can be improved at the margin, we strongly believe its underline logical structure is capable of handling future research needs, and thus we encourage other researchers and practitioners to freely take advantage of it.

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