Behavioral economic purchase tasks to estimate demand for novel nicotine/tobacco products and prospectively predict future use: Evidence from the Netherlands

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Conflict of interest declaration

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ABSTRACT

Introduction: The demand for alternative nicotine/tobacco products is not well established. This paper uses a behavioral economic approach to test whether smokers have differential demand for conventional factory-made, electronic, and very low nicotine content cigarettes (FMCs/ECs/VLNCs) and uses the prospective cohort design to test the predictive validity of demand indices on subsequent use of commercially available FMCs and ECs.

Methods: Daily smokers (≥16 years) from the Netherlands completed an online survey in April 2014 (*N*=1215). Purchase tasks were completed for FMCs, ECs, and VLNCs. Participants indicated the number of cigarettes they would consume in 24 hours, across a range of prices (0-30 euro). The relationship between consumption and price was quantified into four indices of demand (intensity, Pmax, breakpoint, and essential value). A follow-up survey in July 2015 measured FMC and EC use.

Results: At baseline, greater demand was observed for FMCs relative to ECs and VLNCs across all demand indices, with no difference between ECs and VLNCs. At follow-up, greater baseline FMC demand (intensity, essential value) was associated with lower quit rates and higher relapse. EC demand (Pmax, breakpoint, essential value) was positively associated with any EC use between survey waves, past 30 day EC use, and EC purchase between waves.

Conclusions: Smokers valued FMCs more than ECs or VLNCs, and FMCs were less sensitive to price increases. Demand indices predicted use of commercially available products over a 15 month period. To serve as viable substitutes for FMCs, ECs and VLNCs will need to be priced lower than FMCs.

Implications: Purchase tasks can be adapted for novel nicotine/tobacco products as a means to efficiently quantify demand and predict use. Among current daily smokers, the demand for ECs and VLNCs is lower than FMCs.

INTRODUCTION

With the increased availability of alternative nicotine/tobacco products, conventional factory-made cigarette (FMC) smokers today have more options to use less harmful products. Over the past decade, electronic cigarettes (ECs) have become a popular and rapidly evolving class of non-combustible products used and available to consumers. Smoking-related morbidity and mortality would certainly be reduced if smokers switched completely from FMCs to ECs.[1] Very low nicotine content cigarettes (VLNCs) are another alternative product with potential to disrupt the use of conventional cigarettes. Many researchers and policy experts have argued for comprehensive reduced-nicotine policy,[2,3] thereby **limiting** cigarette availability to VLNCs that are unable to produce/maintain dependence.[4,5] Others have warned that mandatory nicotine reductions[6] might not be successful noting that similar products (Quest 3) have not fared well in the past. Although VLNCs are not widely available commercially, research studies of VLNCs suggest they are perceived by smokers to be less rewarding than FMCs and result in lower cigarette consumption even when provided at no cost.[7,8]

Development of methods to forecast the acceptability of novel products would facilitate research to inform tobacco regulatory decisions. Estimation of consumer demand for alternative products may allow for the forecasting of product uptake, before they come to market and/or become widely popular. This is particularly timely for ECs, which are regulated differently across countries, ranging from no regulation to sales bans, and recently **have become** subject to FDA regulation in the United States. FDA has the authority to enact regulatory standards for nicotine levels in cigarettes, but cannot mandate complete elimination of nicotine.

Behavioral economics offers a time- and cost-efficient approach to assess product demand,[9] regardless of product availability. Hypothetical purchase tasks, a self-report analogue

of a progressive-ratio operant schedule, quantify participants' cigarette consumption across varying levels of cost.[10,11] Greater consumption and insensitivity to price are indicative of higher product demand or abuse liability.[12] Elevated cigarette demand is associated with higher levels of nicotine dependence,[13] lower motivation to quit,[14] and greater difficulty quitting.[15-17] Purchase tasks have also been used to assess change in acute motivational states,[18-21] and to inform tax policy.[22,23]

Relatively few purchase task studies of alternative products have been published. One online study examined smokers' demand for a variety of oral nicotine/tobacco products (snus, nicotine lozenges, and dissolvables), and found lower demand compared to FMCs which is consistent with low reported prevalence of these same products.[24] Importantly, this study demonstrated the validity of purchase tasks for products that many smokers had no experience using. Another online study found EC and FMC demand varied as a function of current/past EC use.[25] In the context of a large clinical trial, participants randomized to receive VLNCs (≤2.4 mg/g) for six weeks had lower product demand relative to those provided normal nicotine content cigarettes (15.8 mg/g), and demand was strongly associated with use during the week preceding demand assessment.[26] A lab-based operant demand study found no differences in the relative reinforcement value**, or abuse liability,** of FMCs and VLNCs when assessed independently, but lower demand for VLNCs when both products were concurrently available.[27] No study to date has simultaneously compared smokers' demand for ECs, VLNCs, and FMCs. In addition, the predictive validity of EC purchase tasks has not been established.[28]

The current study was designed to help fill these knowledge gaps and test the validity of hypothetical purchase tasks as an assessment of alternative product acceptability. We herein present findings from a longitudinal cohort study that characterizes demand for FMCs, ECs, and

VLNCs **(specifically, zero nicotine)** among smokers aged 16 and older. First, we hypothesized that smokers would show greater demand for FMCs relative to VLNCs and ECs, and differential demand would be moderated by age, EC use, and motivation to quit smoking. Second, consistent with past studies we hypothesized that FMC demand at baseline would predict FMC smoking status at follow-up. Third, we hypothesized that EC demand at baseline would predict EC uptake among smokers **that were not current EC users (past 30 days)**.

METHODS

Participants

Respondents to the baseline survey were recruited by a commercial online survey research firm (TNS NIPO) in April 2014. The sampling frame was constructed to provide a nationally representative sample age 16 years and older in the Netherlands. ECs were available and regulations were not as restrictive as those for FMCs.[29] When we initiated the baseline survey we had expected that VLNCs were going to be introduced into marketplace in the Netherlands within a few months. However, this did not happen because the government raised concerns with the product distributor about proposed product labeling (i.e., zero nicotine) and the use of genetically modified tobacco which was thought to violate rules regarding the marketing of genetically modified foods in the Netherlands. Thus, we could not test the predictive validity of the baseline demand for VLNCs on subsequent use of VLNCs as we could for FMCs and ECs.

Eligibility for inclusion in the current study included: smoked at least 100 FMCs in their lifetime and smoked FMCs daily over the past 30 days. There was no criteria specified for past VLNC or EC use. The final eligible sample consisted of 1215 participants (see Table 1), who smoked an average of 14 cigarettes per day (*SD*=7). **Few participants reported lifetime VLNC**

use (2%), with a larger portion reporting lifetime EC use (31%). Participants were recontacted for follow-up 15 months after the baseline survey; 793 baseline respondents (65%) completed the follow-up survey. Those who completed the follow-up survey were older and more educated than those who did not complete the follow-up survey. Participants were compensated by the survey firm with NIPO Points, which could be used by the respondent to acquire gifts. All procedures were approved by the Institutional Review Board at the University of Waterloo.

Procedure and Measures

After obtaining informed consent, participants completed the online survey. Purchase tasks for FMCs, VLNCs, and ECs were completed in a fixed order (i.e., within-subjects design), as presented. To help orient respondents to the different products, they were shown a colorized picture of a FMC, VLNC, or EC (see Supplementary Figure 1) prior to each task and instructed to assume the products were their preferred type and quality.

Demand

Purchase tasks were based on the previously validated Cigarette Purchase Task:[10,13,30]

"Imagine that for the next 24 hours the only cigarettes available to you are [ORDINARY FACTORY-MADE CIGARETTES/NICOTINE-FREE CIGARETTES/ELECTRONIC CIGARETTES (E-CIGS)]. That is, you have NO ACCESS to any other type of cigarette or nicotine product for the next 24 hours. The following questions ask how many [ORDINARY FACTORY-MADE CIGARETTES/NICOTINE-FREE CIGARETTES/ELECTRONIC CIGARETTES (E-CIGS)] you would smoke/use if they cost various amounts of money."

This was completed when the cost for each cigarette was: €.00, €.05, €.15, €.30, €.45, €.60, €.90, €1.20, €3, and €30 (equivalent to a range of US$0 to US$33 at time of study). The average market price of the most popular FMC was €.30 at the time of the study. Price point selection was informed by review of prior purchase task studies, intended to capture both the transition from inelastic to elastic price sensitivity and breakpoint. Given the variability in number of puffs obtained from an EC, and to better equate the products, participants were also told to assume that 10 puffs of an EC equals 1 EC. Responses across the 10 prices were used to generate four demand indices: 1) intensity (cigarette consumption at the lowest price), 2) Pmax (price at which consumption becomes elastic), 3) breakpoint (price at which consumption reaches zero), and 4) essential value (overall reinforcement value; inversely related to sensitivity of consumption to increases in cost). We also considered Omax (maximum expenditure), but did not include this index because it was highly correlated (i.e., redundant) with essential value across all three products (rs=.93-.96, ps<.0001).

Follow-up Outcomes

Abstinence from FMCs was based on self-reported smoking status at wave 2 (smoker/quitter), with no minimum abstinence duration required. *Relapse status* was based on those who made a quit attempt between waves and who reported smoking at follow-up (still quit/relapsed). EC use outcomes of interest were *any use between waves*, *any purchase of EC between waves*, and *EC use within the past 30 days* (no/yes). EC outcome analyses were restricted to non-users of ECs (past 30 days) at baseline because we aimed to test predictive validity for EC uptake, which had already occurred for those using ECs at baseline.

Potential Moderators

The survey assessed demographic variables such as age, gender, income, and education, which were categorized in a manner consistent with prior International Tobacco Control (ITC) studies. Monthly income was categorized into three levels: low (<€1750), moderate (€1750-€3000), and high (>€3000). Education was categorized into three levels: low (primary education and lower prevocational secondary education), moderate (middle prevocational secondary education and secondary vocational education), and high (senior general secondary education, pre-university education, and higher professional education). Nicotine dependence was measured by the Heaviness of Smoking Index (HSI).[31] HSI was coded as low (0-3) or high (4-6), which represents a validated dependence classification for population-based studies.[32] Motivation to stop smoking[33] was categorized into three levels: none (did not want to quit), low (wanted to quit, but not sure when), and high (intentions to quit within 3 months). The parent study included additional assessments, the results of which are not reported herein.

Data Analyses

Purchase task data were checked for nonsystematic responding.[34] Violation of the trend criterion, due to null demand (zero consumption at all prices), was detected for 29% of VLNC and 30% of EC purchase tasks. Essential value cannot be computed for participants with null demand, however, we coded essential value as zero (i.e., lowest potential value) in these cases because it is plausible that participants did not find the alternative products appealing and exclusion would overestimate alternative product demand.[35] Essential value,[36] $1/(100 \times \propto \times k^{1.5})$, was computed for those with systematic purchase task data, and estimates were square root transformed to improve distributions. Elasticity (α) represents the rate of decline of consumption

in standardized cost, which was derived through a modified exponential demand curve equation,[37] $Q = Q_0 \times 10^{k\left(e^{-\alpha Q_0 C}-1\right)}$. For this equation, Q = consumption at a given cost, Q_0 = consumption when cost is zero, C = cost, and k = a constant that denotes the range of consumption in log powers of 10. For the current study k=2, based on estimated FMC consumption. We also examined k values at 1, 3, and 4, but 2 provided the best fit for the aggregated group mean values (R^2=.99) and individual values (R^2=.89-91). Modeling was conducted using GraphPad Prism version 7 software (La Jolla, CA). With the exception of essential value, demand indices were generated using an observed values approach. Data were examined for distribution abnormalities and outliers, defined as $z > 3.29$, and those identified were recoded as one unit above the next highest non-outlier at the second decimal.[38] This was relevant for breakpoint because a considerable number of participants were willing to consume products at the €30 per cigarette price point (FMCs=16%; VLNCs=11%; ECs=8%). Distributions were normal after imputing one unit higher than the next highest price of €3.

Differential product demand was evaluated using repeated-measures generalized estimating equations (GEE), via SAS 9.4. Each of the four demand indices (intensity, Pmax, breakpoint, and essential value) was modeled separately as the dependent variable and the product type (FMC, VLNC, and EC) as the independent variable. The following moderators were examined: HSI, quit motivation, EC use in the past 30 days, age, sex, income, educational level, and use of roll-your-own (RYO) cigarettes. We implemented a series of stepwise inclusion and exclusion of variables to reach the most parsimonious model including interaction terms, based on QIC and the type 3 effect tests. **Variables with p-value > .05 in the type 3 tests were sequentially removed in the order of decreasing p-value. The removed variables were re-inserted into the reduced model for evaluation of significance prediction. The most**

parsimonious model was determined after a series of the above-mentioned manual stepwise elimination. We report the unadjusted means for each demand outcome and unfold the adjusted means for significant interaction terms (*ps*<.05).

Predictive validity was evaluated using logistic regression analyses, via SPSS 24. Baseline FMC demand indices were tested as predictors of FMC abstinence and relapse at follow-up, and baseline EC demand indices were examined for EC use/purchase between waves and EC use in the past 30 days. For each dependent variable two models were estimated across all demand indices: a bivariate model in which the demand index at baseline predicted the dependent variables at follow-up, and a model that also adjusted for baseline covariates. Results were similar across models, and adjusted models are presented below.

RESULTS

Preliminary Analyses

As presented in Supplementary Table 1, significant correlations were observed between demand indices for each of the purchase tasks (*ps*<.001). Supplementary Table 2 displays the results of logistic regression analyses that examined predictors of null vs. having any demand. Sex was the only significant predictor for VLNCs, with females more likely than males to have VLNC demand (*OR*=1.60, *p*<.001). Type of cigarette smoked and past 30 day EC use were the only significant predictors for ECs. RYO only smokers were less likely than FMC only smokers to have EC demand (*OR*=.65, *p*<.05), and a similar pattern was observed for those that had not used ECs in the past 30 days relative to those that had (*OR*=.26, *p*<.001).

Differential Product Demand

Demand curves are shown in Figure 1. As displayed in Table 2, unadjusted mean values for each of the demand indices were higher for FMCs, relative to VLNCs and ECs. GEE modeling found that intensity, Pmax, breakpoint, and essential value for ECs and VLNCs were all statistically lower than those observed for FMCs (*ps*<.0001). Demand indices did not differ significantly between VLNCs and ECs. Supplementary Table 3 depicts the influence of baseline covariates on product demand, and Table **3** displays adjusted mean estimates of significant moderators.

Intensity Moderators

There was a significant interaction between product type with HSI (*p*<.0001), and past 30 days EC use (*p*=.002). Demand was higher for those more nicotine dependent, particularly for FMCs. Results suggest similar demand for FMCs and VLNCs based on past 30 day EC use, but higher demand for ECs among smokers who used ECs in the past 30 days.

Pmax Moderators

There was a significant interaction between product type with motivation to quit (*p*<.0001). This pattern reflected similar demand for VLNCs and ECs regardless of motivation to quit, and that demand for FMCs was lower among those more motivated.

Breakpoint Moderators

There was a significant interaction between product type with motivation to quit (p=.001), past 30 days EC use (p<.0001), and RYO smoking status (p=.04). Similar to the Pmax results, demand for FMCs was lower among those more motivated. Similar to intensity results, those who used ECs in the past 30 days had higher demand for ECs. RYO only users had less demand for FMCs and ECs, relative to groups that used FMCs.

Essential Value Moderators

There was a significant interaction between product type with HSI (p=.01), motivation to quit (p<.0001), and RYO smoking status (p=.002). Consistent with intensity results, demand for FMCs was higher for those more nicotine dependent. Those with high motivation to quit had lower demand for FMCs, but not for the VLNCs or ECs. Similar to breakpoint findings, RYO only users had less demand for FMCs and ECs, relative to groups that used FMCs.

Predictive Validity

Smoking status at follow-up

Abstinence was reported by 11% of the sample at follow-up. Among those who made a quit attempt (31%) between waves 71% relapsed. As displayed in Table **4**, intensity and essential value were the only FMC demand indices to significantly predict abstinence or relapse (ps<.05). Greater demand for FMCs was associated with a lower likelihood of being quit, and higher rates of relapse. Effect sizes were generally small in magnitude.

EC use at follow-up

Rates of EC use outcomes among those who did not use ECs at baseline (83%) were 14% for any EC use between waves, 7% for any purchase of EC between waves, and 4% for EC use within the past 30 days. All EC demand indices significantly predicted any use of ECs between surveys (*ps*<.05; see Table **4**). Higher EC demand at wave 1 was associated with greater likelihood of EC use. A similar pattern was observed for EC purchase between waves and past 30 day EC use at follow-up, with larger effect sizes observed (*ps*<.05).

DISCUSSION

The current study is the first to compare estimated demand of ECs, VLNCs **(i.e., nicotine-free)**, and FMCs, and to examine the predictive validity of EC demand. Differential demand results suggest daily smokers valued FMCs approximately two times more than they did either VLNCs or ECs, which is consistent with findings from econometric studies.[39,40] The generally low rates of use of alternative products observed in prior studies which have attempted to switch smokers to alternative nicotine products may be explained by the lower overall valuation of these alternative products compared to FMCs.[41-43] Regardless, the fact that 70% of smokers expressed at least some demand for these alternative products offers the possibility that their availability could potentially have an impact on the use of FMCs.

This study provides evidence that responses to a series of hypothetical purchase tasks can predict product use over a year later. EC demand indices were positively associated with EC uptake, as measured by any EC use, past 30-day use, and any EC purchase. We also found higher demand for FMCs was associated with less quitting and higher relapse rates, albeit this pattern was less robust across demand indices.

Uptake of alternative products is likely to be highly dependent upon the availability of FMCs and their price relative to FMCs. If products such as ECs and VLNCs are going to serve as substitutes for FMCs, our results suggest their cost must be at least 50% less than FMCs with conventional nicotine levels. Indeed, when Phillip Morris withdrew price promotions for its de-nicotinized cigarettes sold in three markets in 1988, repeat sales declined.[44] These results have important policy implications since econometric studies show that the demand for FMCs is inversely related with price,[45] and this relationship may be even stronger for alternative nicotine products.[39,40] Thus, differential taxation and pricing promotion policies have the potential to motivate smokers to switch from FMCs to a lower risk alternative tobacco/nicotine products. Conversely, not providing such incentives may greatly reduce the potential of alternative products such as ECs and VLNCs to replace conventional FMCs. Indeed, some have suggested that it will be necessary to mandate nicotine reductions in FMCs in order for VLNCs replace conventional cigarettes.[4,5]

To the extent that greater differential demand indicates the need for differential pricing, this may be particularly important for smokers with greater nicotine dependence, lower motivation to quit, and for those who smoke FMCs (vs. RYO). Demand for FMCs, compared to ECs/VLNCs, was higher in these groups such that consumption of FMCs was less responsive to cost increases. This suggests these groups may be willing to try alternative products, but only at low costs. This pattern may also be the case for smokers who have not tried the alternative product, as suggested by the lower EC demand among EC **nonusers** relative to those who had used ECs in the past 30 days. **Between-group difference in EC demand based on EC use at baseline supports the construct validity of our EC purchase task, and that within-group variation among non-users predicted EC outcomes provides initial evidence of predictive**

validity. An important research question to address is how demand for alternative products may change upon initial use. Prior to use, estimated demand will be driven by expectancies about the product shaped through exposure to information (e.g., advertising), use and attitudes of others, and regulatory environment. Enjoyment experienced from initial use will influence expectations and consequentially demand and patterns of consumption. The product itself will have a strong impact here, and given the wide array of available products there is likely to be great variability. The complex interaction between regulatory environment and demand highlights the importance of thoughtful yet swift policy decision-making. Product standards can be leveraged to set the stage for a market of alternative products perceived by consumers to be of high quality and appealing, thereby promoting transitions away from combustible cigarettes and improved population health.

There are several limitations to the current study that are worth noting. First, that the current sample was recruited from a commercial online survey panel and does not include smokers unconnected to the internet. The online nature of the study does offer the advantage of the ability to recruit larger numbers of diverse subjects thereby improving both the efficiency and generalizability of the more commonly utilized laboratory-based methods that have been used to study product demand. A second limitation of the study was our use of presenting subjects with a single picture of one specific brand for each type of product **in a fixed order**. Future studies could **randomize** multiple brands of each product thereby offering respondents a more representative presentation of the marketplace of products available to them in the real **world and controlling for potential order effects**. A third limitation was the purchase tasks required estimating demand for each product independently, assuming no other nicotine/tobacco products were available. Testing demand in the context of other substitutable products provides a more

realistic assessment of how consumers make product choices. Methods have been developed that allow for the measurement of cross-price elasticity, a direct test of product substitutability and a more robust test of the likely impact of having alternative products available to consumers at different price points.[46-48] Predictive validity analyses were limited in that outcomes were based on self-reported FMC/EC use, without biochemical verification. However, this approach conforms to recommendations for population-based studies.[49] Our use of 10 price points for the purchase tasks is another consideration. Most studies include approximately 20 price points, which affords greater demand curve resolution. Nonetheless, our data fit the exponential demand equation very well and was feasible within the context of the parent study. Future studies would benefit from inclusion of more frequent and comprehensive follow-up assessments to improve retention rates and allow for better characterization of how demand relates to product use. Finally, replication should be attempted in different contexts and with different products to clarify how strongly purchase task responses map onto future consumption patterns, and their potential utility to inform population health modeling.[50]

Conclusions

This study shows that among current daily smokers the demand for ECs and VLNCs is low relative to FMCs, and demand prospectively predicts product use. Those with greater demand for FMCs were more likely to maintain smoking, and EC uptake was more likely among those with greater EC demand. That smokers valued FMCs more than VLNCs and ECs suggests that alternative nicotine/tobacco products will need to be priced lower if they are to serve as viable substitutes at the population-level.

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Table 1

Participant characteristics at baseline, and differences between those followed up or not.

	Full sample at wave 1 N=1215	Followed up at wave 2 n=793	Not followed up n=422	Followed up vs. not
Age, mean (SD)	38 (18)	40 (18)	34 (18)	*t*=-2.03***
Sex, n (%)				χ^2=.01
Male	625 (51)	407 (51)	218 (52)	
Female	590 (49)	386 (49)	204 (48)	
Income, n (%)				χ^2=5.67
Low	357 (29)	218 (28)	139 (33)	
Moderate	250 (21)	165 (21)	85 (20)	
High	265 (22)	186 (24)	79 (19)	
Unknown	343 (28)	224 (28)	119 (28)	
Educational level, n (%)				χ^2=8.32*
Low	284 (23)	191 (24)	93 (22)	
Moderate	594 (49)	365 (46)	229 (54)	
High	329 (27)	232 (29)	97 (23)	
Unknown	8 (1)	5 (1)	3 (1)	
Type of cigarette, n (%)				χ^2=4.35
FMC only	394 (32)	252 (32)	142 (34)	
RYO Only	283 (23)	199 (25)	84 (20)	
Both FMC and RYO	529 (44)	335 (42)	194 (46)	
Unknown	9 (1)	7 (1)	2 (1)	
EC use (past 30 days), n (%)				χ^2=2.78
Yes	228 (19)	138 (17)	90 (21)	
No	987 (81)	655 (83)	332 (79)	
Motivation to quit, n (%)				χ^2=.35
No motivation	733 (60)	477 (60)	256 (61)	
Low motivation	412 (34)	210 (27)	112 (27)	
High motivation	61 (5)	102 (13)	49 (12)	
Unknown	9 (1)	4 (1)	5 (1)	
HSI, n (%)				χ^2=1.00
Low	1079 (89)	699 (88)	380 (90)	
High	136 (11)	94 (12)	42 (10)	

Note: Data from daily smokers in the Netherlands collected in April 2014.
*p<0.05; ***p<0.001
FMC: Factory-made cigarette; RYO: roll-your-own; EC: electronic cigarette; HSI: Heaviness of smoking index; SD: Standard deviation

Table 2

Unadjusted means (SDs) of demand indices.

	Type of Cigarette		
	Factory Made (FMC)	Very Low Nicotine Content (VLNC)	Electronic (EC)
	Mean (SD)	Mean (SD)	Mean (SD)
Intensity***	14.65 (8.52)	9.59 (9.29)	8.76 (8.96)
Pmax***	1.35 (1.16)	.49 (.57)	.48 (.65)
Breakpoint***	2.39 (1.28)	1.39 (1.46)	1.34 (1.47)
Essential Value***	.59 (.37)	.29 (.26)	.25 (.22)

Note: Data from daily smokers in the Netherlands collected in April 2014.
SD: standard deviation
N=1215
*** Tukey-adjusted p-values all < .0001 for FMC vs. VLNC and FMC vs. EC comparisons, across all demand indices.
No significant differences between VLNC and EC

Table 3

Adjusted mean estimates (and 95% CIs) of demand indices based on significant moderators.

	Intensity¥ N=1215	Pmax$ N=1215	Breakpoint§ N=1215	Essential Value€ n=662
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Product type x HSI				
FMC & low HSI	12.21 (11.54-12.89)	-	-	.59 (.56-.62)
VLNC & low HSI	7.62 (6.93-8.30)	-	-	.30 (.27-.32)
EC & low HSI	7.05 (6.37-7.74)	-	-	.26 (.24-.29)
FMC & high HSI	23.58 (22.01-25.16)	-	-	.74 (.68-.80)
VLNC & high HSI	14.77 (12.57-16.98)	-	-	.39 (.33-.44)
EC & high HSI	11.97 (9.89-12.89)	-	-	.32 (.27-.37)
Product type x MTQ				
FMC & no MTQ	-	1.45 (1.33-1.57)	2.56 (2.44-2.69)	.72 (.67-.77)
VLNC & no MTQ	-	.46 (.37-.55)	1.47 (1.33-1.62)	.39 (.34-.43)
EC & no MTQ	-	.43 (.34-.53)	1.38 (1.24-1.52)	.34 (.30-.39)
FMC & low MTQ	-	1.19 (1.05-1.32)	2.31 (2.16-2.46)	.64 (.59-.69)
VLNC & low MTQ	-	.56 (.44-.68)	1.57 (1.37-1.78)	.39 (.34-.44)
EC & low MTQ	-	.72 (.42-1.03)	1.52 (1.11-1.93)	.42 (.32-.51)
FMC & high MTQ	-	.87 (.64-1.11)	1.94 (1.62-2.27)	.57 (.49-.65)
VLNC & high MTQ	-	.25 (-.02-.51)	1.21 (.83-1.58)	.33 (.23-.42)
EC & high MTQ	-	.41 (.25-.57)	1.15 (.83-1.48)	.35 (.29-.41)
Product type x EC use-30day				
FMC & no EC use	20.58 (19.14-22.03)	-	2.52 (2.40-2.64)	-
VLNC & no EC use	15.51 (13.98-17.03)	-	1.52 (1.39-1.66)	-
EC & no EC use	14.24 (12.73-15.75)	-	1.38 (1.24-1.51)	-
FMC & EC user	22.61 (20.88-24.34)	-	2.59 (2.39-2.79)	-
VLNC & EC user	17.61 (15.71-19.52)	-	1.59 (1.37-1.82)	-
EC & EC user	18.75 (16.94-20.57)	-	1.95 (1.72-2.17)	-
Product type x RYO status				
FMC & FMC only	-	-	2.56 (2.44-2.69)	.71 (.66-.76)
VLNC & FMC only	-	-	1.47 (1.31-1.63)	.39 (.34-.43)
EC & FMC only	-	-	1.38 (1.28-1.54)	.35 (.31-.39)
FMC & RYO only	-	-	1.98 (1.81-2.16)	.58 (.53-.64)
VLNC & RYO only	-	-	1.22 (.98-1.46)	.35 (.30-.40)
EC & RYO only	-	-	.93 (.71-1.15)	.23 (.17-.30)
FMC & both	-	-	2.47 (2.35-2.59)	.72 (.68-.77)
VLNC & both	-	-	1.71 (1.43-1.98)	.49 (.42-.56)
EC & both	-	-	1.42 (1.28-1.55)	.37 (.33-.41)

Note: Data from daily smokers in the Netherlands collected in April 2014.
FMC: Factory-made cigarette; VLNC: very low nicotine cigarette; EC: electronic cigarette; RYO: roll-your-own; HSI: heaviness of smoking index; MTQ: motivation to quit; EC use-30day: EC use in the past 30 days
¥: adjusted for product, HSI, EC use-30day, product*HSI, product* EC use-30day, and product*RYO
§: adjusted for product, MTQ, EC use-30day, product*MTQ, product* EC use-30day, and product*RYO
$: adjusted for product, MTQ, educational level, RYO, product*MTQ, product*RYO
€: adjusted for product, HSI, MTQ, RYO, product*HSI, product*MTQ, product*RYO

Table 4

Predictive validity of purchase tasks for factory made cigarette (FMC) and electronic cigarette (EC) use at follow-up.

	Smoking Cessation Outcomes (predictors based on FMC purchase task)				**EC Use Outcomes** (predictors based on EC purchase task)					
	Quit Status		Relapse Status		Any Use Between Waves		EC Purchase Between Waves		Past 30 Days Use	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Intensity	.97*	(.94-.99)	1.05**	(1.02-1.10)	1.03*	(1.01-1.05)	1.02	(.99-1.06)	1.02	(.98-1.07)
Pmax	.99	(.81-1.22)	1.05	(.82-1.35)	1.45*	(1.05-1.99)	1.85**	(1.25-2.72)	2.01**	(1.23-3.30)
Breakpoint	.89	(.74-1.06)	1.19	(.96-1.49)	1.19*	(1.02-1.38)	1.28*	(1.05-1.57)	1.36*	(1.05-1.77)
Essential Value	.45*	(.21-.97)	2.55	(.98-6.63)	3.96**	(1.46-10.70)	6.63**	(1.68-26.14)	6.34*	(1.09-36.75)

Note: Data from daily smokers in the Netherlands collected in April 2014 and July 2015.
*p<0.05; **p<0.01
Quit Status sample size: n=782
Relapse Status sample size: n=242
EC Use sample size: n=645
Adjusted models included: sex, age, roll-your-own smoking status, motivation to quit, and heaviness of smoking index; cessation outcomes also included baseline EC use in the past 30 days

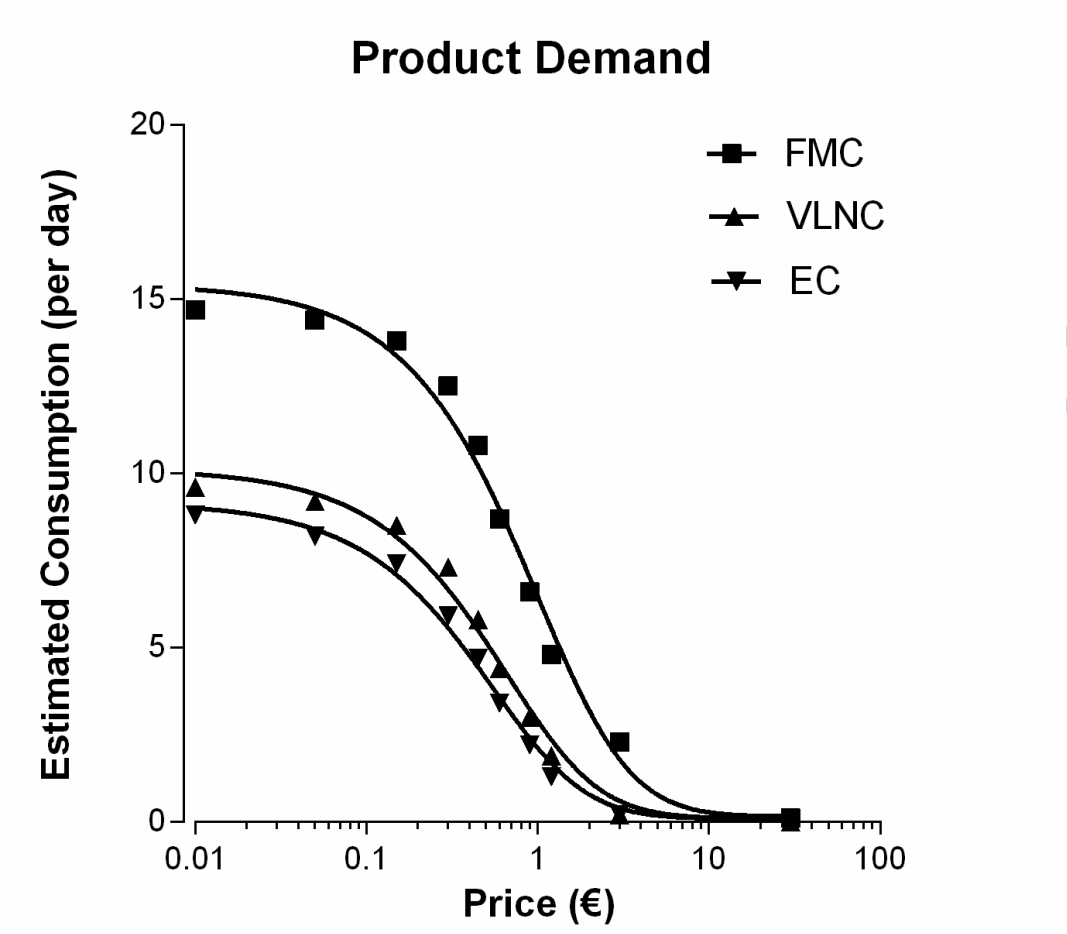

Fig. 1 Demand curves for factory-made cigarettes (FMC), very-low nicotine cigarettes (VLNC) and electronic cigarettes (EC; 1 EC=10 puffs)

Note: Data from daily smokers in the Netherlands collected in April 2014.