Hedonic Pricing of Attributes of Nicotine Delivery Systems and the Impact of Bans on Specific Attributes

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THESIS

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This thesis is dedicated to

my late uncle, Farouk A. Chowdhury, because of whom this journey began,

and my husband, Khalid S. Hossain, because of whom it was completed.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

APV	**A**dvanced **P**ersonal **V**aporizers
BIS	**B**usiness **I**ntelligence and **S**trategy Research
BLS	**B**ureau of **L**abor **S**tatistics
CAGR	**C**ompound **A**nnual **G**rowth **R**ate
CDC	**C**enters for **D**isease **C**ontrol and Prevention
CO	**C**arbon Mon**o**xide
CPI	**C**onsumer **P**rice **I**ndex
CV	**C**on**v**enience Stores
ENDS	**E**lectronic **N**icotine **D**elivery **S**ystems
FDA	**F**ood and **D**rug **A**dministration
FDM	**F**ood, **D**rug and **M**ass
FTC	**F**ederal **T**rade **C**ommission
ITS	**I**nterrupted **T**ime **S**eries
MRTP	**M**odified **R**isk **T**obacco **P**roduct
NDS	**N**icotine **D**elivery **S**ystem
NIDA	**N**ational **I**nstitute on **D**rug **A**buse
NRT	**N**icotine-**R**eplacement **T**herapy
OLS	**O**rdinary **L**east **S**quares
R&D	**R**esearch & **D**evelopment
SFA	**S**moke-**F**ree **A**ir
UK	**U**nited **K**ingdom
UPC	**U**niversal **P**roduct **C**ode
WHO	**W**orld **H**ealth **O**rganization
WTP	**W**illingness-**T**o-**P**ay
ZUL	**Z**ero or **U**ltra-**l**ow Strength

SUMMARY

Tobacco use is the leading preventable cause of death in the world, and has spurred much regulation over the decades. In recent times, regulatory bodies have honed in on specific aspects of Nicotine Delivery Systems (NDS) to streamline policy. Two recent policies that do this are the ban on sales of all non-menthol flavoured cigarettes, in effect since September 2009, and the ban on the use of descriptors on cigarette packaging that misleadingly convey a message of reduced harm, in effect since June 2010. Few studies measure the economic valuation of such attributes that can be used to direct future policy. This thesis aims to contribute to regulatory policy by measuring the economic willingness-to-pay (WTP) for different attributes of three types of NDS, electronic, or e-, cigarettes, conventional cigarettes, and little cigars, which are a close substitute for cigarettes. It also evaluates the impact of the recent flavour and descriptor bans mentioned above.

I use a hedonic pricing method and retail scanner data to measure vapers' WTP for different flavour and strength options in e-cigarettes. I find that users of disposable e-cigarettes value exotic-flavoured products the most, and menthol-flavoured ones the least, paying 8¢ more for an exotic-flavoured e-cigarette compared to a tobacco-flavoured one, and paying 17¢ less for a menthol-flavoured one compared to tobacco. The results are similar for rechargeable starter kits, with vapers paying 3¢ more for exotic and 32¢ less for menthol compared to tobacco flavour. However, vapers who buy individual refill cartridges for rechargeable e-cigarettes value both exotic and menthol flavours more than tobacco, paying 6¢ and 3¢ more respectively than they do for a tobacco-flavoured cartridge. The results are similar for nicotine strength. I find that vapers who buy disposables and rechargeable starter kits value low-strength products more than full-strength ones, paying 14¢ and $6 more respectively for low-strength compared to full-strength. However, those who buy individual refill cartridges value full-strength the most, paying 4¢ less for a low-strength option compared to full-strength. This indicates that casual and new users who possibly begin with buying disposables or starter kits value attributes differently from regular users who continue to buy refills.

Next, the same technique and data are used to measure smokers' WTP for flavour, strength, length, packaging and filter tips of cigarettes, and for flavour and filter tips of little cigars. I find that smokers pay a 1.25¢ price premium for menthol-flavoured cigarettes compared to tobacco-flavoured ones. They also pay a 15¢ premium for both nicotine-free/ultra-low- and low-strength cigarettes compared to full-strength ones. Smokers pay 10¢ less for long cigarettes and 47¢ less for one containing a filter tip. Finally, smokers prefer to buy their cigarettes in small amounts, paying 64¢ more per pack when they can buy a single pack as opposed to buying in bulk in the form of a multi-pack carton. I find that the results for little cigars vary by store type. Smokers who buy little cigars in convenience stores tend to value non-tobacco flavours and filter tips more than tobacco and non-filter. Those who buy from food, drug and mass stores value tobacco flavour and non-filter tips the most. This discrepancy suggests a difference in the profile of smokers who buy from the two types of stores.

In the final section of the dissertation, I evaluate the impact of the flavour and descriptor bans on the sales of cigarettes and little cigars using an interrupted time series model. Following the flavour ban, I find that although there is a short-term impact in the market for menthol- and for exotic-flavoured cigarettes – a jump in the former and a dip in the latter – these impacts do not persist over time, with sales levels reverting to the pre-ban levels within a few years. The results are similar for little cigars, with an immediate jump in sales of tobacco and menthol flavours in the short run, but no lasting impact over time. Following the ban on descriptors, I find that there are both short- and long-term impacts on the markets for low- and full-strength cigarettes. Both markets experience a jump in sales immediately following the ban, but while the sales of low-strength cigarettes decline permanently, those of full-strength cigarettes continue to thrive, but at a permanently slower rate.

Chapter I

INTRODUCTION

Tobacco use is the leading preventable cause of death worldwide, and it is estimated to cause more than 8 million deaths annually by 2030, according to a report by the World Health Organization (WHO). The average smoker dies ten years earlier than the non-smoker (Jha et al., 2013), and if smoking continues at the current rate, one in every 13 Americans aged 17 years or younger today will die prematurely from a smoking-related illness (World Health Organization, 2011). Nearly ($)170 billion was spent in direct medical care alone for adults due to smoking-related illnesses (Xu et al., 2015), yet not a single state within the US currently meets the Centers for Disease Control and Prevention's (CDC) recommended levels for prevention and cessation programs (Campaign for Tobacco-Free Kids, 2017).

A major shift has occurred in the tobacco use landscape in the past decade or so with the introduction of electronic nicotine delivery systems (ENDS), or electronic cigarettes (e-cigarettes). While ENDS were initially marketed as smoking cessation devices, they have rapidly gained popularity among smokers and non-smokers alike. The global ENDS market has grown rapidly in the past decade, and was valued at an estimated $22.6 billion in 2018, up from $4.2 billion in just five years. According to a report by market research group, Euromonitor, the vaping market has seen unprecedented growth – 818% over 2011-2016 and a projected 176% over 2016-2021. The US market is the largest in the world, driving 43% of global sales in 2015 – triple the volume of the second largest market, the United Kingdom. The vapour market in the US was valued at close to $14 million in 2017 and is forecasted to grow at a compound annual growth rate (CAGR) of 19.6% between 2018 and 2023 (Prescient & Strategic Intelligence, 2018).

Another report by Business Intelligence and Strategy Research (BIS), a global market research and advisory company, predicts that the global ENDS industry will grow to $50 billion by 2025, at an estimated CAGR of 22.36%.

According to the National Institute on Drug Abuse (NIDA), there were more than 250 brands of ENDS available in the US market as of 2016. While initially comprised of many small and independent vendors, the US ENDS industry has been increasingly dominated by Big Tobacco players such as Altria Group Inc., Reynolds American Inc. and, more recently, Japan Tobacco; a phenomenon that holds greater significance when viewed in light of the fact that ENDS sales are predicted to surpass those of traditional cigarettes by 2020, according to a report by Wells Fargo. A report by Euromonitor International shows that in 2016, for the first time in several decades, the percentage of cigarettes in the global tobacco market fell below 90%, and the rapid growth in the vapour and heated tobacco markets is the single greatest driving factor behind this.

This shift in the landscape of the ENDS industry has brought with it a transition from traditional cigarette-like products to more innovative and unique tank-like systems, as well as nicotine salts in the form of pods that deliver a stronger nicotine hit than more traditional ENDS products. With this comes a marketing tactic based on increased expenditure on marketing and advertising (Kornfield et al., 2015; Huang, Kornfield, and Emery, 2016; Huang et al., 2014) that increases social acceptability of this modern technology of vaping, while undermining the desirability of traditional cigarettes. This is a tactic not only in response to the changing social attitudes towards smoking, but also provides a means to circumvent smoke-free air laws and allow users to vape in places where smoking is prohibited. The research & development (R&D) budget of many large manufacturers is on the rise – for instance, Reynolds American Inc. increased its R&D expenses by 27% in 2015 – and much of this budget is geared towards the development of innovative technologies such as new flavours, advanced and powerful vaping devices and even Bluetooth-enabled products, according to a report by Beige Market Intelligence. The JUUL e-cigarette, which packages nicotine salts into sleek pods that resemble USB drives, has largely dominated the vaping market since 2017, claiming around three-quarters of the market share at the end of 2018 (Craver, 2019). Because of the device's discreet appearance, as well as the ease of use, it has become largely popular among youth who can use one at home or in school – even reportedly in class – with relative ease. Furthermore, JUUL pods use nicotine salts that are based on leaf-based tobacco rather than free-base nicotine and deliver a faster, stronger nicotine hit similar to conventional cigarettes compared to other ENDS products (Lawler, 2018). Finally, JUUL has a strong presence on social media platforms such as Twitter, Instagram, Reddit and YouTube, and because these platforms have more of an audience in young people, it is more likely to appeal to this segment of the population (Huang et al., 2019).

Marketing schemes include aggressive promotion of products via television and radio advertisements, celebrity endorsements and attempts to glamorize these products with the use of sexual content and imagery (Surgeon General's Report, 2016). Repetitions in the media and celebrity endorsements have also propagated the view that ENDS are a more effective form of nicotine-replacement therapy (NRT). Finally, contrary to traditional tobacco products, there are few restrictions on advertising of ENDS products. A study by Kim et al., 2015 finds that 66% of people who viewed an advertisement of ENDS on the television reported they were likely to try them in the future, and 76% of current smokers reported being reminded of smoking when viewing these.

The ENDS market has also historically been characterized by a myriad of flavour options, from energy drinks and cocktails, to coffee, chocolate and spices, to candy flavours; this marketing scheme seems to be largely aimed at motivating a new generation of young users to take up vaping. According to the Surgeon General's Report 2016, ENDS are currently the most commonly-used tobacco product used by youth, their use having grown 900% among high school students between 2011 and 2015. The use of ENDS among middle and high school students tripled within a single year in 2014 (Arrazola et al., 2015). The same study finds that 16% of high school and 5.3% of middle school students were current users of ENDS in 2015, up from 1.5% and 0.6% among high and middle school students in 2011. Furthermore, 81% of young vapers cited their primary reason for use to be the range of appealing flavours. Together, the emergence of Big Tobacco in the ENDS industry and the use of marketing ploys that appeal to non-users, especially youth, brings on an eerie sense of déjà vu.

Alongside the risks potentially posed by this new technology, cigarettes continue to be a threat; they remain the leading preventable cause of sickness and mortality, responsible for over 400,000 deaths in the US each year (Surgeon General's Report, 2016). Much of the harm comes from tar and combustible compounds in traditional cigarettes. Decades of research on cigarettes have shown that tobacco smoke contains over 7,000 chemicals, at least 250 of which are known to be harmful, and tobacco contains at least 69 carcinogenic chemicals. According to the Federal Trade Commission's (FTC) Reports on cigarettes and smokeless tobacco in 2016, tobacco companies spent $9.5 billion in 2016 on advertising and promotion of tobacco products – that is about $1 million every hour. The bulk of this spending goes into discounting products to retailers so that the overall prices of these products can remain low. This investment into advertising and marketing pays off; youth who are exposed to cigarette advertising find the ads appealing and display increased desire to smoke (Perks, Armour, and Agaku, 2018).

Furthermore, tobacco manufacturers thrive on the misconception that "light" or "ultralight" NDS are less harmful. A study by Bansal-Travers et al., 2011 finds that smokers are more likely to pick cigarettes that claim to be "light", "silver" and "smooth" that imply smoother taste, less tar content and lower nicotine content. Furthermore, O'Connor et al., 2013 find that smokers who buy cigarette labelled with these desciptors are more likely to find them milder-tasting, thereby lulling current and new smokers into a false sense of security (O'Connor et al., 2005).

There is a general consensus that ENDS are less toxic and less harmful than traditional cigarettes. Because ENDS are a reduced-risk alternative to combustible NDS, it is desirable from a public health perspective for smokers to switch over to ENDS products (Glasser et al., 2017). Levy et al., 2018 find that replacing cigarette with e-cigarette use at the current rate will result in between 1.6 to 6.6 million fewer premature deaths over the next 10-year period, along with 21 to 87 million fewer life years lost, depending on whether a pessimistic or optimistc scenario is considered. They also find that the greatest gains are among youth.

The real threat lies in the initiation of non-smokers into a lifetime of nicotine addiction, since studies show that most nicotine-dependence is established in adolescence (US Department of Health and Human Services and others, 2012; US Department of Health and Human Services and others, 2014). ENDS as nicotine-delivery products pose a significant and particular threat to youth as nicotine is known to affect brain development leading to physical and mental health issues. Some early evidence points towards ENDS being a potential gateway for youth to other tobacco products, including traditional cigarettes. Several recent studies find that in a nationally-representative sample of US high and middle school students from 2011-2013, ever-use of ENDS was associated with that of traditional cigarettes, with the likelihood of smoking in consequent years and with increased openness in attitude towards smoking in the future (Bunnell et al., 2015; Dutra and Glantz, 2014; Coleman et al., 2014). Another longitudinal study of 9th graders in Los Angeles, California, by Leventhal et al., 2015 finds that non-smokers with prior experience of using ENDS were 30% more likely to take up smoking in the following 6 months compared to those with no such experience. ENDS are a novel item that appeal to youth who are more likely to be sensation-seeking and curious about new experiences (Carpenter et al., 2005; Manning, Kelly, and Comello, 2009). Furthermore, they are available in a myriad of flavourings – a study by market research group Mordor Intelligence reports that more than 3,000 ENDS flavours are available in the US market, with 300 new flavours being introduced each month. In 2014, the CDC's Morbidity and Mortality Weekly Report stated that 73% of high school students who had used tobacco products in the past 30 days had reported using a flavoured one, while 56% of middle school students had reported the same. Several studies find that of all youth tobacco users, a vast majority report their first product ever tried being a flavoured one, giving rise to concerns that these may act as a gateway into a lifelong tobacco addiction (Villanti et al., 2017; Ambrose et al., 2015; Oliver et al., 2012). The study by Villanti et al., 2017 finds that 81% of youth and 86% of young adult tobacco users reported their first product was a flavoured one, compared to only 54% of adults aged 25 and over.

The uptake of ENDS by non-smoking youth and adults alike can dilute some of the progress that has been made in curbing the tobacco epidemic in recent years if they are indeed a gateway into smoking or if they prove to have similar long-term effects on health as traditional cigarettes. While it is too early to say exactly how harmful ENDS are in the long run, they *are* nicotine-delivery devices which are definitely not beneficial to health, so it is safe to assume that informed policy and regulation targeted towards ENDS use by youth can only benefit future generations by potentially averting a health crisis and breeding a whole new generation of addicts.

In June 2009, the Family Smoking Prevention and Tobacco Control Act was signed into effect, giving the US Food and Drug Administration (FDA) the authority to regulate the tobacco industry. A few months later, in September 2009, the FDA implemented a complete ban on the sale of all flavoured cigarettes, with the exception of menthol. No corresponding ban was imposed in the market for other flavoured tobacco products, particularly little cigars, which are often marketed as being distinguishable from cigarettes but are as close to cigarettes as legally possible in terms of manufacturing (Delnevo and Hrywna, 2007) – they are almost identical in terms of size, packaging and the presence of filters but are considered to be a different product because they are typically either wrapped in tobacco leaves or in paper containing tobacco. Because there is no corresponding ban on flavoured non-cigarette tobacco products, the effectiveness of the ban is lowered and manufacturers may intentionally be using them as a way to get around the flavour ban. In November 2018, the FDA proposed an extension of the flavour ban to include menthol cigarettes as well.

Before 2016, when there was no federal regulation of vaping products, some states took matters into their own hands and enacted a variety of regulations targeted towards ENDS. Some prohibit sales to minors, others tax ENDS as tobacco products, and yet others extend indoor smoking bans to include these products. Appendix A shows a summary of proposed and enacted regulations in all the states. In August 2016, the US FDA extended its regulatory authority to include ENDS by classifying them as tobacco products, and seeks to evaluate vaping-related issues such as health risks, product features and appeal to youth and non-users. Under this ruling, the FDA has banned sales to minors (under 18 years of age), requiring a photo-ID to buy ENDS and banning sales in vending machines that are accessible to all ages, and it prohibits the advertising of ENDS are safer alternatives to cigarettes unless they have "received modified risk tobacco product (MRTP) status", which no product has as of August, 2018 (Fleberbaum, 2017). As of May 2018, the FDA has been cracking down on e-liquid brands that package their products to resemble food or beverage products that may appeal to children and cause accidental poisoning (US Food and Drug Administration, 2018). In August 2014, attorneys general from more than two dozen states advised that the FDA impose restrictions on ENDS, including banning flavours (CardioSmart, 2014).

So far, the FDA has enacted or proposed several policies that are aimed at very specific features of tobacco or ENDS products; in particular, flavour and nicotine content. This dissertation focuses on attribute-specific policies like the flavour and descriptor bans and attempts to inform future tobacco control policy. In the second chapter, I estimate vapers' WTP for various flavours and nicotine strengths of disposable and rechargeable ENDS products using a revealed preferences technique, an approach that is novel within this literature. In the third chapter, I use the same technique to estimate smokers' valuation of various attributes of cigarettes and little cigars. These two chapters look at consumer preferences within two of the most significant markets in nicotine delivery systems – cigarettes and ENDS – and inform future policy by highlighting the areas where interventions might have the maximum impact and suggesting users' reactions to such policies. In the fourth chapter, I evaluate the impact of the two attribute-oriented policies the FDA has enacted since it gained regulatory authority over the tobacco market – the ban on sales of flavoured cigarettes and the ban on the use of descriptors on cigarette packaging – using an interrupted time series model. My work is the first to use this method to paint a complete picture of the short- and long-term impacts of a policy intervention. Overall, this thesis aims to fill in a few of the gaps in the research using novel techniques and pinpoint areas of effective intervention, thereby helping to steer future tobacco and ENDS control policy.

Chapter II

ESTIMATING THE WILLINGNESS TO PAY FOR FLAVOUR AND NICOTINE STRENGTH IN ELECTRONIC CIGARETTES USING A HEDONIC PRICING MODEL

Abstract

In this chapter, I estimate vapers' willingness-to-pay (WTP) for the electronic cigarette attributes, flavour and strength, for disposable and rechargeable e-cigarettes. I use a hedonic pricing model to estimate the implicit price of each attribute and use it to calculate the WTP at mean prices. I find that buyers of disposable e-cigarettes value exotic-flavoured products more and menthol-flavoured products less than tobacco, paying 8¢ more and 17¢ less respectively for them. It is the same for rechargeable starter kits, with vapers paying 3¢ more and 32¢ less for exotic- and menthol-flavoured products compared to tobacco. However, when they buy individual refill cartridges, vapers pay more for both non-tobacco options, paying 6¢ and 3¢ more for exotic and menthol flavours respectively. Regarding nicotine strength, I find that buyers of disposable products value lower strength options more, paying 7¢ more for nicotine-free/ultra-low strength (ZUL) and 14¢ for low-strength compared to full-strength variants. This result is flipped for buyers of individual refills, who value full-strength the most, paying 13¢ and 4¢ less for ZUL- and low-strength options respectively. Finally, when they buy starter kits, vapers value low-strength the most, paying up to $6 more for a kit that includes low-strength cartridges. However, they value ZUL-strength less than full-strength, paying $6.5 less for a kit that comes with ZUL-strength cartridges.

1 Background

The use of electronic nicotine delivery systems (ENDS), or electronic cigarettes (e-cigarettes), has increased rapidly since they first appeared in the market about a decade ago. The global ENDS market has grown rapidly in the past decade, and was valued at an estimated $22.6 billion in 2018, up from $4.2 billion in just five years. Figure 1

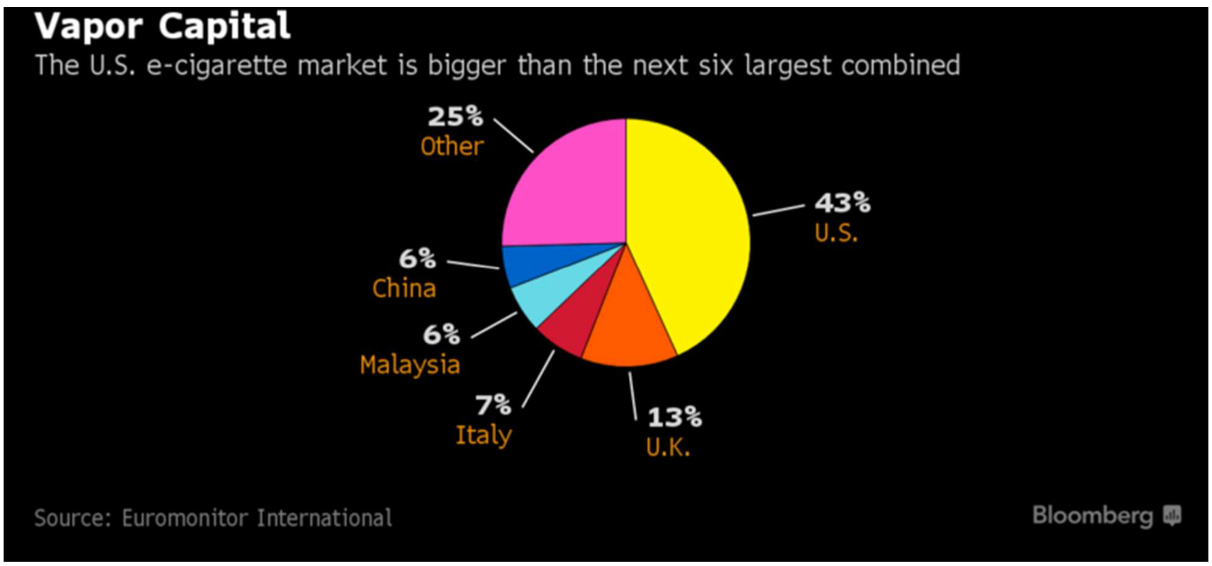

Figure 1: Global share of the US in the vaping products market

shows the relative shares of the top five markets in the global vapour market. According to a report by market research group, Euromonitor, the vaping market has seen unprecedented growth – 818% over 2011-2016 and a projected 176% over 2016-2021. The US market is the largest in the world, driving 43% of global sales in 2015 – triple the volume of the second largest market, the United Kingdom.

There is a general consensus that ENDS are less toxic and less harmful than traditional cigarettes, making them a much safer alternative for current smokers (Glasser et al., 2017). The real threat lies in the initiation of non-smokers into a lifetime of nicotine addiction, since studies show that most nicotine-dependence is established in adolescence (US Department of Health and Human Services and others, 2012; US Department of Health and Human Services and others, 2014). Some early evidence points towards ENDS being a potential gateway for youth to other tobacco products, including traditional cigarettes. Several recent studies find that in a nationally-representative sample of US high and middle school students from 2011-2013, ever-use of ENDS was associated with the that of traditional cigarettes, with the likelihood of smoking in consequent years and with the openness in attitude towards smoking in the future (Bunnell et al., 2015; Dutra and Glantz, 2014; Coleman et al., 2014). Another longitudinal study of 9th graders in Los Angeles, California, by Leventhal et al., 2015 finds that non-smokers with prior experience of using ENDS were 30% more likely to take up smoking in the following 6 months compared to those with no such experience. ENDS are a novel item that appeal to youth who are more likely to be sensation-seeking and curious about new experiences (Carpenter et al., 2005; Manning, Kelly, and Comello, 2009). Furthermore, they are available in a myriad of flavourings – a study by market research group Mordor Intelligence reports that more than 3,000 ENDS flavours are available in the US market, with 300 new flavours being introduced each month. In 2014, the CDC's Morbidity and Mortality Weekly Report stated that 73% of high school students who had used tobacco products in the past 30 days had reported using a flavoured one, while 56% of middle school students had reported the same. Several studies find that of all youth tobacco users, a vast majority report their first product ever tried being a flavoured one, giving rise to concerns that these act as a gateway into a lifelong tobacco addiction (Villanti et al., 2017; Ambrose et al., 2015; Oliver et al., 2012). The study by Villanti et al., 2017 finds that 81% of youth and 86% of young adult tobacco users reported their first product was a flavoured one, compared to only 54% of adults aged 25 and over.

So far, the FDA has targeted several tobacco control policies towards specific attributes of products. In 2009, the FDA imposed a ban on the sales of flavoured cigarettes, excluding menthol, and, more recently, in November 2018, proposed to extend this ban to menthol cigarettes as well. In 2010, it imposed a ban on the inclusion of descriptors on cigarette packaging, prohibiting the use of words such as "mild", "smooth" and "light" that imply reduced risk. In November 2018, the FDA also announced plans to ban the sales of flavoured ENDS at retail stores, although the ban excluded menthol flavour. Other non-menthol flavoured ENDS will still be available under this regulation, but can only be sold at age-restricted stores or through online retailers that verify age. While this is a first step towards curbing the uptake of vaping by youth and non-users, there is a significant gap in policy. More information about how vapers value different characteristics of ENDS is needed in order to steer future policy and identify areas of effective intervention.

Some research exists on vapers' and smokers' valuation of ENDS attributes. Nonnemaker et al., 2016 estimate cigarette smokers' WTP for various ENDS attributes, and find that they would be willing to pay lower prices if ENDS do not offer different flavours, cannot be used indoors, do not offer reduced harm than cigarettes and do not help to quit smoking. Using a discrete choice experiment among adult smokers, Marti et al., 2016 find similar results. Many studies show that flavour is the most important attribute when choosing ENDS, especially among youth and non-users, who also prefer low- or zero-nicotine varities. Shang et al., 2018b use discrete choice experiments to find that fruit/sweets/beverage flavours (i.e. what I refer to as "exotic" flavours in this chapter) significantly increase the probability of choosing ENDS among youth, and that flavour is the most important of three attributes. Pesko et al., 2016 find that restricting flavour availability to tobacco and menthol only is associated with a lower rate of uptake of ENDS products, and that young adult smokers are more likely than adult smokers to choose ENDS when multiple flavour options are available. Current smokers or those trying to quit seem to prefer tobacco flavour and opt for higher nicotine strengths (Zare, Nemati, and Zheng, 2018).

To the best of my knowledge, none of the existing literature uses revealed preferences to extract users' valuation of ENDS attributes. Experimental auctions and discrete choice experiments often overestimate valuation because they depict hypothetical scenarios and rely on stated preferences. Hedonic pricing, on the other hand, is a revealed preference method that is based on real-life sales data. In this chapter, I use retail scanner data to estimate implicit prices of flavour and strength in ENDS, using a hedonic pricing technique. This method is novel in this field, and fills an important gap in the literature. I estimate dollar values for diffferent flavours and strengths in ENDS, which will inform and guide future ENDS regulation policy.

The remainder of this chapter is organized as follows. In Section 2, I briefly discuss the structure of an e-cigarette and the types available. Section 3 lays out the theoretical basis for the model, along with the empirical framework used. Section 4 discusses in detail the data sources and the construction of variables. Section 5 presents and discusses the findings of the chapter. Section 6 wraps up the chapter with the estimated WTP measures for disposable and rechargeable ENDS products and discusses the policy implications.

2 Structure of ENDS products

Electronic nicotine delivery systems (ENDS), or electronic cigarettes (e-cigarettes) as they are more commonly known, are battery-operated devices to deliver nicotine, flavour and other chemicals. Contrary to traditional cigarettes that burn tobacco leaves to release smoke that is inhaled by the user, ENDS contain a heating element that atomizes a liquid and the resulting vapour or aerosol is inhaled by the user. Some ENDS physically resemble traditional cigarettes, and others even have "soft-tips" to simulate the experience of smoking a traditional cigarette. There are currently four types of e-cigarettes: (1) cigalikes, that resemble traditional cigarettes and may either be disposable or rechargeable, (2) tank systems, or "personal vaporizers" (PVs), that contain refillable tanks, (3) modifiable tanks, “mods”, or Advanced Personal Vaporizers (APVs), which allow the user to assemble the atomizer itself (wick, coil, etc.) to customize the amount of vapour produced and typically produce a lot of vapour, and, (4) nicotine salts such as JUUL pods.

For the purposes of this chapter, I categorize e-cigarettes as disposable or rechargeable cigalikes, tanks/APVs, which include both E-Go and mod styles, and nicotine salts. Even though some rechargeable cigalikes no longer resemble traditional cigarettes in appearance, I still classify these as cigalikes because they are all composed of the same 3-part system consisting of a battery, an atomizer and a cartridge (see description below for details). Disposables include disposable e-cigarettes, e-hookahs or hookah pens and e-cigars. Disposable ENDS have the distinct advantage of being hassle-free; the user can experiment with flavours and brands at minimal cost, and are a popular starting point for previous non-vapers. They require almost no assembly and are available on hand whenever the craving should arise, without the need to be charged. Manufacturers often claim that a single disposable e-cigarette is equivalent to two packs of traditional cigarettes. These come in a variety of flavours and nicotine strengths (including nicotine-free variants). Disposable ENDS are usually the beginner’s introduction to vaping, before progressing to rechargeable cigalikes, PVs or even APVs, once they have decided on their exact preferences. A disposable cigarette (cigar) often takes the appearance of a traditional cigarette (cigar), while disposable e-hookahs look very much like pens.

Rechargeable cigalikes typically consist of a battery, an atomizer, a cartridge and one or more charging options. They are also available as a starter kit that contains all of the separate components, and may come with one or more cartridge refills. Newer models contain a “cartomizer” instead of separate atomizer and cartridge; these combine the cartridge with the atomizer and market it as a single unit. Cartomizers work a little differently from the combination of atomizers and cartridges; they contain polyfill soaked in e-juice and wrapped around the heating coils that vapourize the liquid upon drawing puffs. A distinct advantage that cartomizers have over atomizer-cartridge devices is that the vaper may switch flavours around and not get a contaminated flavour if the atomizer has not been cleaned properly. The user must assemble the e-cigarette by screwing together the battery, atomizer and cartridge (or battery and cartomizer). For many starter kits, one or more reusable cases, often with a flip top that resembles traditional cigarette packs, may be included. A later innovation in cartomizers is the "switchable" model, where the user may switch flavours simply by flicking a switch/button.

The next category, PVs, range from basic ones such as the E-Go models to advanced modifiable ones that allow the user to regulate the exact vapour density, strength and flavour. Some models allow an adjustable voltage to change the strength of vapour as required. They have the largest capacity for e-juice, the strongest and most dense vapours, and offer a high degree of customization. They often do not look like traditional cigarettes. Typically, all PVs are rechargeable and refillable with e-liquids, or e-juice, that can be purchased separately or even mixed together to create unique flavours. Some PVs come in the form of a clear polycarbonate plastic or pyrex glass tank containing a wick that absorbs the e-liquid and must be attached to a battery; these are referred to as "clearomizers", and make it easy to monitor the level of liquid inside the tank. PVs can be bought as a starter kit or as separate components. A starter kit usually consists of one or more batteries, one or more charging options, a tank atomizer/clearomizer, and one or more e-liquids/e-juices. As for rechargeable cigalikes, these components may also be purchased separately, although the PV user has significant flexibility in terms of mixing and matching components compared to cigalikes.

Finally, nicotine salts have become increasingly popular in recent years, growing quickly into the most popular form of e-cigarettes since 2017 (Craver, 2019). The most popular nicotine salt product is JUUL, which comprised nearly three-quarters of the e-cigarettes market in 2018. Like more conventional e-cigarettes, the JUUL device consists of two parts – the e-cigarette that contains the battery and atomizer units, and the "pods" or cartridges that house the e-liquid containing nicotine and other substances, as well as flavouring. Because of its inconspicuous design, the JUUL looks like a standard USB flash drive, and has quickly become popular among youth.

The retail scanner data used in this chapter is comprised mostly of disposables and rechargeable cigalikes and it covers the market until 2016, before JUUL became popular. Therefore, the analysis is limited to disposable and rechargeable cigalikes only, and all PVs and nicotine salt products are excluded.

3 Theoretical & empirical framework

This chapter is based on the hedonic pricing model originally proposed by Rosen, 1974. The basic premise of this model is that the price of a differentiated product is the sum of the prices paid for each of its attributes. The underlying assumption is that the good in question is a differentiated product. In such a case, the variations in the price of the product is the sum of the value added implicitly by changing the level of individual attributes. Thus, the price of a product can be decomposed into the valuation or "implicit prices" of the individual attributes.

$$P = f(X, Y) = f(x_1, x_2, Y) \tag{1}$$

where X represents a bundle of characteristics & consists of x_1 and x_2, and Y is a vector of control variables, including income. This can be empirically estimated by regressing the price, P, or a transformation – the most commonly-used being the semi-logarithmic form (Cropper, Deck, and McConnell, 1988) – on the attributes, x_1 and x_2; i.e. by estimating the following equation:

$$\ln P = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 Y \tag{2}$$

Taking differentials,

$$\partial(\ln P) = \frac{1}{P} \cdot \partial P = \alpha_1 \cdot \partial x_1 + \alpha_2 \cdot \partial x_2 + \alpha_3 \cdot \partial Y$$

Once the coefficients of regression are known, the implicit price function of attribute 1 is given by the change in price paid when the attribute is increased by one unit.

$$implicit\ price\ of\ x_1 = \frac{\partial P}{\partial x_1} = \hat{\alpha_1} \cdot P \tag{3}$$

There is a slight complication in this regard. Typically, in a regression with continuous variables, the regression coefficients, α, represents the change in P due to a unit change in x. However, in the case of dummy variables, which I use to represent all the attributes in this chapter, regression coefficients must be transformed for an unbiased estimate of the coefficient (Kennedy, 1981) and this transformation is given by the following expression on the RHS:

$$\frac{\partial(\ln P)}{\partial x_1} = \frac{1}{P} \cdot \partial P = (\exp^{\hat{\alpha}-0.5var(\hat{\alpha})} - 1) \tag{4}$$

where $\hat{\alpha}$ is the estimated coefficient of dummy variable, x. The implicit price function of each attribute, i, is then given by:

$$implicit\ price\ of\ x_1 = \frac{\partial P}{\partial x_1} = (\exp^{\hat{\alpha}-0.5var(\hat{\alpha})} - 1) \cdot P \tag{5}$$

The dollar value of the WTP for attribute, i, is the above expression evaluated at the mean price.

Rosen's hedonic pricing model is well-suited to the ENDS market because in the period covered in this analysis (2010-2016), there were a large number of suppliers offering ENDS products, each being a close substitute of the other, yet distinctive in some way. Because the number of firms was large and the market share of each small, no firm had too great an extent of control over prices. In other words, it can be safely assumed that the market structure was that of a monopolistic competition during the period in question. The demand curve faced by a supplier under monopolistic competition is downward-sloping, and therefore market equilibrium is reached through consumers' utility maximizing and producers' profit maximizing behaviours. As a result, the implicit price functions obtained can be assumed to be reflective of consumers' valuations of different ENDS attributes and not just producers' cost functions, as in the case of perfect competition in the long run.

For the purposes of this chapter, I use a log-linear functional form because doing so allows for calculation of implicit prices according to Equation 3. I express the price of a disposable e-cigarette as a function of flavour and nicotine strength. Since rechargeable e-cigarettes can take many forms, including a bundle or a starter kit, I include variables for the number of each of the components – cartridges or cartomizers, batteries, charging options and durable cases – in addition to flavour and strength.

The following models are estimated for disposable and rechargeable e-cigarettes respectively:

$$\ln price_{ijkl} = \alpha_0 + \alpha_{11} menthol_i + \alpha_{12} exotic_i + \alpha_{21} ZUL_i + \alpha_{22} low_i + \alpha_{31}(menthol \cdot ZUL)_i + \alpha_{32}(menthol \cdot lowL)_i + \alpha_{33}(exotic \cdot ZUL)_i + \alpha_{34}(exotic \cdot low)_i + \alpha_4 regulation_i + brand\ FE_i + marketstore\ FE_j + year\ FE_k + quarter\ FE_l \tag{6}$$

$$\ln price_{ijkl} = \beta_0 + \beta_{11} menthol_i + \beta_{12} exotic_i + \beta_{21} ZUL_i + \beta_{22} low_i + \beta_{31}(menthol \cdot ZUL)_i + \beta_{32}(menthol \cdot lowL)_i + \beta_{33}(exotic \cdot ZUL)_i + \beta_{34}(exotic \cdot low)_i + \beta_{41}(\#cartridges)_i + \beta_{42}(\#batteries)_i + \beta_{43}(\#chargers)_i + \beta_{44}(\#cases)_i + \beta_5 regulation_i + brand\ FE_i + marketstore\ FE_j + year\ FE_k + quarter\ FE_l \tag{7}$$

where i = product, j = market-store, k = year, l = quarter

Details on the construction of each of these variables are provided in Section 4. I control for brand, market-store, year and quarter fixed effects, to take into account any variations in policy, macroeconomic, demographic and cultural differences within markets over time, and to account for any seasonality of the data [1]. The dependent variable is the inflation-adjusted price of a disposable or rechargeable ENDS product within a market-store-year-quarter.

Ordinary least squares (OLS) regression is used to estimate the model. A log-linear functional form is used and the coefficients can be interpreted as the percentage change in the price of the product due to presence of a particular attribute. The implicit price of that attribute can then be calculated as the product of the coefficient and the mean price, as per Equation 5.

4 Data & variables

4.1 Data

Retail scanner data

This analysis is conducted using retail scanner data collected by the Nielsen Company, a global marketing research firm that collects sales data at retail outlets in order to allow purchasing patterns to be reported and analysed. A "Nielsen market" in the US consists of a group of counties, which may cross geographic state boundaries. Markets

[1] Sensitivity analysis was conducted by including socioeconomic and demographic variables at the Nielsen market-level, and the results were robust to this.

are typically named after the largest city, which is often located at or near the center of the designated area. Sales information is available for each product by Universal Product Code (UPC) number, which includes information on brand, product attributes such as flavour, strength, packaging type, etc., and "unit size" (i.e. how many of the product are sold as a single unit). Detailed sales data is available from 2010 to 2016 for all Nielsen participating stores, which consist of food, drug and mass (FDM) merchandise stores in 52 markets, and convenience stores (CV) in 30 markets.

The data used in this chapter represents 336 unique UPCs and 60 brands for disposable e-cigarettes, and 310 unique UPCs and 38 brands for rechargeable e-cigarettes (77 UPCs and 26 brands for starter kits, and 233 UPCs and 36 brands for cartridge or cartomizer refills). Sales data includes quarterly information on the sales revenue from each product and number of units sold when no promotions were offered, as well as the corresponding numbers when promotions were offered. From the UPC number and description, information on brand, type of e-cigarette product (disposable or rechargeable), the sub-category of the product (e-cigarette, e-hookah or e-cigar for disposable products, and cartridge or starter kit for rechargeable products), flavour, nicotine strength, unit size and the type of promotion were extracted.

Vaping policy data

Quarterly e-cigarettes policy data at the Nielsen-market level was constructed from the American Nonsmokers' Rights Foundation US Tobacco Control Laws Database, which includes policies at both the state and local levels. This is discussed in more detail in the following section.

4.2 Measures

Outcome variables

Prices of disposables and rechargeables: The outcome variable is the price of a single unit of product sold. In the case of disposables, this is a single stick of disposable e-cigarette, and for rechargeables, it can be a starter kit, a single refill cartridge or a pack of refill cartridges. Because the units are so different for disposables and rechargeables, I discuss the two separately.

The Nielsen data contains information on the number of units of a particular product sold, regardless of the type of packaging (e.g. single disposable vs multipack). For instance, a 5-pack of disposable e-cigarettes is recorded as being a unique product with a different UPC than a single-stick of the same product, and is coded as being one unit of sale of that product. However, the actual number of the product sold (the volume) at that price is 5. To derive the price of a disposable ENDS product, details of the product are first extracted from the UPC allowing identification of the kind of packaging – single sticks, multipacks, etc. The detailed product information provided by Nielsen is used to calculate the number of sticks purchased at a time. Next, the total number of sticks of disposables sold in a particular market-year-quarter is calculated as the product of the number of units sold and the number of individual sticks included in each unit. Using the available information, the price of a single disposable e-cigarette is then calculated as the ratio of the total sales revenue to the total number of sticks sold. Prices are allowed to vary within the range of 2 standard deviations from the mean; all data points outside this range are considered to be outliers and are dropped from the analysis. Sensitivity analysis is also conducted by excluding observations within one standard deviation of the mean.

Rechargeable e-cigarettes may be purchased as a starter kit or as individual components. Prices of cartridge or cartomizer refills for rechargeables are calculated using the same methodology as for disposables. The case is a little different for starter kit. I use the product description provided by Nielsen to represent all starter kits in terms of the numbers of cartridges or cartomizers, batteries, charging options and an indicator variable for the inclusion of a durable case(s). For example, for a starter kit containing one of each of these components, except cartomizers, a value of 1 is assigned to each except cartomizers, which gets a value of 0. While there are no reported purchases of batteries, chargers or atomizers individually, these constitute a large portion of the data as components of starter kits. Atomizers were dropped because they alone only accounted for less than 1% of all sales. Because the number of components is accounted for within the model, I use the Nielsen-derived average unit price in this case, regardless of the actual volume of the product purchased.

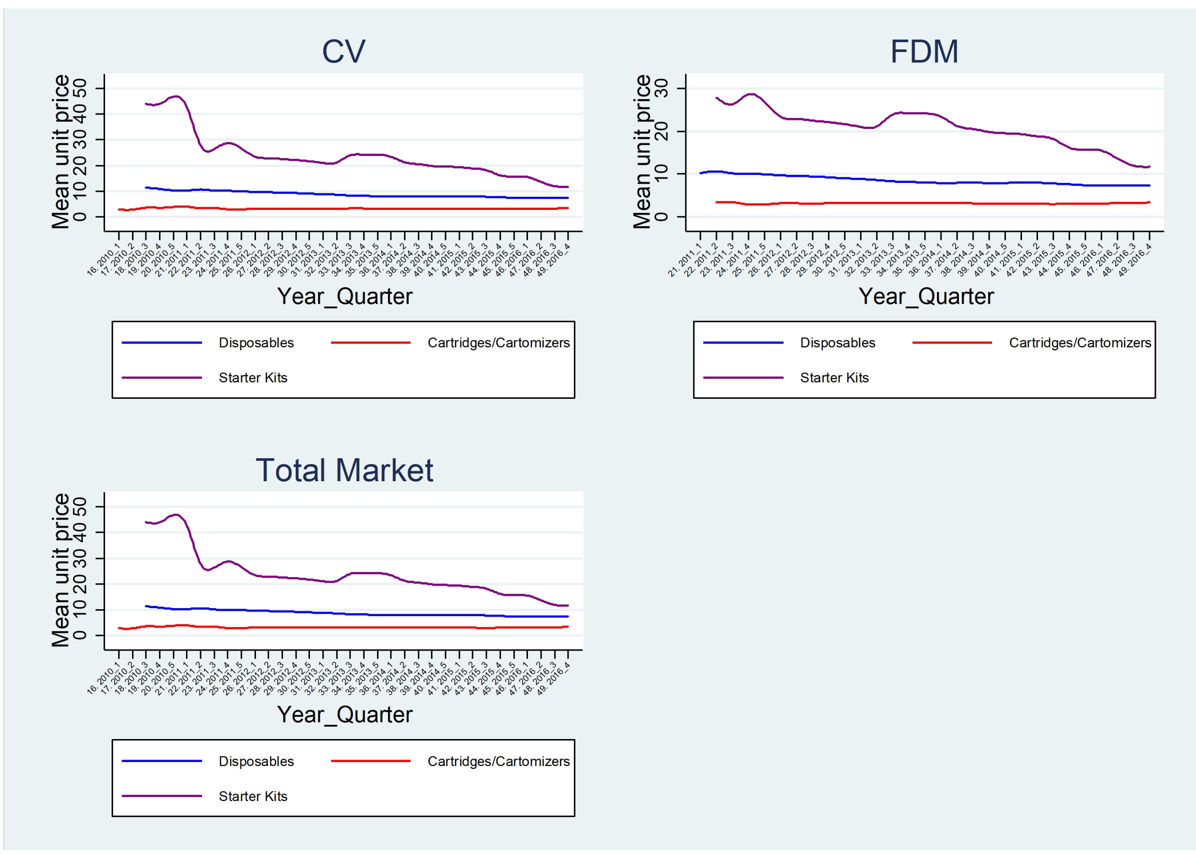

Figure 2: Trend in the prices of disposables, rechargeable starter kits and refills

Figure 2 shows the trend in mean real prices of disposables and rechargeables over time for the total market as well as by store type. The real prices of disposables and refills have remained more or less steady over time, while starter kits have become cheaper over time, more so in convenience stores than in FDM stores.

The Nielsen data also contains information about sales promotions and discounts, as well as the type of promotion offered (price discounts, free products, and free add-ons such carrying cases or batteries). A wide variety of promotions were offered, and for reasons of consistency, I only look at products sold at full price (covering approximately 90% of the data for which all relevant information is available) in this chapter. Finally, all prices are adjusted for inflation using the Consumer Price Index (CPI) data from the Bureau of Labor Statistics (BLS), indexed to 1 for 2016 prices. All products for which sales information was not available were dropped from the analysis. For the regressions, I use the natural log of prices as the dependent variable.

Explanatory variables

Flavour: There are three major flavour categories included in the analysis – tobacco (or regular flavour), menthol, and "exotic" flavours that include all others such as fruit, candy, beverage or spice flavours. In this analysis, exotic flavours make up 26% of all disposable sales and almost 16% of all rechargeables, while menthol is the most-purchased flavour (45% and 51% of disposables and rechargeables respectively). Only 21 brands sold exotic-flavoured disposable e-cigarettes, as opposed to 44 that sold tobacco and 41 that sold menthol flavours. The corresponding numbers are 14, 28 and 32 respectively for exotic-, tobacco- and menthol-flavoured rechargeable products. Binary indicator variables were constructed for each of the three flavour categories. In the analysis, I include the indicators for menthol and exotic flavours, with tobacco as the reference flavour category.

Strength: Strength of the product was classified into four categories: regular strength or full-flavoured e-cigarettes contain 18-24mg of nicotine, "light" e-cigarettes contain 12-16mg nicotine, "ultra-light" e-cigarettes contain 6-8mg nicotine, and zero nicotine e-cigarettes contain no nicotine. Only 1.32% of the sample constitutes nicotine-free products. Consequentially, the zero and ultra-low strength categories (henceforth ZUL-strength) were combined to represent 14.1% of the data, with almost 57% of the data consisting of full-strength products, and the remaining 29% of low-strength products. Similar to the method used for flavour, strength was included in the analysis as a factor variable, with dummy variables being included for each category, using regular/full strength as the reference.

Control variables

Vaping policies: Measures of vaping policies are available for three different venues (bars, restaurants, and workplaces respectively) and are weighted using county population weights within a single market. They represent the percentage of the population in each market that is covered by a comprehensive ban in each venue at the end of each quarter and in each Nielsen market. Because the three measures are highly correlated, only the percentage of the population covered comprehensively by a ban on vaping inside bars is included in the regressions.

The breakdown of the data set by product sub-type is shown in Table 1. The vast majority of disposables in the analysis constitute of e-cigarettes, with e-hookahs a far second. Rechargeables are mostly purchased in one of three forms: either as starter kits that include the rechargeable atomizer unit, one or more cartridges, batteries, chargers and sometimes cases; cartomizers, that are cartridges and atomizer units in one; or refill cartridges. The two latter categories are combined into one representing all refills, and accounts for nearly 38% of all sales and almost 70% of rechargeables, with the remaining 30% being comprised of starter kits.

Table 1: ENDS products, by sub-type

	Type of Product	Frequency	Percentage
Disposable ENDS Product (N=36,448)	Disposable e-cigarette	29,440	80.77
	Disposable e-cigar	11	0.03
	Disposable e-hookah	6,233	17.1
	Disposable e-tank	764	2.1
Rechargeable ENDS Product (N=43,384)	Starter kit	13,220	30.47
	E-cigarette cartomizer only	15,603	35.96
	E-cigarette cartridge only	13,234	30.5
	Unspecified e-cigarette refill (cartridge or cartomizer)	174	0.4
	Liquid capsule refill	1,147	2.64
	E-hookah cartridge only	6	0.01

Table 2: Flavour and strength profile, by product type

	Disposables				Rechargeables			
	ZUL	Low	Full	Total	ZUL	Low	Full	Total
Tobacco	245	2574	7253	10072	479	5127	8615	14221
	(2.57)	(33.23)	(37.83)	(27.63)	(27.25)	(33.04)	(33)	(32.78)
Menthol	3689	3480	9379	16548	663	6711	14925	22299
	(38.71)	(44.93)	(48.92)	(45.4)	(37.71)	(43.24)	(57.17)	(51.4)
Exotic	5596	1691	2541	9828	616	3681	2567	6864
	(58.72)	(21.83)	(13.25)	(26.96)	(35.04)	(23.72)	(9.83)	(15.82)
Total	9530	7745	19173	36448	1758	15519	26107	43384

[Percentages shown in parentheses]

Table 3: Summary statistics, by product type

	Disposables (N=37,892)				Rechargeables (N=43,460)							
					Starter Kits (N=13,291)				Refills (N=30,169)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Price	8.04	2.06	2.01	13.54	19.12	10.26	0.01	44.61	3.14	1	0	10.79
Tobacco flavour	0.28	0.45	0	1	0.34	0.47	0	1	0.32	0.47	0	1
Menthol flavour	0.45	0.5	0	1	0.56	0.5	0	1	0.49	0.5	0	1
Exotic flavour	0.27	0.44	0	1	0.1	0.3	0	1	0.18	0.39	0	1
ZUL strength	0.26	0.44	0	1	0.01	0.07	0	1	0.06	0.23	0	1
Low strength	0.21	0.41	0	1	0.38	0.48	0	1	0.35	0.48	0	1
Regular strength	0.53	0.5	0	1	0.62	0.49	0	1	0.59	0.49	0	1
# of refills	-	-	-	-	2.61	2.31	1	24	4.13	2.33	1	100
# of batteries	-	-	-	-	1.33	0.55	1	6	-	-	-	-
# of chargers	-	-	-	-	1.43	0.86	0	6	-	-	-	-
# of cases	-	-	-	-	0.57	0.51	0	2	-	-	-	-
% population covered by complete vaping ban in bars	14.55	20.64	0	100	13.61	20.46	0	100	14.55	20.94	0	100
% population covered by complete vaping ban in restaurants	15.79	21.3	0	100	14.53	20.96	0	100	15.69	21.52	0	100
% population covered by complete vaping ban in workplaces	14.29	21.77	0	100	13.18	21.22	0	100	14.46	21.87	0	100

Table 2 shows the distribution of flavour and strength by product type. While more than half of ZUL disposables purchased are exotic-flavoured, the majority of full-strength ones are menthol-flavoured. A look at sales of rechargeables by flavour profile for each strength category shows that there is an almost even split between the three flavours for ZUL products, while the majority of all full-strength products sold are either tobacco- or menthol-flavoured.

Summary statistics for each product type are shown in Table 3, by product subcategory. The mean price of a disposable e-cigarette is $8, while that of single cartridge for a rechargeable one is $3.1 and that of a full starter kit is $19.1. For both disposables and rechargeables, the majority of products sold are menthol-flavoured (45%, 49% and 56% for disposables, cartridges only and starter kits respectively), while exotic flavours make up the smallest volume of sales (27%, 18% and 10% respectively for disposables, cartridges only and starter kits). More tobacco-flavoured rechargeables (32% and 34% for cartridges only and starter kits respectively) were sold than disposables (28%). Regular- or full-strength products were purchased most often (53%, 59% and 62% for disposables, cartridges only and starter kits). Zero- or ultra-low strength products were more frequently purchased in the form of disposables (26%) as opposed to rechargeables (6% and 1% respectively for cartridges only and starter kits), while low strength products made up 21%, 35% and 38% of all sales of disposables, cartridges only and starter kits respectively.

The components of starter kits show that on average, a rechargeable starter kit consisted of 2.6 cartridges or cartomizers, 1.3 batteries, 1.4 charging options and just over half of them came with durable cases. When only cartridges or cartomizers were purchased, on average, a pack of 4.1 refills was purchased at a time.

As far as vaping regulation policy goes, on average, about 14.4% of the population in Nielsen markets was covered by a comprehensive vaping ban inside bars as of 2016. The corresponding figures for restaurants and workplaces are 15.5% and 14.2%

respectively. While these numbers are quite low, it should be noted that in 2010, the coverage was only 5.4% in bars and restaurants, and 1.5% in workplaces respectively, but the numbers had risen to 24.3%, 26.6% and 25.1% respectively by 2016 as more states started regulating e-cigarette use.

4.3 Sample size & weights

After dropping all the missing values and outliers, the final sample size is 79,832, of which 36,448 are disposables and 43,384 rechargeables (13,220 starter kits and 30,164 refills). The data used in this chapter represents 336 unique UPCs and 60 brands of disposables, and 310 unique UPCs and 38 brands of rechargeables. All regressions are weighted by sales quantity. The weights are calculated as the ratio of sales of a product to the total sales, by market, store type, product, quarter and year. All statistical analysis is conducted using Stata 14.

5 Results

Disposables

I estimate two versions of Equation 6 – one with separate flavour and strength dummies, and another that includes interactions between the flavour and strengths. As I will explain below, the interpretation of the flavour- and strength-coefficients change with the specification of the model.

Table 4 shows the results of the OLS estimation for disposable e-cigarettes. Beside the coefficients, I show the percentage impact of each variable on the price, calculated as the transformed coefficient from Equation (4) multiplied by 100.

In Model 1, with individual flavour and strength variables, the coefficients of the menthol and exotic variables show the valuation of these products relative to tobacco. We see that menthol is valued less than tobacco, while exotic flavours are valued more

Table 4: Estimation results for disposable e-cigarettes

	No interactions (1)		Flavour-strength interactions (2)	
	Coefficient	% impact on price	Coefficient	% impact on price
Tobacco flavour (base)				
Menthol flavour	-0.0211***	-2.09	-0.0277***	-2.73
	(0.0041)		(0.00447)	
Exotic flavour	0.00985**	0.99	0.0267***	2.7
	(0.005)		(0.00514)	
ZUL strength	0.0587***	6.04	-0.196***	-17.88
	(0.00823)		(0.0446)	
Low strength	0.0174**	1.75	0.0199	2
	(0.00874)		(0.0126)	
Regular (full) strength (base)				
Menthol*ZUL strength		-	0.281***	32.31
			(0.0447)	
Menthol*Low strength		-	0.0111	1.11
			(0.0111)	
Menthol*Regular strength (base)				
Exotic*ZUL strength		-	0.136***	14.45
			(0.0462)	
Exotic*Low strength		-	-0.0759***	-7.33
			(0.0195)	
Exotic*Regular strength (base)				
2010 (base)				
2011	-0.0768***	-7.4	-0.0751***	-7.24
	(0.00965)		(0.00959)	
2012	-0.0171	-1.7	-0.0159	-1.58
	(0.0113)		(0.0114)	
2013	-0.0854***	-8.19	-0.0854***	-8.19
	(0.0119)		(0.0121)	
2014	-0.179***	-16.4	-0.180***	-16.48
	(0.0132)		(0.0134)	
2015	-0.196***	-17.81	-0.196***	-17.81
	(0.0137)		(0.0139)	
2016	-0.252***	-22.28	-0.247***	-21.89
	(0.0137)		(0.0138)	
Quarter 1 (base)				
Quarter 2	0.00148	0.15	0.00156	0.15
	(0.00509)		(0.00507)	
Quarter 3	-0.00818*	-0.82	-0.00731	-0.73
	(0.00473)		(0.00471)	
Quarter 4	-0.0187***	-1.85	-0.0184***	-1.82
	(0.00468)		(0.00466)	
% of population comprehensively covered by SFA ban in bars	0.000108	0.01	0.000111	0.011
	(0.00014)		(0.00014)	
R^2	*0.572*		*0.576*	
N	*34,938*		*34,938*	

*[Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

– all other factors being held constant, people pay 2.1% less for menthol-flavoured disposables, and 1% more for exotic flavours like fruit or candy.

Similarly, the coefficients of the ZUL- and low-strength variables show the impact of these strength categories relative to the full-strength category. The results show that vapers of disposable products pay a positive premium for nicotine-free or ultra-low strength (ZUL) products, paying 6% more than for full-strength products. Low-strength products are also valued more than full-strength options, with vapers paying 1.8% more for these products.

The interpretation of Model 2 is slightly less straightforward. With the inclusion of interaction terms, we can compare between the different flavours for each strength level, and between different strength levels of each flavour. The methodology for the calculation of the full impact of each flavour and strength profile is shown in Appendix B and the results of Model 2 are summarized in Table 5.

Table 5: Full impact of flavour and strength with interaction terms, disposables

Comparing flavours for each strength	% impact on price	Comparing strengths for each flavour	% impact on price
Full-Tobacco (base)		Full-Tobacco (base)	
Full-Menthol	-2.73	ZUL-Tobacco	-17.84
Full-Exotic	2.7	Low-Tobacco	2
ZUL-Tobacco (base)		Full-Menthol (base)	
ZUL-Menthol	29.62	ZUL-Menthol	14.51
ZUL-Exotic	17.13	Low-Menthol	3.11
Low-Tobacco (base)		Full-Exotic (base)	
Low-Menthol	-1.62	ZUL-Exotic	-3.42
Low-Exotic	-4.62	Low-Exotic	-5.33

We see that a full-strength menthol product is valued 2.7% less compared to a tobacco-flavoured one, while a full-strength exotic-flavoured product is valued 2.7% more compared to a tobacco-flavoured one of the same strength. For ZUL-strength products, menthol and exotic flavours are both valued more than tobacco products with the same strength – by 29.6% and 17.2% respectively. For low-strength products, this is reversed, with both menthol and exotic flavours being valued 1.6% and 4.6% less than tobacco products of the same strength. This is potentially indicative of the profile of users: bearing in mind that between 65% and 72% of smokers smoke tobacco-flavoured products (World Health Organization, 2016), someone looking to substitute the smoking experience with vaping would likely pick full-strength, tobacco-flavoured products over menthol because they are accustomed to the taste or nicotine content. Alternatively, dual users might be experimenting with exotic full-flavoured products or lower-strength tobacco products. On the contrary, many new users would be likely to start off with a non-tobacco flavour and minimum strength level.

Turning now to comparisons between strength profiles for different flavours, ZUL-strength tobacco products are valued almost 18% lower than full-strength tobacco products, while low-strength tobacco flavours are valued 2% more than their full-strength counterparts. Both ZUL- and low-strength menthol disposables are valued more than full-strength menthol, by 14.5% and 3.1% respectively. On the contrary, full-strength exotic-flavoured disposables are valued more than both ZUL- and low-strength variations of the same flavours, by 3.4% and 5.3% respectively.

Let us now look at some of the other regression coefficients included in the analysis. In hedonic pricing models, the coefficients on the time dummies show how the price of the product has changed over the years (Triplett, 2004), presumably for reasons other than inflation since all prices have been indexed to 2016 levels. It shows how the exact same bundle of attributes change in value over time; in other words, it is the quality-adjusted price of the product. It appears that disposable vaping devices became cheaper over time compared to 2010 with the coefficient becoming larger and more negative over time.. There is also evidence of seasonality in vaping prices; as the year advances, disposable products become cheaper with people paying almost 2%

lower prices in the last quarter of the year compared to the first. This may be because more people trying to quit smoking and switch to vaping in the beginning of the year.

Rechargeables

As with disposables, I estimate two versions of Equation 7 – one with separate flavour and strength dummies, and another that includes interactions between the flavour and strengths.

Table 6 shows the results of the OLS estimation of Equation 7 for rechargeable e-cigarettes. As for disposables, I run two separate regressions with and without flavour-strength interactions and show the percentage impacts of each variable on price beside the coefficients. I estimate separate models for starter kits and cartridge or cartomizers refills.

Let us first consider the model without any flavour-strength interactions (Models 1 and 3 for starter kits and individual refills respectively). Looking first at starter kits, we see that compared to tobacco-flavoured products, vapers pay 1.7% less for rechargeable starter kits containing menthol-flavoured cartridges and 0.2% more for those containing exotic-flavoured ones, although this is statistically insignificant. Furthermore, they pay nearly 34% lower price for ZUL-strength products, but 32% more for low-strength ones compared to full-strength rechargeable products. The same analysis on purchases of refills (Model 3) shows that both menthol- and exotic-flavoured refills are valued more highly than tobacco-flavoured ones, by almost 1% and 2% respectively. As far as strength is concerned, regular or full-strength refills are valued the most, with buyers paying 4% and 1.3% less for ZUL and low-strength products respectively. This may indicate that vapers who use rechargeable products prefer most to start off with a kit that contains low-strength cartridges. However, for future refills, they prefer full-strength and non-tobacco flavours the most.

Table 6: Estimation results for rechargeable e-cigarettes

	Starter Kits				Refills			
	(1) No interactions		(2) Flavour-strength interactions		(3) No interactions		(4) Flavour-strength interactions	
	Coefficient	% impact on price	Coefficient	% impact on price	Coefficient	% impact on price	Coefficient	% impact on price
Tobacco flavour (base)								
Menthol flavour	-0.0170***	-1.69	0.0569***	5.85	0.00930**	0.93	0.0216***	2.18
	(0.00613)		(0.00965)		(0.00435)		(0.00627)	
Exotic flavour	0.00182	0.18	0.189***	20.65	0.0183***	1.85	0.0633***	6.53
	(0.00606)		(0.0503)		(0.00423)		(0.0065)	
ZUL strength	-0.412***	-33.79	-0.339***	-28.78	-0.0420***	-4.12	-0.0147	-1.47
	(0.024)		(0.0275)		(0.0112)		(0.012)	
Low strength	0.280***	32.03	0.363***	43.48	-0.0126	-1.26	0.00634	0.63
	(0.0659)		(0.0633)		(0.00859)		(0.00963)	
Regular (full) strength (base)								
Menthol*ZUL strength	-		(omitted)		-		-0.0394***	-3.87
							(0.0118)	
Menthol*Low strength	-		-0.137***	-12.81	-		-0.0245***	-2.42
			-0.0137				(0.00851)	
Menthol*Regular strength (base)								
Exotic*ZUL strength	-		(omitted)		-		-0.0889***	-8.52
							(0.0139)	
Exotic*Low strength	-		-0.216***	-19.53	-		-0.0767***	-7.39
			(0.0507)				(0.00863)	
Exotic*Regular strength (base)								
# of cartridges/cartomizers	-0.00269	-0.28	-0.0148	-1.48	-		-	
	(0.0151)		(0.0166)					
# of batteries	0.281***	32.17	0.316***	36.82	-		-	
	(0.065)		(0.0711)					
# of chargers	0.0177	1.74	-0.0113	-1.16	-		-	
	(0.0311)		(0.0287)					
# of durable cases	0.137***	14.66	0.164***	17.8	-		-	
	(0.0194)		(0.0191)					
2010 (base)								
2011	-0.190***	-17.37	-0.186***	-17.03	-0.0916***	-8.76	-0.0894***	-8.56
	(0.0395)		(0.0378)		(0.0121)		(0.0117)	
2012	-0.273***	-23.95	-0.261***	-23.03	-0.116***	-10.96	-0.113***	-10.69
	(0.0390)		(0.0377)		(0.00984)		(0.00983)	
2013	-0.410***	-33.68	-0.401***	-33.08	-0.157***	-14.53	-0.152***	-14.11
	(0.0375)		(0.0362)		(0.0103)		(0.0103)	
2014	-0.498***	-39.27	-0.485***	-38.48	-0.188***	-17.14	-0.183***	-16.73
	(0.0398)		(0.039)		(0.0105)		(0.0106)	
2015	-0.568***	-43.38	-0.552***	-42.46	-0.257***	-22.67	-0.253***	-22.36
	(0.0394)		(0.0386)		(0.0113)		(0.0114)	
2016	-0.630***	-46.79	-0.603***	-45.33	-0.243***	-21.58	-0.242***	-21.5
	(0.0422)		(0.0423)		(0.0132)		(0.0134)	
Quarter 1 (base)								
Quarter 2	-0.0251***	-2.48	-0.0245***	-2.42	-0.00364	-0.36	-0.0036	-0.36
	(0.00919)		(0.00928)		(0.00477)		(0.00475)	
Quarter 3	-0.0673***	-6.51	-0.0650***	-6.3	-0.0116**	-1.15	-0.0113**	-1.12
	(0.00722)		(0.00727)		(0.00454)		(0.00451)	
Quarter 4	-0.0747***	-7.2	-0.0702***	-6.78	-0.0179***	-1.78	-0.0184***	-1.82
	(0.0086)		(0.00871)		(0.00499)		(0.005)	
% of population comprehensively covered by SFA ban in bars	-0.00107***	-0.11	-0.00107***	-0.11	-0.00013	-0.01	-0.000117	-0.01
	(0.000329)		(0.000326)		(0.00022)		(0.000215)	
R^2	*0.901*		*0.903*		*0.544*		*0.546*	
N	*12,572*		*12,572*		*29,015*		*29,015*	

*[Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

While the results for starter kits are similar to those for disposables, with the exception of ZUL-strength, they are largely contrary for refills. This is an indication that buyers of disposables and of rechargeable starter kits are similar, while the more experienced vapers who continue to purchase refills have contrasting preferences. In the long run, rechargeables possibly draw more experienced vapers and/or smokers who want full-strength products, but may value non-tobacco flavours. Disposable products, on the other hand, might attract more experimentation with exotic flavours and nicotine-free options.

Table 7: Full impact of flavour and strength with interaction terms, rechargeables

	Comparing flavours for each strength	% impact on price	Comparing strengths for each flavour	% impact on price
Starter Kits	Full-Tobacco (base)		Full-Tobacco (base)	
	Full-Menthol	5.85	ZUL-Tobacco	-28.75
	Full-Exotic	20.59	Low-Tobacco	43.47
	ZUL-Tobacco (base)		Full-Menthol (base)	
	ZUL-Menthol	(omitted)	ZUL-Menthol	(omitted)
	ZUL-Exotic	(omitted)	Low-Menthol	30.64
	Low-Tobacco (base)		Full-Exotic (base)	
	Low-Menthol	-6.98	ZUL-Exotic	(omitted)
	Low-Exotic	1.04	Low-Exotic	23.92
Refills	Full-Tobacco (base)		Full-Tobacco (base)	
	Full-Menthol	2.18	ZUL-Tobacco	-1.47
	Full-Exotic	6.53	Low-Tobacco	0.63
	ZUL-Tobacco (base)		Full-Menthol (base)	
	ZUL-Menthol	-1.7	ZUL-Menthol	-5.34
	ZUL-Exotic	-1.98	Low-Menthol	-1.79
	Low-Tobacco (base)		Full-Exotic (base)	
	Low-Menthol	-0.25	ZUL-Exotic	-9.97
	Low-Exotic	-0.86	Low-Exotic	-6.76

Table 7 shows the comparisons between flavour profiles for each strength level and between strength levels for each flavour when flavour-strength interactions are included (Models 2 and 4 for starter kits and individual refills respectively). Data is not available for ZUL-strength menthol- and exotic-flavoured starter kits in certain years, so these have been dropped from the regressions. These are included for cartridge or cartomizer refills as data is available for all years.

For cartridges included in starter kits, full-strength non-tobacco flavours (menthol and exotic) are valued more highly than full-strength tobacco flavour, by almost 6% and 21% respectively. This is also true for refill cartridges purchased separately, with menthol being value 2% more and exotic 6.5% more than their full-strength tobacco counterpart. While this result is consistent with that for disposables as far as exotic flavour is concerned, it is not so for menthol.

As far as low strength options are concerned, kits containing low-strength exotic flavours are valued the most, followed by those containing low-strength and tobacco-flavoured cartridges. When refill cartridges are purchased individually, vapers value low-strength tobacco flavour the most, followed by low-strength menthol flavour, consistent with the results for disposables. For ZUL-strength refills, vapers value tobacco flavour the most, followed by menthol. This is contrary to the results for disposables, where menthol is the most highly valued in ZUL-strength and tobacco the least. Once again, this seems to indicate a difference in the customer profile for disposables and repeat users of rechargeables.

Turning now to comparisons between strength levels for each flavour, the results show that starter kits containing low-strength cartridges are valued more than full-strength variants of each flavour – by 43.5%, 30.6% and 24% respectively for tobacco, menthol and exotic flavours. For tobacco flavour, ZUL-strength is valued less than full-strength, by nearly 29%. For individual refills, the results for both ZUL- and low-strength tobacco-flavour are consistent with those of starter kits, but to a much smaller extent (1.5% less and 0.6% more respectively for ZUL- and low-strength refills compared to 28.8% less and 43.5% more for starter kits). The results for the other two flavours are not consistent between starter kits and refills. Compared to their full-strength counterparts, both low-strength menthol and exotic flavours are valued less (by 1.8% and 6.8% respectively), as are their ZUL-strength counterparts (by 5.3% and 10% respectively for menthol and exotic flavours).

Moving on to the results of Models 1 and 2 for the different components of starter kits, vapers pay more for each additional battery included and for durable cases over disposable or blister packs. The results for the number of cartridges and chargers are not statistically significant in either model.

Finally, a look at the coefficients of the time trends shows that, like disposables, quality-adjusted prices of both starter kits and of individual refills have gone down significantly between 2010 and 2016, by almost 47% for starter kits and by 21.5% for individual refills. Also, both kinds of products are cheaper in the last quarter of the year compared to the first, consistent with the results of disposable e-cigarettes.

6 WTP estimates & discussion

The regression results allow the valuation of different attributes of disposable and rechargeable e-cigarettes respectively to be derived. The exact dollar values of each attribute can now be obtained using the formula for WTP from Equation 5, i.e. by multiplying the transformed coefficients for each attribute by the mean price of each type of product.

First, I calculate the implicit prices using the transformed coefficients from the simpler model that does not include any flavour-strength interactions.

Table 8 shows the obtained implicit prices of flavour and strength for disposables and refills for rechargeables, and of flavour, strength and various components of the product for rechargeable starter kits. The implicit prices of menthol and exotic flavours are relative to those of tobacco, while those of ZUL- and low-strength products are relative to their full-strength counterparts.

Table 8: Dollar values of WTP for attributes without interaction terms

	Disposables	Rechargeables	
		Starter Kits	Refills
Flavour:			
Menthol	-17¢	-32¢	3¢
Exotic	8¢	3¢	6¢
Strength:			
Zero or ultra-low (ZUL)	49¢	-$6.50	-13¢
Low	14¢	$6.10	-4¢
Components of rechargeables:			
Cartridge/cartomizer		-5¢	
Battery		$6.20	
Charger		33¢	
Case		$2.80	

I find that users of disposable products are willing to pay 17¢ less for a menthol-flavoured disposable e-cigarette, and 8¢ more for an exotic-flavoured one, compared to a tobacco-flavoured product. It is the same for rechargeable starter kits, with vapers paying 32¢ lower prices when a starter kit comes with menthol-flavoured cartridges and 3¢ more when one comes with exotic-flavoured ones. However, when cartridges or cartromizers are purchased individually as refills, they pay 3¢ and 6¢ more for menthol and exotic flavour than they would for a tobacco.

Users of disposable cigarettes seem to value both ZUL- and low-strength products more highly than full-strength ones, paying 49¢ more for ZUL- and 14¢ more for low-strength respectively. For users of rechargeables, when they purchase starter kits, they value low-strength options the most, paying upto $6 more for a kit that comes with low-strength cartridges. However, they seem to value full-strength more than ZUL, paying $6.5 less for a kit containing ZUL-strength cartridges. However, when they buy individual refills, users appear to value full-strength the most highly, paying 13¢ and 4¢ less for ZUL- and low-strength options respectively.

Turning now to the components of rechargeable e-cigarettes, a typical user is willing to pay about 5¢ less for each additional cartridge included in a starter kit. However, users value additional batteries and charging options (such as another USB charger cable or wall charger) positively, paying \$6 and 33¢ more respectively if a starter kit contains one more of each. They also value durable cases over disposable ones, paying almost \$3 more when a starter kit comes in a durable case.

Table 9: Dollar values of WTP for attributes across different flavour and strength profiles

	Disposables	Rechargeables	
		Starter Kits	Refills
Comparing between flavours for each strength level:			
Full-Tobacco (base)			
Full-Menthol	-22¢	\$1.1	7¢
Full-Exotic	22¢	\$3.9	21¢
ZUL-Tobacco (base)			
ZUL-Menthol	\$2.4		-5¢
ZUL-Exotic	\$1.4		-6¢
Low-Tobacco (base)			
Low-Menthol	-13¢	-\$1.3	-1¢
Low-Exotic	-37¢	-20¢	-3¢
Comparing between strength levels for each flavour:			
Full-Tobacco (base)			
ZUL-Tobacco	-\$1.4	-\$5.5	-5¢
Low-Tobacco	16¢	-\$8.3	2¢
Full-Menthol (base)			
ZUL-Menthol	\$1.2		-17¢
Low-Menthol	25¢	\$5.9	-6¢
Full-Exotic (base)			
ZUL-Exotic	-27¢		-31¢
Low-Exotic	-43¢	\$4.6	-21¢
Components of rechargeables:			
Cartridge/cartomizer		28¢	
Battery		\$7.1	
Charger		-22¢	
Case		\$3.4	

Next, I calculate the implicit prices of the same attributes using the transformed coefficients from the model including flavour-strength interactions. This allows comparison across flavour profiles for same strength products, and across strength profiles for each flavour. Table 9 shows the obtained dollar values for disposable and rechargeable e-cigarettes respectively. I find that users of disposable products pay 22¢ less for full-strength menthol products and 22¢ more for exotic flavours, compared to tobacco products of the same strength. Users of rechargeable products seem to value both menthol- and exotic-flavoured products over tobacco-flavoured ones at the same strength level, by $1 and $4 more respectively when they buy starter kits, and by 7¢ and 21¢ respectively for each cartridge they buy as individual refills. For zero- or ultra-low-strength products, users of disposables are willing to pay $2.4 and $1.4 more for menthol and exotic flavours respectively relative to tobacco, but 13¢ and 37¢ less respectively for their low-strength counterparts compared to tobacco. The result for low-strength products is consistent with those for disposables when we consider both kinds of rechargeable products – starter kits and refills. Low-strength menthol and low-strength exotic is valued 20¢ are valued $1.3 and 20¢ less than low-strength tobacco in starter kits, and 1¢ and 3¢ less respectively in refills bought separately. Both non-tobacco flavours are also valued less than their tobacco-flavoured counterparts when we look at ZUL-strength refills, with vapers paying 1¢ and 3¢ less respectively for menthol and exotic.

Looking at different strength levels for each flavour for disposable e-cigarettes, I find that vapers value low-strength tobacco- and menthol-flavoured products more than full-strength ones, paying 16¢ and 25¢ more respectively. However, I get mixed results for ZUL-strength products compared to full-strength – vapers pay less for ZUL-strength tobacco- and exotic-flavoured disposables compared to full-strength tobacco- and exotic products respectively (by $1.4 and 27¢ respectively). On the contrary, they pay more for ZUL-strength menthol-flavoured products compared to full-strength menthol (by $1.2). When we turn to starter kits, vapers appear to value full-strength tobacco flavour more than any lower-strength options, paying $5.5 and $8.3 less for starter kits containing tobacco-flavoured cartridges that are ZUL- and low-strength respectively. For refill cartridges or cartomizers purchased separately, vapers appear to value full-strength products the most for all three flavours, with the exception of low-strength tobacco-flavour which is valued 2¢ more than full-strength tobacco. Buyers of menthol refills pay 17¢ and 6¢ less for each ZUL- and low-strength refill, compared to a full-strength one, while those of exotic refills pay 31¢ and 21¢ less respectively for ZUL- and low-strength compared to full-strength exotic refills.

To the best of my knowledge, no other study calculates dollar values of different flavours and strengths of e-cigarettes using a hedonic pricing technique. Estimates based on stated preference methods, such as experimental auctions and discrete choice experiments, are likely to overstate their valuations because they are based on hypothetical situations and choices. A revealed preferences method like hedonic pricing does not have that limitation because it is based in actual choices made by buyers. Monchuk et al., 2007 use experimental auctions on a small sample of smokers and find that they are willing to pay more for higher nicotine content – about 20¢ more for low-strength cigarettes of a particular brand compared to its nicotine-free counterpart, and 7¢ more for the same low-strength brand compared to its ultra-low strength counterpart. Buckell, Marti, and Sindelar, 2019 have results similar to this chapter; they find using a discrete choice experiment that recent quitters generally prefer e-cigarettes of all flavours to conventional cigarettes and that vapers prefer exotic-flavoured e-cigarettes to tobacco flavour, but not to menthol. While this result is consistent with the findings of this chapter with respect to exotic flavour compared to tobacco, they are contrary to my results with respect to menthol (which I find to be the least valued for disposables and starter kits, and valued less than exotic but more than tobacco for rechargeable refills). Shang et al., 2018a find that adult smokers are willing to pay more for tobacco flavour compared to menthol and exotic flavours (by \$3.3 and \$4.5 respectively), and for lower-strength options compared to full-strength (by 50¢). However, given that several studies have found that youth smokers and vapers prefer non-tobacco flavours over tobacco, my results are likely reflective of the mixed customer base captured by the Nielsen data.

Measures of the exact valuation of e-cigarette attributes of flavour and strength have important implications in the regulation of e-cigarettes. By pinpointing what vapers value most and by how much, the FDA and other policymakers can identify areas of potential future intervention. Even though the FDA does not have authority to tax products, these measures also aim to inform makers of tax policy by showing how vapers might adjust the bundle of attributes they buy in reaction to changes in price. A dollar valuation of how much a typical vaper will pay for one flavour or strength over another might allow policymakers to adjust taxes to influence vaping patterns in a particular direction.

There remains potential for a lot more research in this vein. With a richer data set, these same methods can be used to scrutinize the valuation of the different exotic flavour categories, possibly by gender, age and other such factors. Furthermore, with data on advanced personal vapourizers and nicotine salt pods from vaping shops and webstores, the analysis could be extended to these products as well. This study is only a preliminary attempt at valuing various attributes of e-cigarettes. With more detailed data, such as exact nicotine content of products in milligrams, it is possible to go a step further and derive a continuous demand function for specific attributes, and subsequently, price- and tax elasticities, which will go a long way towards informing future policy.

Chapter III

ESTIMATING THE WILLINGNESS TO PAY FOR DIFFERENT CIGARETTE AND LITTLE CIGAR ATTRIBUTES USING A HEDONIC PRICING MODEL

Abstract

Fifty years after the first Surgeon General's report, tobacco use remains the leading preventable cause of death and disease. Since 2009, the US FDA has been implementing a series of regulations targeted to specific features of cigarettes in an attempt to curb smoking. Understanding in greater detail how smokers value different attributes of cigarettes and their unregulated substitutes, little cigars, will help to inform future policy. Using a hedonic pricing model on retail scanner data, I estimate the dollar value of various attributes of cigarettes and little cigars. I find that smokers are willing to pay a 1.25¢ premium for menthol cigarettes over regular ones, but 2.7¢ and 2.6¢ less for menthol- and other non-menthol-flavoured little cigars compared to tobacco-flavoured. Smokers pay a 15¢ premium for both low- and nicotine-free/ultra-low-strength cigarettes, and 53¢ and 10¢ less respectively for cigarettes that are shorter or longer than the usual range of 80−90mm. A filter tip is valued 47¢ less than a non-filter tip, and the typical buyer is willing to pay around 64¢ to buy an individual pack of cigarettes than to buy in bulk in the form of a carton. In the market for little cigars, smokers' valuation of attributes varies according to the type of store they buy from. They value all non-tobacco flavoured little cigars more than tobacco-flavour and filter tips more than non-filter tips when they buy from convenience stores, but these results are flipped for those who buy from food, drug and mass stores. Finally, I find that quality-adjusted prices of both cigarettes and little cigars have increased between 2007 and 2016.

1 Background

Tobacco use is the leading preventable cause of death worldwide, and it is estimated to cause more than 8 million deaths annually by 2030, according to a report by the World Health Organization. The average smoker dies ten years earlier than the non-smoker (Jha et al., 2013), and if smoking continues at the current rate, one in every 13 Americans aged 17 years or younger today will die prematurely from a smoking-related illness (WHO 2011). Nearly $170 billion was spent in direct medical care alone for adults due to smoking-related illnesses (Xu et al., 2015), yet not a single state within the US currently meets the Centers for Disease Control and Prevention's (CDC) recommended levels for prevention and cessation programs (Campaign for Tobacco-Free Kids, 2017).

In June 2009, the Family Smoking Prevention and Tobacco Control Act was signed into law, giving the US Food and Drug Administration (FDA) the authority to regulate the tobacco industry. Immediately following this, the FDA implemented two bans: one prohibiting the sale of any flavoured cigarettes, barring menthol, and the other banning the use of any descriptors on cigarette packaging that misleadingly convey the message of reduced harm. More recently, in November 2018, the FDA announced a further upcoming ban on the sale of menthol cigarettes. This is a crucial step in tobacco control, since studies show that flavoured products are preferred by young and novice smokers because they mask the acrid taste of tobacco and by appealing to "sensation-seeking" youth (Carpenter et al., 2005; Manning, Kelly, and Comello, 2009; Wayne and Connolly, 2002), and are often considered to be a gateway into a lifelong battle with tobacco addiction (Ambrose et al., 2015; Oliver et al., 2012; Villanti et al., 2017).

According to the Federal Trade Commission's Reports on cigarettes and smokeless tobacco in 2016, tobacco companies spent $9.5 billion in 2016 on advertising and promotion of tobacco products – that is about $1 million every hour. The bulk of this spending goes into discounting products to retailers so that the overall prices of these products can remain low. This investment into advertising and marketing pays off; youth who are exposed to cigarette advertising find the ads appealing and display increased desire to smoke (Perks, Armour, and Agaku, 2018).

Furthermore, tobacco manufacturers thrive on the misconception that "light" or "ultralight" cigarettes are less harmful. A study by Bansal-Travers et al., 2011 finds that smokers are more likely to pick cigarettes that claim to be "light", "silver" and "smooth" that imply smoother taste, less tar content and lower nicotine content. Furthermore, O'Connor et al., 2013 find that smokers who buy cigarette labelled with these desciptors are more likely to find them milder-tasting, thereby lulling current and new smokers into a false sense of security (O'Connor et al., 2005). The FDA made an attempt to address this by imposing the ban on descriptors on cigarette packaging, but studies indicate that cigarette manufacturers have largely evaded this by assigning colours to the packaging or substituting the prohibited words with others (Alpert, Carpenter, and Connolly, 2018; Connolly and Alpert, 2014; Strasser et al., 2014; Yong et al., 2016).

While the FDA has taken some very important steps to curb tobacco use by imposing these bans, there remains a lot more to be done. Knowing smokers' valuations of different attributes of cigarettes and other tobacco products plays a large role in highlighting which policies work best and how smokers may react to different policies, and in identifying the areas where regulations will have the greatest impact. O'Neill and Philips, 1999 use a hedonic pricing technique to estimate the valuation of cigarette nicotine, carbon monoxide (CO) and tar levels on a market segmented by cigarette size in the United Kingdom (UK). Using data representing about 21% of the brands sold in the UK at the time, they find that smokers of regular-sized cigarettes attach a positive value to reduced nicotine and CO, while smokers of "long" cigarettes do the reverse. Monchuk et al., 2007 use experimental auctions to estimate smokers' valuation of nicotine, and find that smokers would be willing to pay $1.25-$1.45 for nicotine-free cigarettes and $1.59-$1.66 for cigarettes with low levels of nicotine. Nonnemaker et al., 2016 estimate cigarette smokers' willingness-to-pay (WTP) for various electronic cigarette (e-cigarette) attributes, and find that they would be willing to pay lower prices if e-cigarettes do not offer different flavours, cannot be used indoors, do not offer reduced harm than cigarettes and don't help to quit smoking. Using a discrete choice experiment among adult smokers, Marti et al., 2016 find similar results.

To the best of my knowledge, the study by O'Neill and Philips is the only one that uses a hedonic pricing model to evaluate the impact of several cigarette attributes on price. However, they did not go through with calculating actual WTP for any of those attributes. This chapter attempts to address the gap in the literature by estimating dollar values for several attributes of cigarettes and little cigars using a hedonic pricing method. Using the same method, I also estimate the quality-adjusted real price of cigarettes and little cigars. This has important implications in tobacco control policy: knowing how much smokers value individual attributes will help policymakers can identify the areas of regulation that will have the maximum impact and project smokers' reactions to attribute-oriented policies. Furthermore, exact dollar estimates for the different attributes can inform tax policy by providing a measure of the price gap that needs to be filled for smokers to refrain from, or at the very least, curb the use of cigarettes and little cigars.

The rest of this chapter is organized as follows: Section 2 lays out the theoretical basis for the model, along with the empirical framework used. Section 3 discusses the data sources and the construction of variables. Section 4 presents and discusses the results of the analysis, and Section 5 discusses the WTP estimates constructed from the regression results. Finally, Section 6 wraps up this chapter with a discussion of the policy implications.

2 Theoretical & empirical framework

This chapter is based on the hedonic pricing model originally proposed by Rosen, 1974. The basic premise of this model is that the price of a differentiated product is the sum of the prices paid for each of its attributes. The underlying assumption is that the good in question is a differentiated product. In such a case, the variations in the price of the product is the sum of the value added implicitly by changing the level of individual attributes. Thus, the price of a product can be decomposed into the valuation or "implicit prices" of the individual attributes.

$$P = f(X, Y) = f(x_1, x_2, Y) \tag{8}$$

where X represents a bundle of characteristics & consists of x_1 and x_2, and Y is a vector of control variables, including income. This can be empirically estimated by regressing the price, P, or a transformation – the most commonly-used being the semi-logarithmic form (Cropper, Deck, and McConnell, 1988) – on the attributes, x_1 and x_2; i.e. by estimating the following equation:

$$\ln P = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 Y \tag{9}$$

Taking differentials,

$$\partial(\ln P) = \frac{1}{P} \cdot \partial P = \alpha_1 \cdot \partial x_1 + \alpha_2 \cdot \partial x_2 + \alpha_3 \cdot \partial Y$$

Once the coefficients of regression are known, the implicit price function of attribute 1 is given by the change in price paid when the attribute is increased by one unit.

$$implicit\ price\ of\ x_1 = \frac{\partial P}{\partial x_1} = \hat{\alpha_1} \cdot P \tag{10}$$

There is a slight complication in this regard. Typically, in a regression with continuous variables, the regression coefficients, α, represents the change in P due to a unit change in x. However, in the case of dummy variables, which I use to represent all the attributes in this chapter, regression coefficients must be transformed for an unbiased estimate of the coefficient (Kennedy, 1981) and this transformation is given by the following expression on the RHS:

$$\frac{\partial(\ln P)}{\partial x_1} = \frac{1}{P} \cdot \partial P = (\exp^{\hat{\alpha}-0.5var(\hat{\alpha})} - 1) \tag{11}$$

where $\hat{\alpha}$ is the estimated coefficient of dummy variable, x. The implicit price function of each attribute, i, is then given by:

$$implicit\ price\ of\ x_1 = \frac{\partial P}{\partial x_1} = (\exp^{\hat{\alpha}-0.5var(\hat{\alpha})} - 1) \cdot P \tag{12}$$

The dollar value of the WTP for attribute, i, is the above expression evaluated at the mean price.

Rosen's hedonic pricing model is well-suited to the cigarettes (little cigars) market because in the period covered in this analysis (2007-2016), there were a large number of brands of cigarettes and little cigars, each being a close substitute of the other, yet distinctive in some way. Both these markets are oligopolistic, giving the suppliers a degree of control over prices and thereby likely to reflect consumers' true valuation of attributes and not just producers' cost functions.

For the purposes of this chapter, I use a log-linear functional form because doing so allows for calculation of implicit prices according to Equation 10. I express the price of a cigarette as a function of flavour, strength level, pack type, length and the presence of a filter. Because there should legally be no sales of exotic-flavoured cigarettes following the flavour ban in 2009, I estimate two models for cigarettes – one including exotic-flavoured cigarettes and only using information prior to the ban, and another that looks only at tobacco- and menthol-flavoured cigarettes and includes all the data available prior to and following the ban.

The following two models are estimated for cigarettes for the periods before and after the flavour ban:

$$\ln price_{ijkl} = \alpha_0 + \alpha_{11} menthol_i + \alpha_{12} exotic_i + \alpha_{21} ZUL_i + \alpha_{22} low_i + \alpha_{31} carton_i + \alpha_{41} short_i + \alpha_{42} long_i + \alpha_5 filter_i + \alpha_6 SFA_i + brand\ FE_i + marketstore\ FE_j + year\ FE_k + quarter\ FE_l \tag{13}$$

$$\ln price_{ijkl} = \beta_0 + \beta_1 menthol_i + \beta_{21} ZUL_i + \beta_{22} low_i + \beta_{31} carton_i + \beta_{41} short_i + \beta_{42} long_i + \beta_5 filter_i + \beta_6 SFA_i + brand\ FE_i + marketstore\ FE_j + year\ FE_k + quarter\ FE_l \tag{14}$$

where i = product, j = market-store, k = year, l = quarter

The variables of interest in this chapter are the flavour, strength and length categories, pack type (i.e. carton) and inclusion of a filter tip. Each of these variables is described in further detail in Section 3. The variable *SFA* represents smoke-free air laws in each market-year. I control for brand, market-store, year and quarter fixed effects, to take into account any variations in policy, macroeconomic, demographic and cultural differences within markets over time, and to account for any seasonality of the data. The dependent variable is the inflation-adjusted price of a pack of 20 cigarettes or little cigars in a market-store-year-quarter.

Ordinary least squares (OLS) regression is used to estimate the model. A log-linear functional form is used and the coefficients can be interpreted as the percentage change in the price of the product due to presence of a particular attribute. The implicit price of that attribute can then be calculated as the product of the coefficient and the mean price, as per Equation 12.

I estimate a similar model on the little cigars market as well. Data on strength levels or length are not available for little cigars, and all sales were for single sticks or packs. The flavour ban on cigarettes did not extend to little cigars, and I estimate the following equation for the full data set for the period 2007-2016:

$$\ln price_{ijkl} = \gamma_0 + \gamma_{11} menthol_i + \gamma_{12} exotic_i + \gamma_2 filter_i + \gamma_3 SFA_i + brand\ FE_i + marketstore\ FE_j + year\ FE_k + quarter\ FE_l \tag{15}$$

where i = product, j = market-store, k = year, l = quarter

3 Data & variables

3.1 Data

Retail scanner data

This analysis is conducted using retail scanner data collected by the Nielsen Company, a global marketing research firm that collects sales data at retail outlets in order to allow purchasing patterns to be reported and analysed. A "Nielsen market" in the US consists of a group of counties, which may cross geographic state boundaries. Markets are typically named after the largest city, which is often located at or near the center of the designated area. Sales information is available for each product by Universal Product Code (UPC) number, which includes information on brand, product attributes such as flavour, strength, length, etc., and "unit size" (i.e. how many units of the product are sold as a pack). Detailed sales data is available for all Nielsen participating stores, which consist of food, drug and mass (FDM) merchandise stores in 53 markets from 2007 to 2016, and convenience stores (CV) in 30 markets from 2010 to 2016.

The data in this chapter represents 5,244 unique UPCs and 253 brands of cigarettes, and 963 unique UPCs and 104 brands of little cigars. Sales data includes quarterly information on the sales revenue from each product and number of units sold when no promotions were offered, as well as the corresponding numbers when promotions were offered. From the UPC number and description provided by Nielsen, the following information was extracted: brand, type of product (cigarette vs. little cigar), flavour, nicotine strength and length of a stick (cigarettes only), type of packaging, whether or not a filter tip was included.

Smoke-free air laws data

Smoke-free policy data was obtained from Huang et al., 2018, which constructs market-level quarterly policy measures from the American Nonsmokers' Rights Foundation US Tobacco Control Laws Database at the county level.

3.2 Measures

Outcome variables

Price of cigarettes and little cigars: The Nielsen data contains information on the number of units of a particular product sold, regardless of the type of packaging (i.e. whether it is sold as a pack or carton). For both cigarettes and little cigars, details of the product are extracted from the UPC, allowing identification of the kind of packaging – cartons, packs, etc. The number of sticks purchased at a time is not consistent across different products; some are bought in bulk in cartons while others are bought as packs, and even the number of sticks in a pack varies across products. The detailed product information provided by Nielsen is used to calculate the number of sticks purchased at a time. Next, the total number of cigarette sticks sold in a particular market-year-quarter is calculated as the product of the number of units sold and the number of individual sticks included in each unit. Then, assuming that a typical pack of cigarettes contains

20 sticks, the number of packs of 20 sold is calculated for both cigarettes and little cigars. Using the available information, the price of a pack of 20 cigarettes or little cigars is then calculated as the ratio of the total sales revenue to the total number of packs of 20 sold. Prices are allowed to vary within the range of 3 standard deviations from the mean; all data points outside this range are considered to be outliers and are dropped from the analysis.

The data also contains information about whether any promotional offers were used at the time of purchase. A wide variety of promotions were offered, and for reasons of consistency, I only look at products sold at full price in this chapter. Finally, all prices are adjusted for inflation using the Consumer Price Index (CPI) data from the Bureau of Labor Statistics (BLS), indexed to 1 for 2016 prices. All products for which sales information was not available were dropped from the analysis. For the regressions, I use the natural log of prices as the dependent variable.

Figure 3 shows the trend in the mean real prices of cigarettes and little cigars over time for the total market as well as by store type. The sudden hike in prices of both cigarettes and little cigars is likely due to the drastic increase in the federal tax rate on both categories in 2009 that aimed to reduce the gap in tax rates between cigarettes and little cigars. Cigarette prices are inclusive of all three flavours prior to the ban, marked by the green dotted line in the figures, but exclude exotic flavours following the ban. It can be seen that the two prices tend to move in a similar manner.

Explanatory variables

Flavour: There are three major flavour categories included in the analysis – tobacco (or regular flavour), menthol, and "exotic" flavours that include all others such as fruit, candy or spice flavours. The US Food and Drug Administration (FDA) implemented a ban on the sale of exotic flavoured cigarettes in September of 2009. No parallel ban was

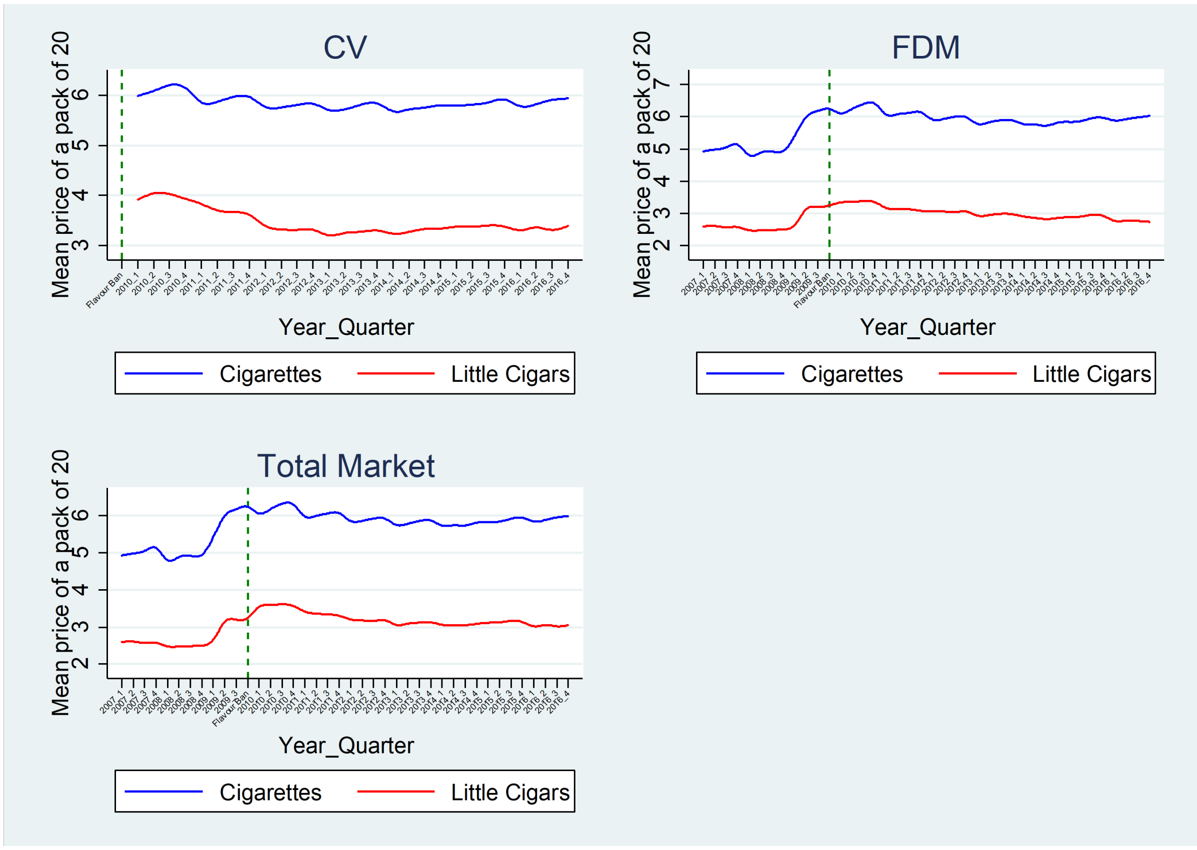

Figure 3: Trend in the prices of cigarettes and little cigars

imposed in the little cigars market. Therefore, exotic-flavoured cigarettes are included in the estimation of Equation 13, but not of Equation 14.

Figure 4 shows the relative percentages of tobacco-, menthol- and exotic-flavoured products sold. For cigarettes, I show the mix of the three flavours prior to the ban on the left, the mix of tobacco and menthol cigarettes in the full data set in the middle, and the mix of the three flavours in the little cigars market on the right. While exotic-flavoured cigarettes make up only a small portion of the market even prior to the ban, it can be seen that this is not the case in the little cigars market, with exotic flavours constituting almost 33% of the market. In terms of sales revenue generated, tobacco-flavoured products generate 73% and 52% of the total sales revenue in the cigarettes and little cigars markets respectively, while the corresponding figures for menthol are 27% and

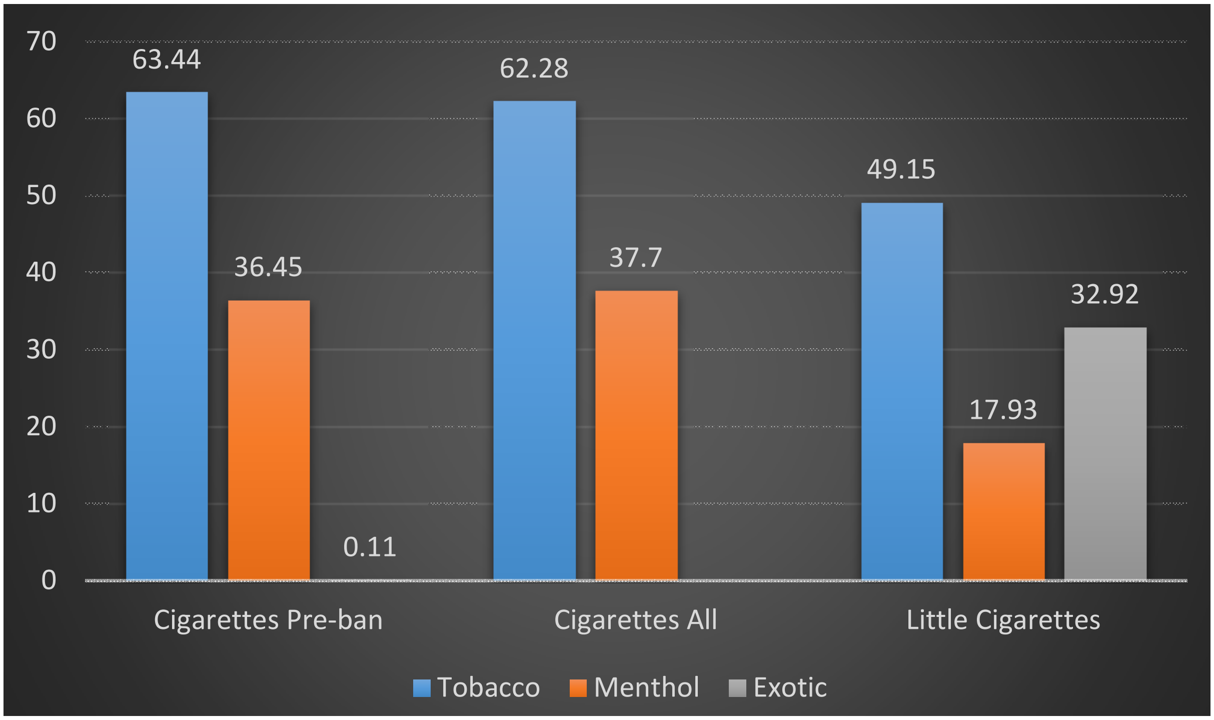

Figure 4: Distribution of flavours, by product

13% respectively. While sales revenue generated by exotic-flavoured cigarettes prior to the ban is negligible, their little cigar counterparts are responsible for more than 35% of revenue generation.

Binary indicator variables are constructed for each flavour category. I use tobacco flavour as the reference category, and only include indicators for menthol and exotic flavours in the regression equations for the analysis of the pre-ban cigarettes and the little cigars markets, and for menthol for the full cigarettes market.

Strength: Three strength categories are included in the analysis – zero- or ultra-low strength (henceforth referred to as ZUL-strength), low-strength and regular- or full-strength. The actual nicotine content within each category varies by brand, and the classification information is extracted directly from the descriptions in the scanner data. The nicotine-free and ultra-low categories were combined into one as sales of the former are very low. Of all cigarettes sold, just under 16% were ZUL-, 36% was low- and the remaining 48% was full-strength. No information on the strength levels of little cigars is available.

Just as for the flavour categories, binary indicator variables are constructed for each of the three strength categories. Using full-strength as the reference category, indicators for ZUL- and low-strength are included in the regression equations. If a product is sold in a bundle with an assortment of strengths, the data is dropped from the analysis.

Pack type: Cigarettes are commonly sold either in packs of 20 to 25, although that number can vary across products, or as cartons (half-cartons) that typically contain 10 (5) packs. Cigarettes cannot legally be sold in the form of single sticks. As mentioned earlier, for the sake of consistency, I measure all prices as the price paid for 20 sticks of cigarettes, regardless of what form they are sold in. This data is scant for little cigars, so pack type was not included in the regressions for little cigars.

For the regressions, binary indicator variables are constructed for each pack type – single sticks, packs, half-cartons or cartons. Of all cigarette sales, nearly 60% is in the form of packs, while 40% and 0.07% are in the form of cartons and half-cartons respectively. Therefore, I combine half-cartons and cartons into one category and adjust the sales volume accordingly in the calculation of prices. The indicator for cartons is included in the regressions, and packs are used as the reference category.

Length: The UPC description of cigarettes contains information about the length of the cigarette. This information is not available for little cigars. Using the description, three categories of length were generated – short, which includes cigarettes under 80mm of length; regular, which includes cigarettes between 80mm and 90mm in length; and long, which covers all cigarettes longer than 90mm. Binary indicator variables are generated for each of the three categories, and the regressions include the short and long categories, with regular length as the reference category. Of all cigarettes sold, only 3% were short, 47% were regular length and the remaining 50% long.

Filter tip: A binary indicator variable was constructed to reflect whether the cigarette or little cigar includes a filter tip or not. Some products sold include an assortment of products with and without filter tips; these are dropped from the analysis. Of all cigarettes, 97.5% include a filter tip. There is more variation among little cigars, with only 59% having a filter tip.

Control variables

Smoke-free air laws: Measures of smoke-free air laws are available for four different venues (bars, restaurants, and private and public workplaces respectively) and are weighted using county population weights within a single market. They represent the percentage of the population in each market that is covered by a comprehensive ban in each venue at the end of each quarter and in each Nielsen market. Because the four measures are highly correlated, only the percentage of the population covered comprehensively by a ban on smoking inside bars is included in the regressions.

Summary statistics for all variables are shown in Table 11. The mean sales of cigarettes and little cigars in each market are 15,896 packs and 2,198 packs respectively (mean per capita sales*mean market population). The mean price of a pack of 20 cigarettes is $5.8 in 2016 dollars, while that of little cigars is almost half of that amount at $3.1. Because

Table 10: Mean price and market size, by product, model and store type

			Mean price ($)	N
Cigarettes	All flavours, 2007 to Q2, 2009	(1) Total market	5.229	494,798
	Tobacco & menthol flavours, All periods	(2) Total market	5.795	2,311,385
		(3) FDM stores	5.763	1,602,976
		(4) CV stores	5.868	708,409
Little cigars	All flavours, All periods	(5) Total market	3.108	142,382
		(6) FDM stores	2.927	90,322
		(7) CV stores	3.424	52,060

the analysis is conducted for the total market as well as by store type for both products, mean prices and market size are shown in Table 10 by store type and the total market

Table 11: Summary statistics, by product type

Variable	Cigarettes Mean	Cigarettes SD	Cigarettes Min	Cigarettes Max	Little Cigars Mean	Little Cigars SD	Little Cigars Min	Little Cigars Max
Price	5.795	1.748	0.001	17.048	3.108	2.103	0.001	11.31
Per capita sales	0.003	0.02	2.48E-08	1.347	4.17E-04	0.001	1.70E-08	0.061
Flavour								
Tobacco	0.624	0.484	0	1	0.497	0.5	0	1
Menthol	0.376	0.484	0	1	0.181	0.385	0	1
Exotic (pre-ban) (N=494,798)	1.05E-03	0.032	0	1	0.322	0.467	0	1
Strength								
ZUL	0.158	0.365	0	1	-			
Low	0.358	0.479	0	1	-			
Full	0.484	0.5	0	1	-			
Length					-			
Short (<80mm)	0.032	0.176	0	1	-			
Regular (80−90mm)	0.467	0.499	0	1	-			
Long (≥90mm)	0.501	0.5	0	1	-			
Carton	0.402	0.49	0	1	-			
Filter tip	0.975	0.157	0	1	0.586	0.493	0	1
% of population comprehensively covered by SFA ban in bars	10.988	27.801	0	100	12.851	29.455	0	100
Mean market population	*5,298,576*				*5,273,855*			
N	*2,311,902*				*142,382*			

size. Note that for the first model for cigarettes, where all three flavours are included and the period before the flavour ban is considered, the total market is comprised only of FDM stores because data for CV stores was not available until 2010.

Tobacco-flavoured cigarettes and little cigars both constitute the majority of sales in their respective markets – 62.4% and 49.7% respectively; while menthol flavour constitutes 37.6% in the cigarette market and 18% in the little cigar market. While the sale of exotic-flavoured products is a negligible proportion in the cigarette market prior to the ban (0.1% of products), they make up a significant portion of the little cigars market (32%).

Nearly half the cigarettes sold are full-strength, 36% is low-strength and the remaining 16% ZUL-strength. 40% of cigarettes are sold in the form of cartons, with the rest being sold as individual packs. About 50% of all cigarettes are long variants, and 46.7% are regular length. Only 3% is shorter than 80mm in length. Finally, the vast majority of cigarettes sold (97.5%) come with a filter tip, while this is the case for only 59% of little cigars.

Turning now to the smoke-free air (SFA) law coverage, about 11% of the cigarette-buying population is covered by a comprehensive ban on smoking in bars, on average, while the corresponding number for buyers of little cigars is just under 13%.

3.3 Sample size & weights

After dropping all the missing data, the final sample size for cigarettes is 2,311,902, while that for little cigars is 142,382. The data used in this chapter represents 5,244 unique UPCs and 253 brands for cigarettes, and 963 unique UPCs and 104 brands for little cigars. All regressions are weighted by sales quantity. The weights are calculated as the ratio of sales of a product to the total sales, by market, store type, product, quarter and year. All statistical analysis is conducted using Stata 14.

4 Results

Cigarettes

Table 12 shows the results of the regression for the cigarette market. Model (1) includes all three flavours and uses data from 2007 to the end of the second quarter of 2009, when the ban on the sale of flavoured cigarettes came into effect. Because no data on convenience stores was available during this period, the analysis covers only sales in FDM stores. Market fixed effects are included in the regressions, but not displayed in the results. All standard errors are clustered at the market level. The first column shows the regression coefficients of each of the variables of interest, while the second column shows the percentage impact on price and is calculated by first transforming the coefficient to get an unbiased estimate according to Equation 11 and then multiplying by 100. Sensitivity analysis was also conducted by including demographic and socioeconomic variables at the market level alongside market fixed effects, and the results were found to be robust. The results for the more parsimonious model using market fixed effects only are displayed.

Model (2) shows the analysis for the tobacco and menthol cigarettes markets and covers all periods from 2007-2016 and data from the full market (both FDM and convenience stores). Model (3) shows the analysis for the tobacco and menthol cigarettes markets from 2007-2016 and includes only data for FDM stores. Model (4) does the same for convenience stores and includes data from 2010-2016. For each of them, the first column shows the coefficients and the second shows the percentage impact on price.

Model (1) shows that among the three flavour categories, tobacco is the most highly valued, with smokers paying 1.5% and 2.7% less for menthol- and exotic-flavoured cigarettes respectively. When we drop exotic flavours from the analysis and turn to Models (2) through (4), this result remains consistent for FDM stores only, but is re-

Table 12: Estimation results for cigarettes

	All flavours, 2007 to flavour ban		Tobacco & menthol flavours, All periods					
	FDM			Total		FDM		CV
		(1)		(2)		(3)		(4)
	Coeff	% impact	Coeff	% impact	Coeff	% impact	Coeff	% impact
Tobacco flavour (base)								
Menthol flavour	-0.015***	-1.5	0.002	0.22	0	-0.01	0.008***	0.85
	(0.001)		(0.002)		(0.003)		(0.003)	
Exotic flavour	-0.027	-2.7						
	(0.04)							
Full strength (base)								
ZUL strength	0.012***	1.23	0.025***	2.55	0.018*	1.82	0.047***	4.76
	(0.002)		(0.009)		(0.011)		(0.004)	
Low strength	0.011***	1.08	0.026***	2.67	0.019***	1.96	0.044***	4.53
	(0.002)		(0.004)		(0.004)		(0.004)	
Regular length (base)								
Short	-0.084***	-8.05	-0.095***	-9.09	-0.100***	-9.54	-0.091***	-8.67
	(0.007)		(0.004)		(0.006)		(0.004)	
Long	0.002*	0.21	-0.017***	-1.67	-0.016**	-1.62	-0.017***	-1.71
	(0.001)		(0.005)		(0.007)		(0.002)	
Carton	-0.120***	-11.31	-0.117***	-11.01	-0.112***	-10.57	-0.131***	-12.28
	(0.009)		(0.008)		(0.01)		(0.009)	
Filter	-0.112***	-10.63	-0.085***	-8.12	-0.094***	-8.95	-0.039***	-3.8
	(0.009)		(0.007)		(0.008)		(0.012)	
2007	-0.184***	-16.82	-0.185***	-16.89	-0.181***	-16.59		
	(0.014)		(0.018)		(0.02)			
2008	-0.202***	-18.29	-0.206***	-18.6	-0.202***	-18.32		
	(0.009)		(0.014)		(0.017)			
2009	(base)		0.008	0.84	0.012	1.15		
			(0.011)		(0.014)			
2010			0.058***	6.01	0.062***	6.42	0.052***	5.3
			(0.01)		(0.014)		(0.008)	
2011			0.018*	1.81	0.029*	2.96	0	-0.04
			(0.01)		(0.015)		(0.007)	
2012			-0.009	-0.95	-0.001	-0.15	-0.022***	-2.19
			(0.009)		(0.014)		(0.007)	
2013			-0.017	-1.72	-0.015	-1.51	-0.020**	-1.98
			(0.011)		(0.015)		(0.01)	
2014			-0.027**	-2.66	-0.030*	-2.93	-0.021	-2.06
			(0.012)		(0.017)		(0.012)	
2015			-0.009***	-0.89	-0.012***	-1.24	-0.003	-0.3
			(0.003)		(0.005)		(0.004)	
2016 (base, except Model (1))								
Quarter 1 (base)								
Quarter 2	0.047***		0.011***		0.015***		0.003***	
	(0.003)		(0.001)		(0.001)		(0.001)	
Quarter 3	0.064***		0.025***		0.029***		0.016***	
	(0.005)		(0.001)		(0.002)		(0.002)	
Quarter 4	0.056***		0.030***		0.035***		0.018***	
	(0.005)		(0.002)		(0.002)		(0.002)	
R^2	*0.81*		*0.7*		*0.68*		*0.8*	
N	*494,798*		*2,311,385*		*1,602,976*		*708,409*	

*[Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

versed for convenience stores and for the full market (both types of stores). The result for FDM stores is not statistically significant, but that for convenience stores is and shows that smokers pay 0.9% higher prices for menthol versus tobacco-flavoured cigarettes.

Turning now to strength levels, lighter than full-strength cigarettes are valued more across all four models, with the highest differential being seen in convenience stores (4.8% and 4.5% for ZUL and lights respectively). The same holds true for shorter than regular cigarettes – across the board, these are valued less than their regular length counterparts. However, long cigarettes are valued 0.2% higher in the pre-ban market including all three flavours, while they are valued less than regular length in all the other three models when we drop exotic flavours from the analysis. The highest differential is once again seen in convenience stores, with buyers paying 1.7% lower prices for long cigarettes compared to regular length. O'Neill and Philips, 1999 offer an explanation for this result: they suggest that smokers may be placing a negative value on the prolongation of the smoking experience and must be compensated to spend more time to finish a single cigarette.

Buying in bulk costs less across the board, with buyers paying between 11% and 12% less when they buy a carton instead of an individual pack. Finally, the few non-filter tip cigarettes that are purchased seem to be significantly higher valued than their filter tip counterparts, with the difference being highest in the pre-ban market including all flavours. For the tobacco and menthol cigarettes market, the differential is least for convenience stores.

There appears to be significant seasonality in the data, with sales being the highest in the last quarter of the year for all models but the first. I also include the results by year because in hedonic pricing models, the coefficient of the year reflects the quality-adjusted price. The results for Models (2) through (4) show that quality-adjusted prices of cigarettes have gone up over between 2007 and 2016.

Little cigars

Table 13 shows the estimation results for the little cigars market. Because of the lack of availability of data on most attributes, the model is estimated only for flavour and inclusion of a filter. Model (5) shows the results of the analysis for the entire little cigars market that includes both store types, while Models (6) and (7) show the results by store type. The percentage impact on price is reversed for convenience stores for all three attributes, compared to the total market and to FDM stores. Buyers appear to value tobacco-flavoured little cigars more than both menthol- and exotic-flavoured ones in the total market as well in FDM stores. The impact is more pronounced in the results for FDM stores – 1.9% and 1.5% less respectively than tobacco – compared to the full market, where the effects are diluted by the presence of convenience stores. In convenience stores, both menthol- and exotic-flavoured little cigars are bought at a premium compared to tobacco-flavour – 1.7% and 1.1% respectively. The same reversal of signs can be seen with respect to filter tips – while buyers pay almost 10% lower prices for filter-tipped little cigars when they buy at FDM stores, they pay 4.2% more when they buy at convenience stores. This could be indicative of a difference in consumer profile in the two store types. Given that around 60% of sales of little cigars are in FDM stores, it is possible that casual smokers or those looking to try out new flavours buy from convenience stores.

There appears to be significant seasonality in the little cigars market as well, with prices being the highest in the last quarter of the year. Similar to the cigarettes market, the quality-adjusted prices of little cigars have also gone up between 2007 to 2016, with the highest prices being observed in 2010. This is most likely a reflection of the fact that there was a large hike in the federal tax rate on cigarettes and cigars in 2009.

Table 13: Estimation results for little cigars

	Total		FDM		CV	
	(5)		(6)		(7)	
	Coeff	% impact	Coeff	% impact	Coeff	% impact
Tobacco flavour (base)						
Menthol flavour	-0.009	-0.86	-0.019**	-1.91	0.017**	1.66
	(0.008)		(0.009)		(0.008)	
Exotic flavour	-0.008	-0.84	-0.015	-1.48	0.011	1.07
	(0.009)		(0.012)		(0.01)	
Filter	-0.081***	-7.77	-0.103***	-9.85	0.042	4.23
	(0.017)		(0.020)		(0.027)	
2007	-0.359***	-30.23	-0.334***	-28.42		
	(0.033)		(0.037)			
2008	-0.348***	-29.42	-0.322***	-27.61		
	(0.031)		(0.035)			
2009	-0.058**	-5.68	-0.035	-3.46		
	(0.026)		-0.029			
2010	0.063***	6.48	0.079***	8.23	0.04*	4.04
	(0.019)		(0.026)		(0.023)	
2011	0.044**	4.47	0.07***	7.22	-0.005	-0.51
	(0.019)		(0.026)		(0.021)	
2012	0.033*	3.32	0.062**	6.31	-0.019	-1.94
	(0.018)		(0.025)		(0.019)	
2013	0.032*	3.27	0.051*	5.18	-0.004	-0.46
	(0.018)		(0.026)		(0.019)	
2014	0.027	2.71	0.045*	4.57	-0.006	-0.61
	-0.017		(0.023)		(0.019)	
2015	0.016***	1.63	0.027***	2.7	0.006	0.63
	(0.006)		(0.008)		(0.006)	
2016 (base)						
Quarter 1 (base)						
Quarter 2	0.022***		0.029***		0.004	
	(0.002)		(0.002)		(0.003)	
Quarter 3	0.03***		0.038***		0.008*	
	(0.003)		(0.003)		(0.004)	
Quarter 4	0.038***		0.046***		0.013**	
	(0.003)		(0.003)		(0.005)	
R^2	*0.88*		*0.87*		*0.9*	
N	*142,382*		*90,322*		*52,060*	

*[Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

5 WTP estimates

From Equation 12, the estimated WTP for each attribute can now be calculated by evaluating the transformed coefficients (% impact in the regression results divided by 100) at mean prices for each market. For both cigarettes and little cigars, the mean price is obtained separately for each model. The mean prices used in the calculations for each market, by product and store type are summarized in Table 10.

Table 14: Dollar values of WTP for attributes of cigarettes and little cigars

	Cigarettes				Little cigars		
	All flavours, 2007 to Q2, 2009	Tobacco & menthol flavours, All periods			All flavours, All periods		
	(1)	Total (2)	FDM (3)	CV (4)	Total (5)	FDM (6)	CV (7)
Tobacco flavour (base)							
Menthol flavour	-7.85¢	1.25¢	-0.07¢	4.99¢	-2.66¢	-5.60¢	5.70¢
Exotic flavour	-14.11¢	-	-	-	-2.61¢	-4.32¢	3.67¢
Full strength (base)							
ZUL strength	6.44¢	14.78¢	10.51¢	27.95¢	-	-	-
Low strength	5.67¢	15.49¢	11.28¢	26.55¢	-	-	-
Regular length (base)							
Short	-42.08¢	-52.69¢	-54.99¢	-50.84¢	-	-	-
Long	1.12¢	-9.70¢	-9.33¢	-10.05¢	-	-	-
Carton	-59.15¢	-63.80¢	-60.93¢	-72.08¢	-	-	-
Filter	-55.58¢	-47.08¢	-51.57¢	-22.31¢	-24.16¢	-28.83¢	14.48¢

Table 14 shows the WTP for different cigarette and little cigar attributes, based on the results of the regressions. In Model (1), when the sale of exotic-flavoured cigarettes was legal prior to the flavour ban, the average smoker was willing to pay 7.9¢ less for a menthol cigarette compared to a regular or tobacco-flavoured one. The corresponding figure for an exotic-flavoured cigarette was almost double that, at 14¢. Looking at the market for tobacco and menthol cigarettes by store type, it can be seen that smokers who buy from FDM stores are willing to pay around 0.1¢ less for menthol cigarettes compared to tobacco, while those who buy from convenience stores are willing to pay almost 5¢ more for a menthol cigarette.

Turning to the WTP for lighter cigarettes compared to full-strength, smokers' valuation of ZUL and light cigarettes over full-strength is 6.5¢ and 5.7¢ respectively in the pre-ban market comprised of all three flavour profiles. The same result holds in the market excluding exotic flavours (Models (2) through (4)), with patrons of convenience stores paying the highest premiums of 28¢ and 27¢ respectively for ZUL and low-strength cigarettes. This figure is much lower for FDM stores – 10.5¢ and 11.3¢ respectively for ZUL and low-strength.

Buyers in all four models pay significantly less for short cigarettes compared to regular length, with the largest gap of 55¢ being in FDM stores. However, only in the pre-ban market do buyers value long cigarettes more than regular length and pay a premium of 1.1¢ for them. In the rest of the models, buyers pay around 10¢ less for long cigarettes compared to regular length, regardless of store type. Buying in a carton lowers WTP for all four models, with the largest difference (72¢) being seen in convenience stores. Finally, the use of a filter tip lowers the price of a cigarette both in the pre-ban market as well as the full market excluding exotic flavours. Non-filter-tipped cigarettes are most highly valued in FDM stores, with buyers paying a premium of nearly 52¢.

Turning to the little cigars market, buyers who buy from convenience stores pay a premium for both menthol and exotic flavours compared to tobacco flavour – 5.7¢ and 3.7¢ respectively. On the contrary, those who buy from FDM stores pay 5.6¢ and 4.3¢ less for menthol and exotic little cigars respectively compared to tobacco flavour. Finally, buyers who buy from convenience stores pay a nearly 15¢ premium for the use of a filter tip, while those who buy from FDM stores pay nearly 29¢ less for it.

If we look instead at the market for tobacco- and menthol-flavoured cigarettes only, it appears that smokers of menthol cigarettes pay a premium of 1.3¢ over the price of a tobacco-flavoured cigarette in the overall market, and of nearly 5¢ in convenience stores. However, the result is reversed for FDM stores – they pay 0.07¢ less for menthol compared to tobacco. For the little cigars market, smokers value menthol little cigars at 3.5¢ lower than tobacco and exotic flavour 3.25¢ less than tobacco. In FDM stores, they are willing to pay 5.6¢ more for tobacco flavoured compared to a menthol little cigar, and 4.3¢ compared to an exotic-flavoured one.

For little cigars, both menthol and exotic flavours are valued lower than tobacco flavour – 3.5¢ and 3.3¢ respectively.

Turning now to the valuation of nicotine strength lower than full-strength – often mistakenly regarded as being less harmful than the latter – we see that smokers of low-strength varieties do indeed pay a premium of 6.3¢ and 5.8¢ for nicotine-free/ultralight and light varieties respectively in the pre-ban market. If we look just at the market for tobacco- and menthol-flavoured cigarettes, we see an even larger premium paid – 15.3¢ for both strength levels lower than full-strength.

Looking now at the length of cigarettes, smokers are willing to pay between 42¢ and 53¢ less for a cigarette that is shorter than the usual length of 80−90mm, depending on which market we are looking at. For a longer than usual cigarette, smokers of all three flavour profiles in the pre-ban period are willing to pay 1¢ more, but when we consider only the tobacco-flavoured and menthol cigarette markets, they seem to pay almost 10¢ less for longer sticks.

Smokers are willing to pay between 60¢ and 65¢ less when they purchase cigarettes in cartons instead of packs. Finally, smokers pay between 47¢ and 55¢ less for a filter tip cigarette and almost 26¢ less for a filter tip little cigar.

Table 15 shows the quality-adjusted prices of cigarettes and little cigars compared to 2016 prices. Figure 5 shows this same information graphically. Since 2016 is the reference year, a negative value of quality-adjusted price means that price is lower than in 2016, while a positive value shows the reverse. Following the large rise in prices due to the tax hike of 2009, most of the prices are lower than 2016 levels, meaning that quality-adjusted prices of both products have increased between 2010 and 2016.

Table 15: Quality-adjusted prices of cigarettes and little cigars over time

	Cigarettes				Little cigars		
	All flavours, 2007 to Q2, 2009	Tobacco & menthol flavours, All periods			All flavours, All periods		
		Total	FDM	CV	Total	FDM	CV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
2007	-87.94¢	-97.85¢	-95.59¢		-93.96¢	-83.19¢	
2008	-95.66¢	-107.79¢	-105.59¢		-91.46¢	-80.80¢	
2009	(base)	4.86¢	6.61¢		-17.64¢	-10.12¢	
2010		34.84¢	37.00¢	31.13¢	20.15¢	24.07¢	13.83¢
2011		10.51¢	17.07¢	-0.25¢	13.89¢	21.12¢	-1.73¢
2012		-5.50¢	-0.86¢	-12.86¢	10.31¢	18.48¢	-6.65¢
2013		-10.00¢	-8.71¢	-11.65¢	10.17¢	15.17¢	-1.56¢
2014		-15.40¢	-16.89¢	-12.10¢	8.4¢	13.38¢	-2.09¢
2015		-5.16¢	-7.14¢	-1.75¢	5.08¢	7.91¢	2.16¢
2016		(base)	(base)	(base)	(base)	(base)	(base)

[Prices are relative to 2016. There was a significant hike in tax rates on all tobacco products in 2009.]

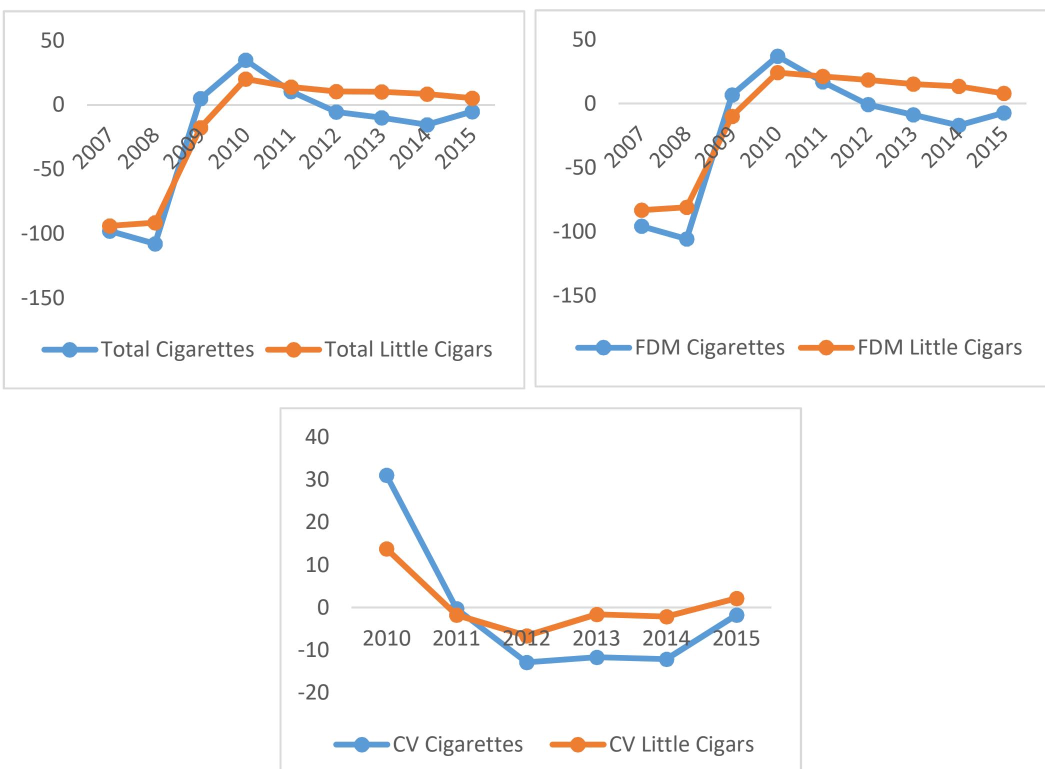

Figure 5: Trend in the quality-adjusted prices of cigarettes and little cigars between 2007–2016; total market and by store type

6 Discussion

While tobacco control has come a long way since the first Surgeon General's report, tobacco use remains the leading cause of preventable death and disease around the world. The FDA acquired authority to regulate the markets for tobacco products in 2009, and has since imposed bans on the sale of flavoured cigarettes excluding menthol and on the inclusion of descriptors on cigarette packaging that may imply a notion of reduced harm, both very particular attribute-specific policies. However, much still remains to be done with respect to the initiation and prevalence of smoking. This chapter aims to inform the regulation policy discourse by providing precise measures of smokers' valuation of various attributes of cigarettes and little cigars. This chapter is novel in its use of a hedonic pricing technique on retail scanner data to estimate smokers' WTP for various attributes.

Using detailed retail scanner data from food, drug and mass, and convenience stores around the US, I conduct the analysis on the full cigarettes market prior to the flavour ban of 2009 and on the market excluding exotic-flavoured cigarettes (i.e. flavoured cigarettes that are not menthol) and on the little cigars market. For the two latter ones, I conduct the analysis separately by store type. I find that smokers value menthol and other flavours less than tobacco flavour (by 7.9¢ and 14¢ respectively) prior to the ban. Excluding exotic flavours from the analysis, it appears that those who buy menthol cigarettes from convenience stores pay a 5¢ premium, while those who buy from FDM stores pay 0.07¢ less. The same holds true for little cigars, with menthol products fetching a 5.7¢ premium over tobacco and exotic flavours fetching a 3.7¢ premium. Low nicotine cigarettes are valued more than their full-strength counterparts, with nicotine-free or ultralow strength varieties fetching a 6.4¢ premium and low strength fetching a 5.7¢ premium. These premiums are even more pronounced when cigarettes are bought at convenience stores, with both varieties being value around 27¢

higher than full-strength. This corroborates what other studies have found: that smokers are willing to pay a premium for what they mistakenly consider a reduced harm choice. The size of a cigarette seems to matter to smokers, with both shorter and longer variants being valued less (around 53¢ and 10¢ respectively) compared to the regular length of $80-90$mm. While the result seems intuitive for "short" cigarettes, it is not so for long ones. A previous study suggests a rationale for this: smokers may resent having to spend more time smoking a long cigarette and therefore require compensation for picking a long cigarette over a regular-sized one. Having a filter in the tip of a cigarette is less preferred, with smokers having to be compensated by almost 56¢ to smoke one compared to a non-filter tip. Finally, smokers pay a premium of almost 60¢ for buying cigarettes in single packs as opposed to multi-pack cartons.

These results open up various pathways to shape future tobacco control policy. Knowing exact values for different cigarette attributes allows policy makers to estimate where to direct future policies to get the maximum impact. For instance, since the results show that low-nicotine cigarettes are preferred, the FDA might extend the ban on descriptors to a policy of plain packaging so that cigarette manufacturers cannot convey a signal of which products might be less harmful. Furthermore, since it appears that the demographic profile of the typical smoker varies by store type, policymakers might consider tailoring policy to the kind of store. Another interesting route might be requiring all cigarettes to be over a certain length, since that seems to irritate the typical smoker. These estimations of WTP can also be used to steer future tobacco tax policy by providing a measure of the magnitude of tax hike that is required. For instance, a tax hike of over 6.44¢ would be sufficient to discourage consumption of both low-nicotine cigarette varieties, thereby making a dent in the number of novice or young smokers. Finally, because most of the regulation so far has been in the cigarettes market so far, some of these might be extended to the little cigars market because the two are practically substitutes. A ban similar to the flavour ban on cigarettes and the upcoming menthol ban, if extended to the little cigars market, would go a long way towards improving the effectiveness of these policies on the cigarettes market and lowering tobacco initiation and use.

To the best of my knowledge, no other study calculates dollar values of different flavours and strengths of cigarettes and little cigars using a hedonic pricing technique. Estimates based on stated preference methods, such as experimental auctions and discrete choice experiments, are likely to overstate their valuations because they are based on hypothetical situations and choices. A revealed preferences method like hedonic pricing does not have that limitation because it is based in actual choices made by buyers.

There remains potential for a lot more research in this vein. With a richer data set, these same methods can be used to scrutinize the valuation of the different attributes by gender, age and other such factors. Alternatively, the same models might be used to estimate the demand function for each attribute, along with price- and tax-elasticities of each. This study is only a preliminary attempt at valuing various attributes of e-cigarettes. With more detailed data, such as exact nicotine content of products in mg, it is possible to go a step further and derive a continuous demand function for specific attributes, and subsequently, price- and tax elasticities, which will go a long way towards informing future policy.

Chapter IV

THE IMPACT OF FLAVOUR AND DESCRIPTOR BANS ON THE SALES OF CIGARETTES AND LITTLE CIGARS

Abstract

In 2009, the Family Smoking Prevention and Tobacco Control Act gave the US Food and Drug Administration authority to regulate the manufacturing, sales and marketing of tobacco products. Immediately afterwards, the FDA implemented a complete ban on the sales of all flavoured cigarettes, with the exception of menthol, and a ban on the use of descriptors on cigarette packaging that allude to reduced harm of certain products. No parallel ban was imposed on little cigars, which are substitutes for cigarettes for all practical purposes. This chapter uses an interrupted time series model to evaluate the impact of these bans on the subsequent sales of cigarettes and little cigars. I find that there is no significant impact of the flavour ban on the overall market or the specific tobacco-flavoured cigarettes market. There is an immediate drop in the level of sales of exotic flavours and a jump in that of menthol flavour. There is also a jump in the level of tobacco- and menthol-flavoured little cigars following the ban. However, none of these effects are long-lasting, as sales decline in the long run. Similarly, for the ban on descriptors, I find no significant impact on the markets for zero or ultra-low nicotine strength, but there is a jump in the sales of low- and full-strength cigarettes. While the sales of low-strength cigarettes permanently decline following the ban, the full-strength cigarette market continues to thrive following the ban, but at a slower rate.

1 Background

Tobacco control has come a long way in curbing the tobacco epidemic, and yet about 7 million people die each year due to smoking-attributable causes, according to the

World Health Organization (WHO). According to the Centers for Disease Control (CDC), 13% of all smokers are aged 18-24 years, with 9 out of 10 current smokers having first tried a cigarette before 18 years of age and 98% having tried by 26 years of age (US Department of Health and Human Services and others, 2014). According to two studies of the tobacco industry's internal documents, Wayne and Connolly, 2002 and Kostygina, Glantz, and Ling, 2016, manufacturers use flavoured products to lure in young and novice smokers, because they are likely to be curious and enjoy trying novel products and flavours, particularly for sensation-seeking adolescents (Manning, Kelly, and Comello, 2009; Carpenter et al., 2005). Furthermore, these groups also benefit from the milder delivery and aftertaste of flavoured products that mask the natural harshness and acrid taste of tobacco smoke (Wayne and Connolly, 2002). In 2014, the CDC's Morbidity and Mortality Weekly Report stated that 73% of high school students who had used tobacco products in the past 30 days had reported using a flavoured one, while 56% of middle school students had reported the same (Corey et al., 2015). Several studies find that of all youth tobacco users, a vast majority report their first product ever tried being a flavoured one, giving rise to concerns that these act as a gateway into a lifelong tobacco addiction (Villanti et al., 2017; Ambrose et al., 2015; Oliver et al., 2012). A study by Villanti et al., 2017 finds that 81% of youth and 86% of young adult tobacco users reported their first product was a flavoured one, compared to only 54% of adults aged 25 and over.

In June 2009, the Family Smoking Prevention and Tobacco Control Act was signed into effect, giving the US Food and Drug Administration (FDA) the authority to regulate the tobacco industry. A few months later, in September 2009, the FDA implemented a complete ban on the sale of all flavoured cigarettes, with the exception of menthol. No corresponding ban was imposed in the market for other flavoured tobacco products, particularly little cigars. These are often marketed as being distinguishable from cigarettes but are as close to cigarettes as legally possible in terms of manufacturing (Delnevo and Hrywna, 2007) – they are almost identical in terms of size, packaging and the presence of filters but are considered to be a different product because they are typically either wrapped in tobacco leaves or in paper containing tobacco. Because there was no corresponding ban on flavoured non-cigarette tobacco products, the effectiveness of the ban was lowered and manufacturers may intentionally have been relabeling cigarettes as little cigars as a way to get around the flavour ban.

There are a few studies that look at the impacts of these bans. Some studies find that the sales of menthol cigarettes and of other flavoured non-cigarette tobacco products, including little cigars, have gone up following the ban (Delnevo, Giovenco, and Miller Lo, 2017; Kuiper et al., 2017). Delnevo and Hrywna, 2015 study the impact of the flavour ban on the sales of clove-flavoured cigars, or kreteks, and find that these increased by 1400% between 2009 and 2012, with the imports of tobacco products from Indonesia – a leader in the production of kreteks – shifting almost entirely from cigarettes to cigars. However, they find that the cigars being sold were essentially relabeled cigarettes, with only the paper wrapper being replaced by homogenized tobacco leaf while the filling remained entirely the same. Courtemanche, Palmer, and Pesko, 2017 study the impact of the flavour ban on adolescents' tobacco use, including the use of cigarettes, cigars, pipes and smokeless tobacco. They find that the ban lowered the probability of being a cigarette smoker, as well as the volume of use of cigarettes. However, the use of menthol cigarettes, cigars and pipes went up, implying that smokers were simply substituting other flavours with menthol cigarettes or other legal flavoured tobacco products.

Following the flavour ban, in July 2010, the FDA implemented an additional ban on labeling tobacco products with descriptor words alluding to nicotine strength and tar content, that may be misleading in implying reduced harm. Bansal-Travers et al., 2011 find evidence that descriptors such as "light", "silver" and "smooth", that imply smoother taste, delivering less tar and lower health risk, are likely to be chosen over their darker-coloured and "full-flavoured" counterparts. O'Connor et al., 2013 find that smokers who buy brands labelled with descriptors such as "light" or "smooth" are more likely to report their cigarettes were lighter or milder-tasting. Several studies have reported that the tobacco industry has largely evaded this ban by substituting other words for those prohibited by the ban or by colour-coding the packaging, and the descriptor ban has been largely ineffective. A study by Connolly and Alpert, 2014 finds that 92% of smokers reported being able to easily identify their preferred brand and 68% could correctly name the colour associated with their usual brand. This study also finds that the sales of "lights" cigarettes remained unchanged following the ban. Alpert, Carpenter, and Connolly, 2018 find that there was no observed change in the market share of lights cigarettes, and no difference in the prevalence of lights versus non-lights smoking or relative smoking initiation of the two groups among youth, and the decline in per capita cigarette consumption slowed down by 37% between the periods 2007-2010 and 2010-2014. Strasser et al., 2014 study a small sample of smokers of lights cigarettes and find that the subtle change in the packaging following the ban went largely unnoticed by regular smokers. The ban also did not seem to impact smokers' misperceptions about reduced harm of lights products (Yong et al., 2016).

However, to the best of my knowledge, none of the aforementioned studies control for any secular trends in sales of tobacco products. Nor do they try to estimate any long-term impacts of the changes. Also, as far as the descriptor ban is concerned, most of the existing literature looks at the impact of lights cigarettes only, but not at nicotine-free or ultralight variants. This chapter looks at the impact of the flavour ban on the subsequent sales of tobacco- and menthol-flavoured cigarettes, and on all little cigars, and the impact of the descriptor ban on the sales of zero- or ultralow, low and full-strength cigarettes. It addresses the gaps in the literature by using an interrupted time series model, which estimates both the level and the slope change in the trend of sales, taking into account any underlying trends in the relevant markets, and thereby paints a more complete picture of the impact. It is also timely, because in November 2018, the FDA proposed a rule to ban menthol-flavoured cigarettes as well.

The rest of this chapter is organized as follows: Section 2 lays out the theoretical framework for interrupted time series regression, followed by the empirical model used in this chapter. Section 3 is divided into two parts; in the first, I describe the data used for the analysis, and in the second, I describe the construction of the variables in detail. The results of the analyses are discussed in Section 4, after which I wrap up with some discussion and concluding remarks in Section 5.

2 Theoretical & empirical framework

In this chapter, interrupted time series (ITS) analysis is used to analyze the impact of the flavour and descriptor bans on the sales of cigarettes. ITS analysis is often stated to be the strongest quasi-experimental research design for evaluating the longitudinal impacts of interventions (Shadish, Cook, and Campbell, 2002; Wagner et al., 2002; Fan et al., 2010), particularly when the intervention is implemented at a population level and at a clear point in time (Soumerai, Starr, and Majumdar, 2015). One of the biggest advantages of using such a model is the ability to control for secular trends in the data in the absence of an intervention (Penfold and Zhang, 2013). The results are also easy to interpret and visualize graphically (Bernal, Cummins, and Gasparrini, 2017). However, there must be a minimum of 8 data points before and after the intervention in order for the results to be statistically valid.

The standard ITS regression model is based on the following equation:

$$Y_t = \alpha_0 + \alpha_1 T_t + \alpha_2 X_t + \epsilon_t \tag{16}$$

Y_t depicts the outcome variable, T_t is the time variable and X_t is an indicator variable representing the intervention, and the term X_tT_t is an interaction term between the time and intervention variables. The actual estimation model is specified based on *a priori* expectations of whether the intervention is expected to have a level or slope effect, or both.

In the estimation of the impact of the bans on cigarette (little cigar) sales, the dependent variable is the per capita sales of cigarettes (little cigars). The coefficient α_1 then depicts the change in per capita cigarette (little cigar) sales over time – i.e. the underlying trend in sales that would have been observed had there been no intervention, α_2 depicts the level change that occurred immediately as a result of the ban, and α_3 the change in slope that occurred due to the ban (the difference between the pre- and post-ban slopes). In other words, α_2 is the immediate effect of the ban, while α_3 is the long-lasting impact of the ban over time. Note that α_3 shows the change in slope, so the new slope of the line is given by $(\alpha_1 + \alpha_3)$. Figure 6 shows this graphically.

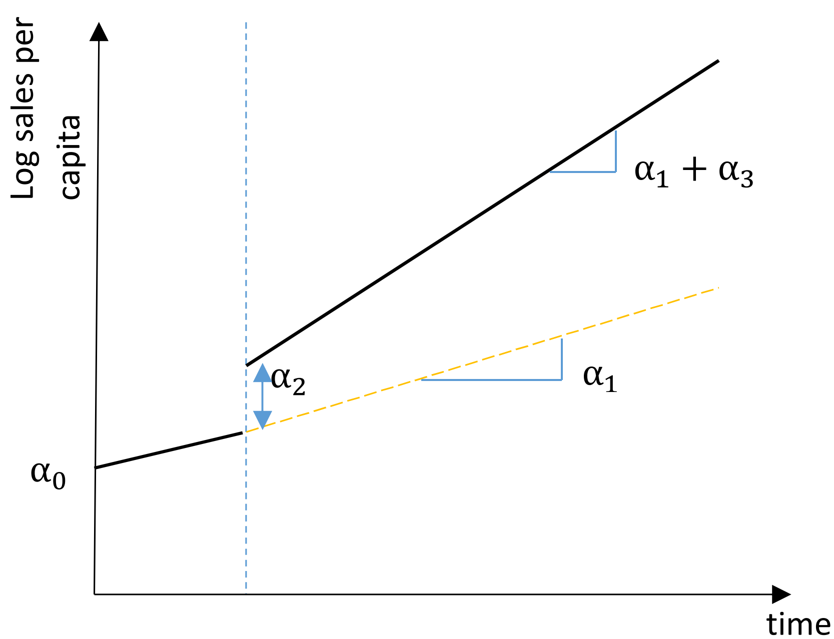

Figure 6: Theoretical depiction of interrupted time series model

The only other study that directly looks at the impact of the flavour ban on the cigarette and little cigar markets is Courtemanche, Palmer, and Pesko, 2017 and they find a reduction in the use of flavoured cigarettes along with a lowered probability of being a cigarette smoker, suggesting both a level and a slope effect, so in this chapter I estimate the full model. For the analysis of the flavour ban, both cigarette and little cigar prices are included in the estimation equation because the two are substitutes. Because the prices are controlled for, the coefficient of the trend variable shows how sales would have changed over time had the prices remained constant.

The data is declared to be panel data and following models are estimated for cigarettes and little cigars respectively:

$$\ln quantitypercapita_{cigarette,ij} = \alpha_0 + \alpha_1 yearquarter_i + \alpha_2 flavourban + \alpha_3[yearquarter_i \cdot flavourban] + \alpha_4 \ln price_{cigarette,ij} + \alpha_5 \ln price_{cigar,ij} + \alpha_6 SFA_i j \tag{17}$$

$$\ln quantitypercapita_{cigar,ij} = \alpha_0 + \alpha_1 yearquarter_i + \alpha_2 flavourban + \alpha_3[yearquarter_i \cdot flavourban] + \alpha_4 \ln price_{cigar,ij} + \alpha_5 \ln price_{cigarette,ij} + \alpha_6 SFA_i j \tag{18}$$

where i = year-quarter, j = market

Price and smoke-free air laws are controlled for as they are possible confounding factors. As a result, the coefficient of the trend variable represents the underlying trend had prices remained constant over time [1]. Ideally, an exogenous variable like taxes would have been a better choice. However, the data in this analysis is available by Nielsen market, which sometimes cross geographic state boundaries, as discussed in the next section. To include tax data in the model, I would merge in tax data at the

[1] The results show a positive trend coefficient in some cases, while the graphs of trend in sales over time always show declining per capita sales over time. This is because the graph shows the trend inclusive of prices, while the trend coefficient represents the trend after controlling for the impact of price on sales.

county-level onto Nielsen markets using population weights. This would likely inflate the impact of average taxes in more densely-populated markets. While this is an area for future improvement of this analysis, prices will have to suffice for the scope of this thesis.

To capture any substitutions of flavour within the cigarette and the little cigar markets, I also estimate the above equations individually for tobacco-, menthol- and exotic-flavoured products. Because sales of exotic-flavoured cigarettes should have stopped completely following the flavour ban, resulting in insufficient data points after the ban, I run the regressions but advise that the results be interpreted cautiously.

Data on the strength of little cigars is not available, so for the impact of the descriptor ban, only cigarettes are included in the analysis, yielding the following estimation equation:

$$\ln quantitypercapita_{cigarette,ij} = \beta_0 + \beta_1 yearquarter_i + \beta_2 descriptorban + \beta_3 [yearquarter_i \cdot descriptorban] + \beta_4 \ln price_{cigarette,ij} + \beta_5 SFA_i j \quad (19)$$

where i = year-quarter, j = market

In each of these models, the vector SFA represents a comprehensive ban on smoking inside bars. Further details on the variables are provided in the following section.

3 Data & variables

3.1 Data

Retail scanner data

This analysis is conducted using retail scanner data collected by the Nielsen Company, a global marketing research firm that collects sales data at retail outlets in order to allow purchasing patterns to be reported and analysed. A "Nielsen market" in the US consists of a group of counties, which may cross geographic state boundaries. Markets are typically named after the largest city, which is often located at or near the center of the designated area. Sales information is available for each product by Universal Product Code (UPC) number, which includes information on brand, product attributes such as flavour or strength, and "unit size" (i.e. how many units of the product are sold as a pack). Detailed sales data is available for all Nielsen participating stores, which consist of food, drug and mass (FDM) merchandise stores in 53 markets from 2007 to 2016, and convenience stores (CV) in 30 markets from 2010 to 2016. Since the main variables of interest in this chapter are the bans on the sale of flavoured cigarettes and on descriptors on packaging of cigarettes, enacted in September 2009 and July 2010 respectively, all the analysis is conducted on FDM store data only. Also, data for two markets was available for certain years only, so these markets are dropped, resulting in the inclusion of 51 markets in the final analysis.

Sales data includes quarterly information on the sales revenue from each product and the number of units sold for each UPC number, and this is used to calculate sales quantity and prices, as described in the following section. Data on individual UPCs is aggregated by market, time period (year-quarter) and flavour, for cigarettes and little cigars respectively, and for nicotine strength for cigarettes only as this data was not available for little cigars. Two panel data sets are constructed, each with year-quarter as the time variable and market as the cross-sectional variable. One of the panel data sets lays out sales figures for individual flavours, regardless of strength level. Since the flavour ban preceded the descriptor ban, the other panel data set is laid out by strength levels of all tobacco- and menthol-flavoured cigarettes, and excludes all exotic-flavoured products. Sales volume and prices for the total market (not broken down by flavour or strength) are also calculated separately and this data is later merged in into both panels.

Smoke-free air laws data

Smoke-free policy data was obtained from Huang et al., 2018, which constructs market-level quarterly policy measures from the American Nonsmokers' Rights Foundation US Tobacco Control Laws Database at the county level.

3.2 Measures

Outcome variables

Per capita sales: The Nielsen data contains information on the number of units of a particular product sold, regardless of the type of packaging (i.e. whether it is sold as a pack or carton). For both cigarettes and little cigars, details of the product are extracted from the UPC, allowing identification of the kind of packaging – cartons, packs or, in rare instances, sticks. The number of sticks purchased at a time is not consistent across different products; some are bought in bulk in cartons while others are bought as packs, and even the number of sticks in a pack varies across products. The detailed product information provided by Nielsen is used to calculate the number of sticks purchased at a time. Next, the total number of cigarette sticks sold in a particular market-year-quarter is calculated as the product of the number of units sold and the number of individual sticks included in each unit. Then, assuming that a typical pack of cigarettes contains 20 sticks, the total sales quantity is calculated as the quantity of cigarette sticks sold divided by 20 (i.e. number of packs of 20 sold). This figure is then divided by the total population in each market to obtain the per capita sales of packs of 20 cigarettes.

For exotic-flavoured cigarettes, data is only available for 288 out of the 2,040 market-year-quarters. Furthermore, there should be no sales of exotic cigarettes following the ban. Since ITS requires at least 8 data points before and after the intervention, this category should be left out of the analysis. I run the regressions nevertheless, but the results should be interpreted cautiously. Some data points are missing for each of the flavour categories as well as in the total market of little cigars; the mean value is substituted in these cases and an indicator for missing data is included in the regressions.

No scanner data is available for strength levels of little cigars. As a result, the analysis of the descriptor ban includes only cigarettes. Also, since the descriptor ban came into effect after the flavour ban, exotic-flavoured cigarettes are dropped from the analysis.

The natural log of the sales of packs of 20 cigarettes is used as the dependent variable in the regressions. Per capita sales of little cigars are calculated for each market-year-quarter using the same method as that for cigarettes. For comparability to cigarettes, I use the natural log of per capita sales of a pack of 20 little cigars as the dependent variable as well.

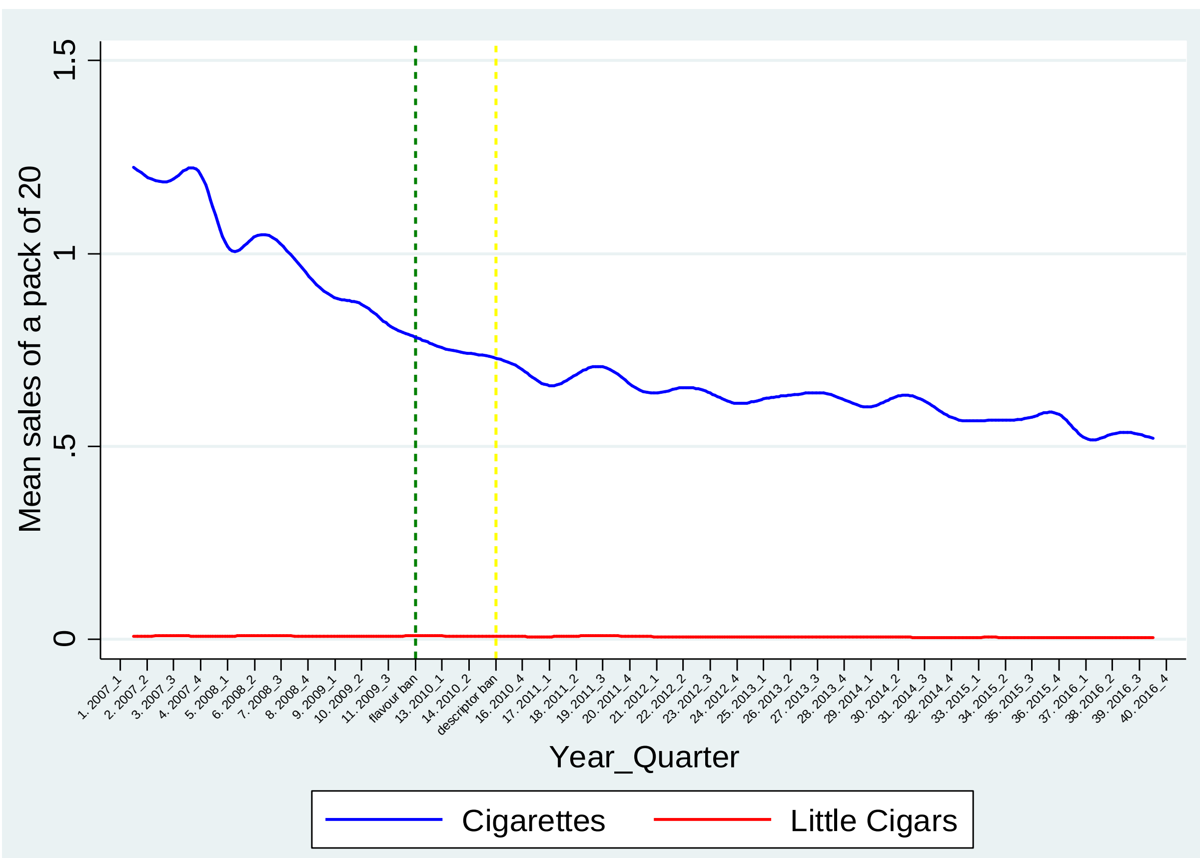

Figure 7: Trend in per capita sales of cigarettes & little cigars over time

Figure 7 shows the trend in mean per capita sales of cigarettes and little cigars for FDM in all markets during the period covered in this analysis. The dotted green line depicts the point in time when the flavour ban was enacted and the yellow line when the descriptor ban was enacted.

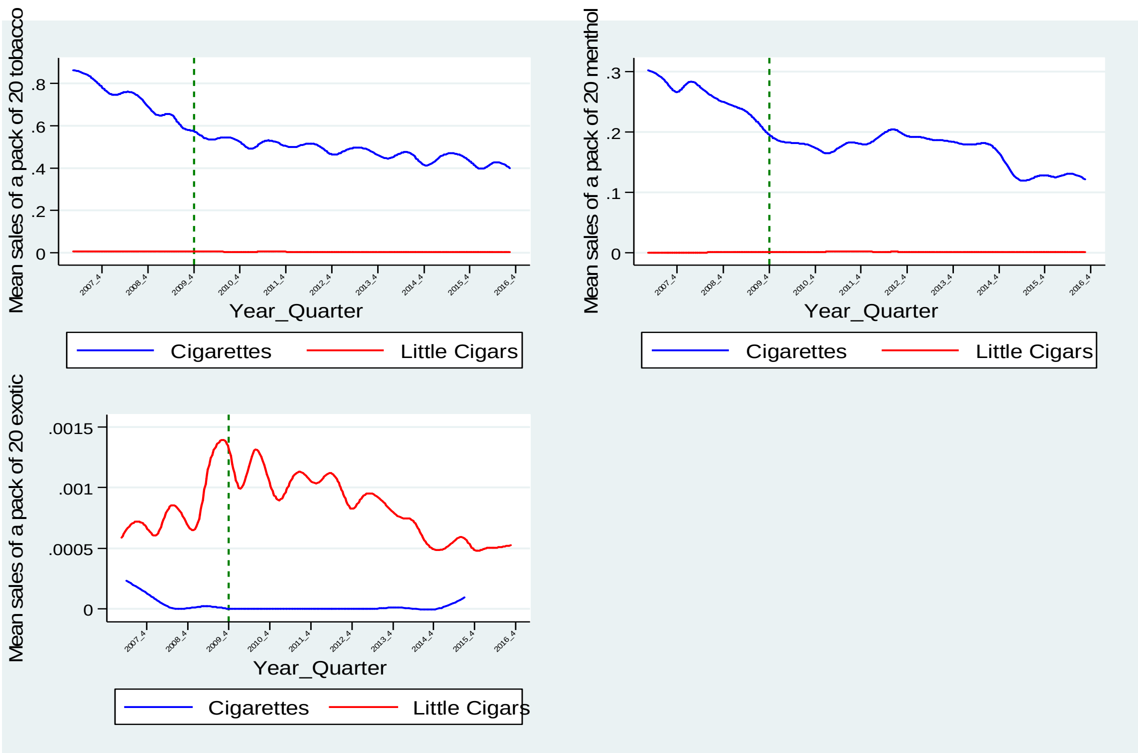

Figure 8: Trend in per capita sales of cigarettes & little cigars over time, by flavour

Figure 8 shows a comparison of the sales of each flavour for cigarettes and little cigars. Because the sales of exotic flavours is much lower than those for tobacco and menthol flavours, note that the scale is different for this type of cigarettes. Similarly, the sales figures for cigarettes are much higher than those of little cigars, so the scale is different for all types of little cigars compared to cigarettes. It can be seen that the sales of exotic-flavoured little cigars increases following the ban on flavoured cigarettes.

Figure 9 shows the same by strength level of cigarettes. It can be seen that while the sales of nicotine-free/zero-strength and of low-strength cigarettes continue to decline

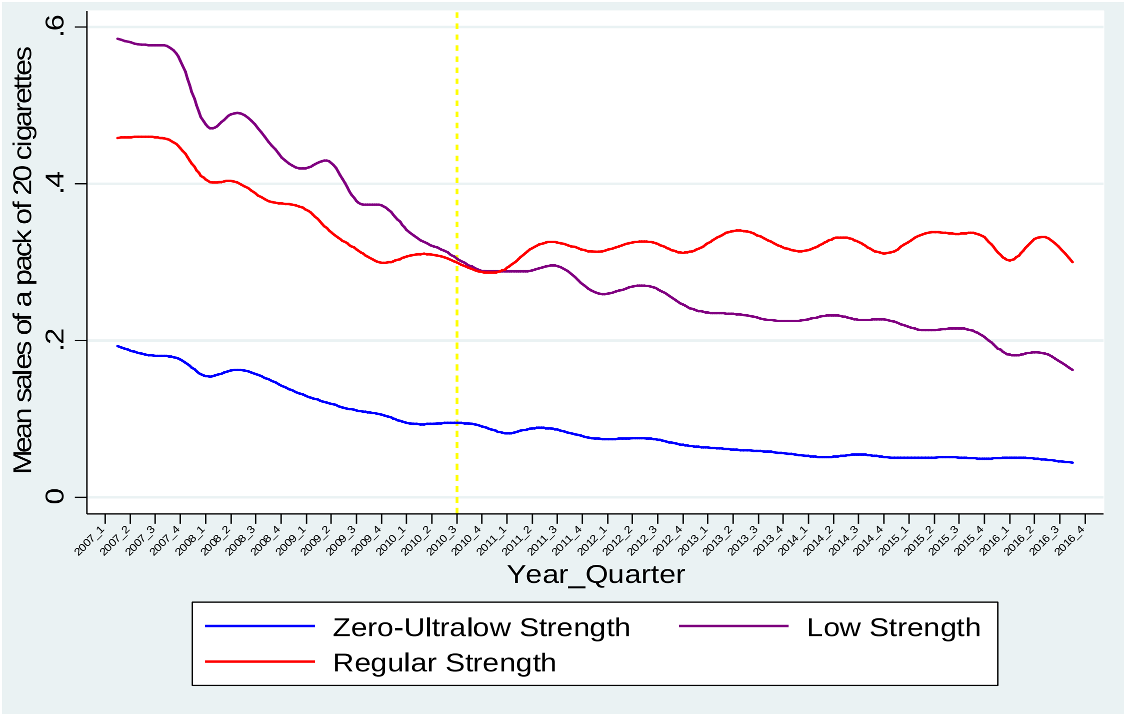

Figure 9: Trend in per capita sales of cigarettes over time, by strength

steadily, those of regular/full-strength cigarettes pick up immediately following the descriptor ban in 2010 and remain steady henceforth.

Explanatory variables

Flavour ban: In September 2009, a ban was imposed on the sale of all flavoured cigarettes, with the exception of menthol cigarettes. A binary indicator variable is constructed to represent all quarters since the ban, taking a value of 1 starting from quarter 4 of 2009 and all quarters since, and of 0 for prior quarters. No such ban was imposed on the sales on flavoured little cigars.

Descriptor ban: In July 2010, a ban was imposed on labeling tobacco products with descriptor words alluding to nicotine strength and tar content on cigarette packaging that "implicitly or explicitly convey a message of reduced risk" – including words like "light", "mild" or "low". Similar to the variable representing the flavour ban, a binary indicator variable is constructed to represent all quarters following the ban, taking a value of 1 starting from quarter 3 of 2010 and of 0 for quarters prior to that.

Flavour: There are three major flavour categories included in the analysis of the impact of the flavour ban – tobacco (or regular flavour), menthol, and "exotic" flavours that include all others such as fruit, candy (including mint) or spice flavours. The sales data for each flavour is calculated separately for each market and year-quarter to allow observation of the impact of the ban on sales of other flavours. Figure 10 shows the

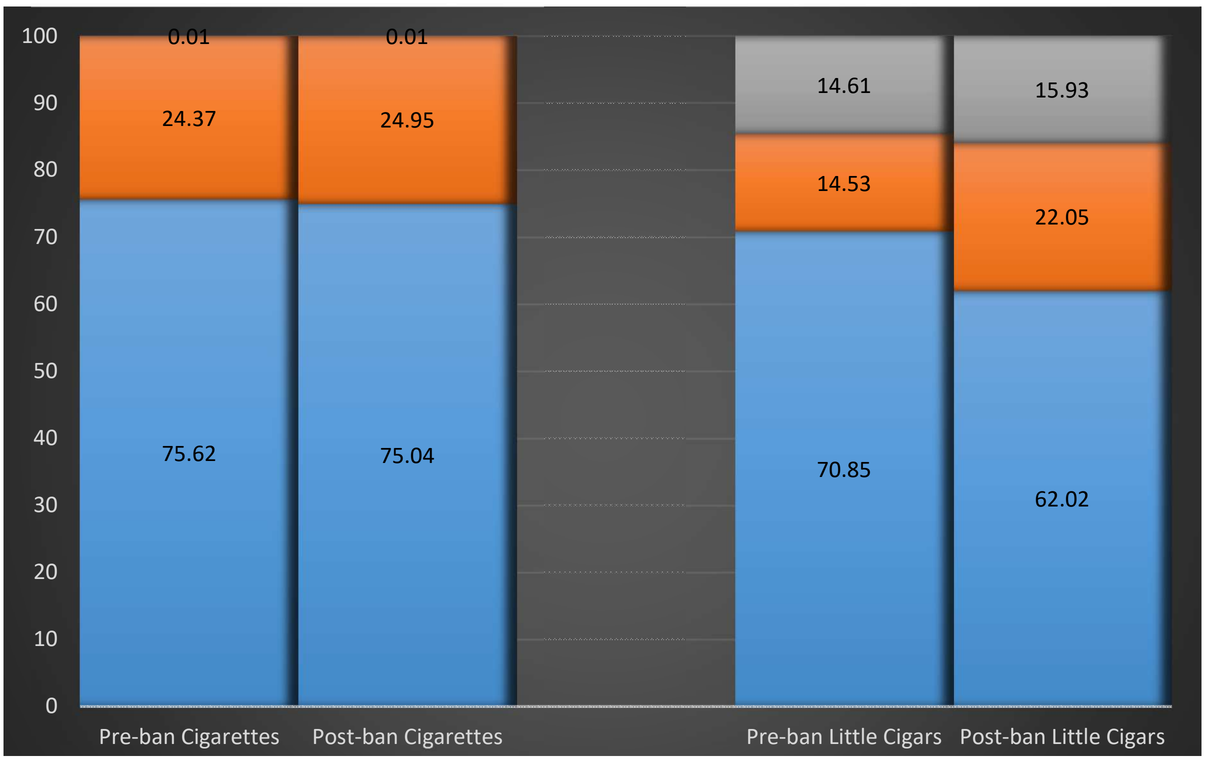

Figure 10: Proportion of sales in each flavour category, before and after the flavour ban

relative percentages of tobacco-, menthol- and exotic-flavoured products sold prior to and since the ban.

Each bar shows the mix of flavours sold as a percentage of total per capita sales before and after the flavour ban, for cigarettes and little cigars respectively. It can be seen that the distribution of sales remains largely unchanged for cigarettes before and after the ban, although the total sales per capita in the cigarette industry went down from 1.2/person to 0.8/person. For little cigars, the sales of exotic-flavoured products remains largely unchanged before and after the ban, but menthol-flavoured products constitute a larger proportion in the post-ban years, and tobacco-flavoured ones a smaller proportion. Similar to cigarettes, the total sales of little cigars also went down from 0.012/person before the ban to 0.010/person.

Strength: Three strength categories are included in the analysis of the impact of the descriptor ban on cigarettes – zero- or ultra-low strength (henceforth referred to as ZUL), low strength and regular or full strength. The actual nicotine content within each category varies by brand, and the classification information is extracted directly from the descriptions in the scanner data. The nicotine-free and ultra-low categories were combined into one as sales of the former are very low. As with the flavour categories, sales data is arranged by strength category in the panel data set to allow comparison between the impacts of the ban on different categories. Figure 11 shows the distri-

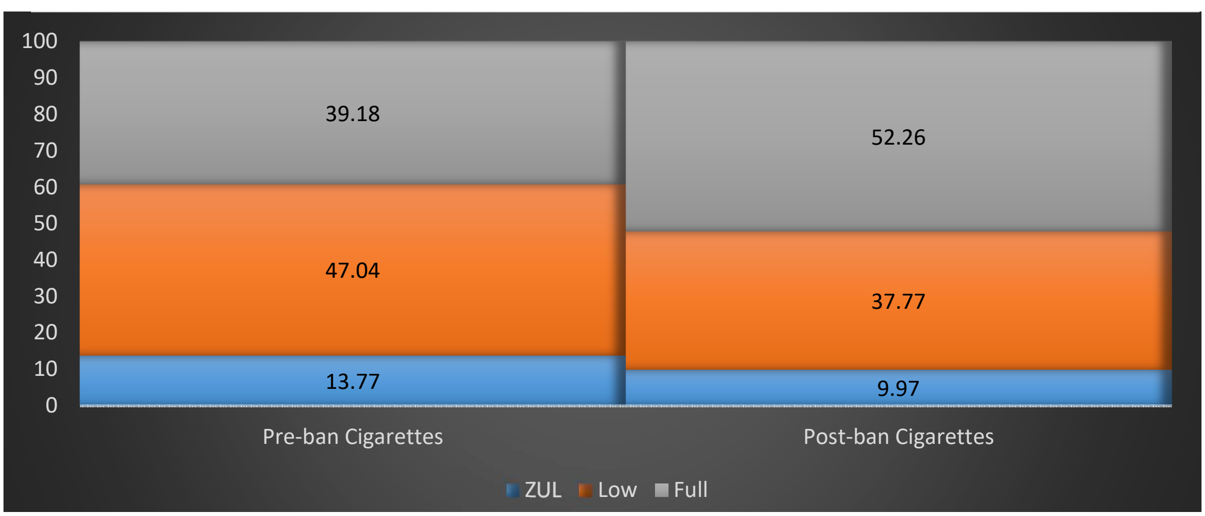

Figure 11: Proportion of sales in each strength category, before and after the descriptor ban

bution of per capita sales of the different strengths of cigarettes before and after the descriptor ban. While the total sales goes down from 1.1/person to 0.8/person following the ban, the proportion of full-strength varieties increase from 39% to 52%, eating into the sales of both ZUL- and low-strength products.

Price of cigarettes and little cigars: As mentioned above, the Nielsen data contains information about the total sales revenue for each product and the total number of units sold. The number of packs of 20 cigarettes or little cigars is calculated described above for per capita sales. Using the available information, the price of a pack of 20 cigarettes or little cigars is then calculated as the ratio of the total sales revenue to the total number of packs of 20 sold.

The Nielsen data also contains an indicator for whether or not any promotional offers were available when each product was purchased. About 13% of all cigarette products sold were done so on such offers, while only about 5.7% of little cigar sales were promoted. Products purchased on promotional offers are excluded from the analysis. Finally, all prices are adjusted for inflation using the Consumer Price Index (CPI) data from the Bureau of Labor Statistics (BLS), indexed to 1 for 2016 prices.

As in the case of sales, missing values of price were replaced with the mean for the full market of little cigars, as well as each flavour category, and an indicator variable included in the analysis. This was not done for exotic-flavoured cigarettes because so few data points were available; instead, the analysis was conducted on a smaller subset of 288 market-year-quarters for which the data was available. No data was found to be missing for any of the strength categories.

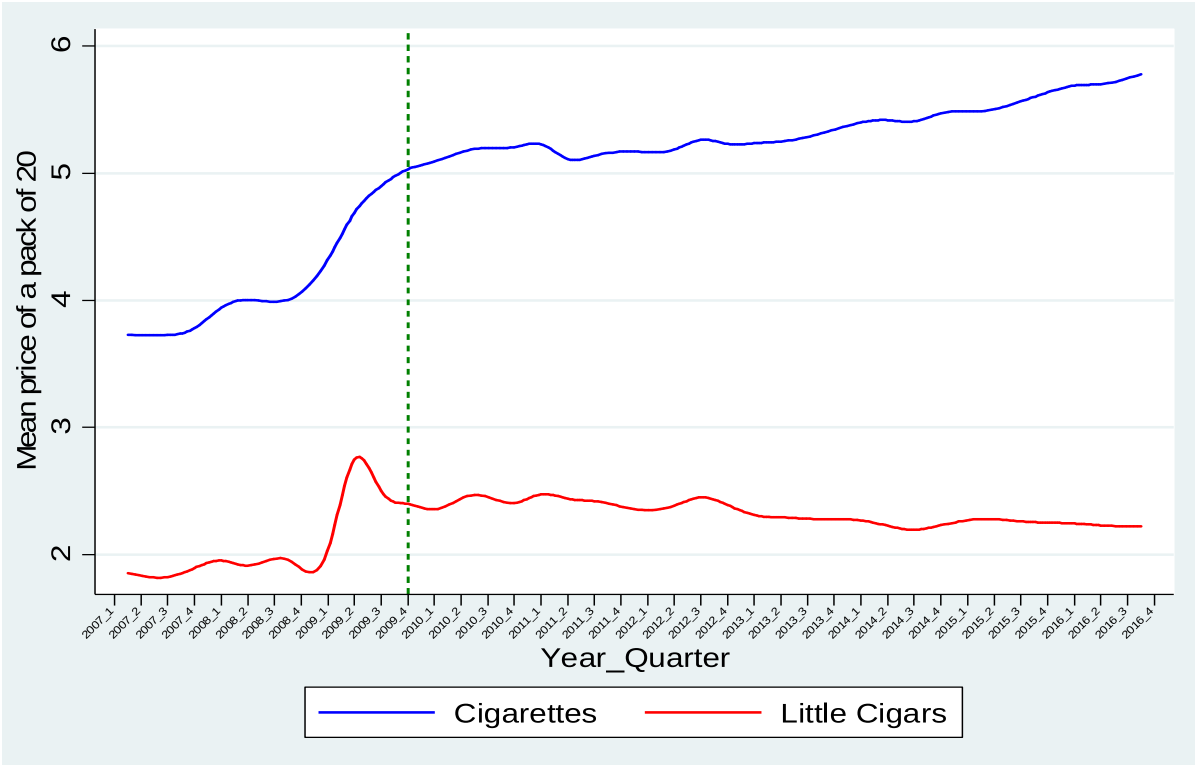

Figure 12: Trend in the price of a pack of 20 cigarettes or little cigars over time

Figure 12 shows the trend in the real prices of cigarettes and little cigars over time. The sudden hike in prices of both cigarettes and little cigars is likely due to the large increase in the federal tax rate on both categories in 2009. The trend broken down by flavour and strength are shown in Figures 13 and 14 respectively. While prices of cigarettes have continued to rise steadily over time, those of little cigars have remained more or less steady. This is reflected in the prices of individual flavours and strengths as well.

Control variables

Smoke-free air laws: Measures of smoke-free air laws are available for four different venues (bars, restaurants, and private and public workplaces respectively) and are weighted using county population weights within a single market. They represent the percentage of the population in each market that is covered by a comprehensive

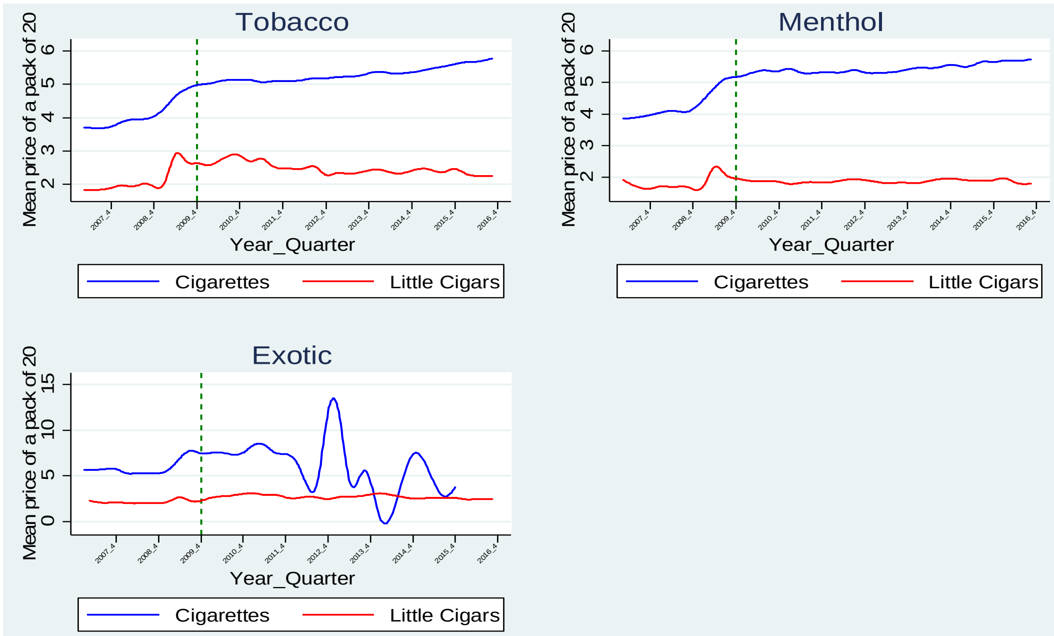

Figure 13: Trend in the price of a pack of 20 cigarettes or little cigars over time, by flavour

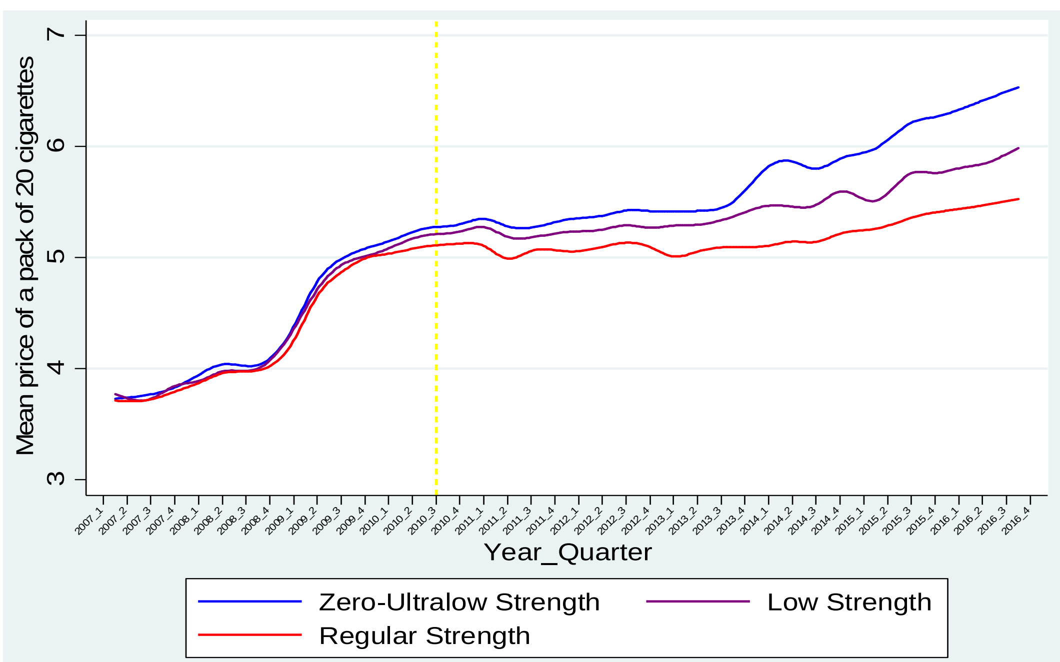

Figure 14: Trend in the price of a pack of 20 cigarettes over time, by strength

Table 16: Summary statistics, by product type

	Cigarettes				Little Cigars			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Per capita sales of packs of 20 (overall market)	0.89	0.59	0.11	3.18	0.01	0.01	3.13E-06	0.11
By flavour:								
Tobacco	0.67	0.44	0.1	2.4	0.01	1.56E-06	1.56E-06	0.07
Menthol	0.22	0.17	0.01	1.14	2.09E-03	2.71E-03	8.49E-08	0.028
Exotic	2.03E-05	1.42E-04	0	2.89E-03	1.62E-03	2.41E-03	4.99E-07	0.023
By strength:								
Zero or ultra-low	0.1	0.09	0.01	0.5	-	-	-	-
Low	0.37	0.28	0.04	1.52	-	-	-	-
Regular (full)	0.42	0.25	0.06	1.37	-	-	-	-
Price of a pack of 20 (overall market)	5.18	1.45	1.9	10.28	2.84	1.52	0.65	8.98
By flavour:								
Tobacco	5.13	1.46	1.86	10.29	2.91	1.52	0.69	9.45
Menthol	5.32	1.45	2.04	10.35	2.32	1.39	0.38	18.8
Exotic *(N=288)*	5.73	2.24	0.14	12	3.13	1.86	0.42	10.54
By strength:								
Zero or ultra-low	5.4	1.5	1.92	10.23	-	-	-	-
Low	5.26	1.45	1.88	10.3	-	-	-	-
Regular (full)	5.09	1.47	1.91	10.29	-	-	-	-
Ban indicator variables								
Flavour ban	0.78	0.42	0	1	0.78	0.42	0	1
Descriptor ban	0.68	0.47	0	1	0.68	0.47	0	1
% of population comprehensively covered by SFA ban in bars	12.03	29.39	0	100	12.03	29.39	0	100
Market population	*4,752,850*	*3,421,395*	*1,078,505*	*20,800,000*	*4,752,850*	*3,421,395*	*1,078,505*	*20,800,000*
N	*2,040*				*2,040*			

ban in each venue at the end of each quarter and in each Nielsen market. Because the four measures are highly correlated, only the percentage of the population covered comprehensively by a ban on smoking inside bars is included in the regressions.

Summary statistics for all variables are shown in Table 16. The mean sales of cigarettes and little cigars in each market are 4,245,287 packs and 49,257 packs respectively (mean per capita sales*mean market population). For both products, the sales of tobacco- and menthol-flavoured products are high – 75.2% and just under 24.8% respectively for cigarettes and 64% and 20% respectively for little cigars. Sales of exotic-flavoured cigarettes is almost negligible for cigarettes (0.002% of total sales overall, 0.007% before the flavour ban and 0.001% after), while that of exotic-flavoured little cigars is substantial around 15.6%.

The mean price of a pack of 20 cigarettes is $5.2 in 2016 dollars, while that of little cigars is almost half of that amount at $2.8. While the prices of the different flavours are similar for cigarettes, they vary greatly in the little cigars market, with the price of a pack of 20 exotic-flavoured cigars costing almost a dollar more than the regular and menthol flavours.

Finally, about 12% of the population is covered by a comprehensive ban on smoking in bars, on average.

4 Results

Two notes are worth making before proceeding on to the results. Firstly, robust standard errors are estimated for all the regression, to simultaneously correct for both heteroskedasticity as well as autocorrelation, according to Stock and Watson, 2008. Second, according to the Stata manual, when estimating a fixed-effects model on panel data, using xtreg, fe in Stata, the adjusted R-squared values shown are incorrect since it estimates the model without creating dummy variables for each of the groups – markets in this case – and thereby shows a larger number for the degrees of freedom. To correct for this, I obtained the adjusted R-squared values by estimating the same model using the areg function, where the model is estimated by including all the dummy variables along with the regressors and thereby lowering the degrees of freedom.

Table 17: Estimation results for the impact of the flavour ban on per capita cigarette sales – overall market and by flavour

	(1) Total Sales	(2) Tobacco	(3) Menthol	(4) Exotic
Year-quarter (trend)	0.000365	-0.00332	0.00811	-0.386***
	(0.00496)	(0.00495)	(0.00514)	(0.0667)
Post-ban dummy (level effect)	0.152**	0.105	0.236***	-2.219
	(0.0691)	(0.0702)	(0.0759)	(1.48)
Year-quarter*Post-ban (slope effect)	-0.00594	-0.00169	-0.0167***	0.188
	(0.00492)	(0.00498)	(0.00507)	(0.122)
Own-price elasticity	-1.388***	-1.368***	-1.216***	-0.134
	(0.19)	(0.188)	(0.249)	(0.384)
Cross-price elasticity	0.128**	0.106*	0.195***	2.098
	(0.0573)	(0.0614)	(0.0569)	(1.328)
% of population covered by smoking ban inside bars	-0.000561*	4.67E-05	-0.00234***	0.0597**
	(0.0003)	(0.0003)	(0.000535)	(0.0231)
Baseline	1.780***	1.499***	0.0231	-9.279***
	(0.229)	(0.226)	(0.317)	(1.123)
Adjusted R^2	*0.9584*	*0.9539*	*0.9523*	*0.6504*
N	*2040*	*2040*	*2040*	*288*
Number of markets	*51*	*51*	*51*	*40*

*[Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

Table 17 shows the results for the analysis of the cigarettes market following the flavour ban. The first column shows the results with the overall sales of cigarettes as the dependent variable. The second column shows the results of the regression for tobacco-flavoured products only, with log sales of tobacco-flavoured cigarettes as the dependent variable and the log prices of tobacco-flavoured cigarettes included as explanatory variables. All other regressors, including the log price of little cigars, are the same. Similarly, the next two columns show the same for menthol- and exotic-flavoured products respectively. As mentioned in Section 3, for exotic-flavoured products, the analysis is run only on 288 market-year-quarters as sales of exotic-flavours tapered off following the ban. Since the dependent variable is the natural logarithm of sales quantity, the coefficients can be interpreted as the percentage change in sales due to a unit change in the explanatory variables, with the exception of prices which are also in logarithmic form and therefore the coefficients represent own- and cross-price elasticities.

The results show that in the absence of any bans on the sale of flavoured cigarettes, cigarettes sales would have continued to grow at a rate of 0.04% per quarter had prices remained constant over the entire period, although this is not statistically significant. Following the flavour ban, there is an immediate 15% jump in the level of cigarette sales, although there is no significant long-lasting slope effect. When we look at the markets for each of the flavours, we see that while there is no significant impact on the tobacco market following the ban, there is a change in the distribution of menthol and exotic cigarettes. Following the ban, there is a 23.6% jump up in the sales of menthol cigarettes, while sales of exotic cigarettes drops by 222%. Turning to the slope effects, it can be seen that there is a significant long-term decline in the sales of menthol cigarettes following the ban by 1.7% after controlling for price increases. Referring back to the distribution of flavours in Figure 10, this may explain why the overall percentage of menthol remains same before and after the ban: even though there is an immediate increase in the sales of menthol cigarettes after the ban, this fizzles out over time and goes back to the pre-ban proportion. The regression results for exotic-flavoured cigarettes are statistically insignificant, with the exception of the trend in pre-ban sales which are seen to be declining even after controlling for price changes over time.

Table 18 shows the results of the same analysis for the little cigars market. It can be seen that the overall sales of little cigars jumps up by almost 62% following the flavour ban on cigarettes, as do those of each individual flavour category (although the results are not statistically significant for exotic flavour).

Table 18: Estimation results for the impact of the flavour ban on per capita little cigar sales – overall market and by flavour

	(1) Total Sales	(2) Tobacco	(3) Menthol	(4) Exotic
Year-quarter (trend)	-0.014	-0.00236	0.00804	-0.0385*
	(0.0118)	(0.0118)	(0.0244)	(0.0219)
Post-ban dummy (level effect)	0.618***	0.725***	1.015***	0.331
	(0.184)	(0.152)	(0.341)	(0.328)
Year-quarter*Post-ban (slope effect)	-0.0151	-0.0304***	-0.0367*	0.00379
	(0.0114)	(0.00918)	(0.0217)	(0.0204)
Own-price elasticity	-1.871***	-1.910***	-1.784***	-1.061***
	(0.176)	(0.189)	(0.399)	(0.257)
Cross-price elasticity	1.176**	0.930*	1.329	2.263***
	(0.458)	(0.485)	(0.959)	(0.812)
% of population covered by smoking ban inside bars	-0.00187*	-0.00167*	-0.00367	-0.00245
	(0.00108)	(0.00094)	(0.0024)	(0.00184)
Baseline	-5.215***	-5.170***	-8.318***	-9.355***
	(0.513)	(0.539)	(1.275)	(1.019)
Adjusted R^2	*0.8914*	*0.8852*	*0.7347*	*0.7051*
N	*2,040*	*2,040*	*2,040*	*2,040*
Number of markets	*51*	*51*	*51*	*51*

*[Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

Menthol-flavoured little cigars seem to be impacted the most, with sales jumping up by just under 102% after the ban. However, just like the case of menthol cigarettes, these effects get negated over time, with the overall sales declining over time. This holds true for tobacco- and menthol-flavoured little cigars, the sales of which decline at a rate of 3% and 3.7% respectively per quarter. The results are not statistically significant for the exotic flavour category. Interestingly, the trend coefficient is negative and statistically significant only for this category, showing that prior to the flavour ban, little cigar sales were declining at a rate of just under 4% per quarter even after the increasing prices were controlled for. Table 20 summarizes each of the pre- and post-ban slopes, along with the level effects.

The own- and cross-price elasticities – given by the coefficients of own- and cross-prices in the regressions – seem to fall within the range normally specified in the literature. The elasticities are summarized in Table 21, along with the statistical significance from the estimations. While the signs of all price-elasticities are as expected, the magnitudes of cross-price elasticities are smaller than typically found in the literature (Huang et al., 2018; Gammon et al., 2016; Da Pra and Arnade, 2009). Finally, as far as the smoke-free air laws are concerned, I find that greater coverage of a smoking ban within bars lowers the sales per capita across the board, with the exception of exotic-flavoured cigarettes.

Table 19: Estimation results for the impact of the descriptor ban on per capita cigarette sales – overall market and by strength

	(1) Total Sales	(2) ZUL	(3) Low	(4) Regular/Full
Year-quarter (trend)	0.0101	-0.00472	0.00524	0.0238***
	(0.00605)	(0.00632)	(0.0063)	(0.00603)
Post-ban dummy (level effect)	0.117	0.0535	0.214**	0.175*
	(0.087)	(0.0764)	(0.0801)	(0.0963)
Year-quarter*Post-ban (slope effect)	-0.0141**	-0.0104*	-0.0213***	-0.0161**
	(0.00589)	(0.00532)	(0.00568)	(0.0064)
Own-price elasticity	-1.218***	-1.251***	-1.255***	-1.272***
	(0.169)	(0.167)	(0.183)	(0.162)
% of population covered by smoking ban inside bars	-0.000776**	-0.000458	-0.000657**	-0.000984**
	(0.000332)	(0.000306)	(0.000308)	(0.000375)
Baseline	1.605***	-0.264	0.930***	0.650***
	(0.206)	(0.203)	(0.228)	(0.195)
Adjusted R^2	*0.9563*	*0.9671*	*0.9619*	*0.9445*
N	*2,040*	*2,040*	*2,040*	*2,040*
Number of markets	*51*	*51*	*51*	*51*

*[Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1]*

Table 19 shows the analysis of the impact of the descriptor ban on the per capita sales of cigarettes. The underlying pre-ban trend in per capita sales was a growth of 1% per quarter, but it is not statistically significant. Full-strength cigarettes are seen to have a positive and statistically significant growth in sales over time prior to the ban, at a rate of 2.4% per quarter. Contrary to expectations, following the ban, the sales of low- and full-strength products jumped up by 21.4% and 17.5% respectively. However, there was a permanent decline in the slope coefficient across the board, meaning that each individual strength category grew at a slower rate than before following the ban. So, while sales of full-strength cigarettes continued to grow, the ban just slowed down the rate of growth from 2.4% per quarter to 0.8% per quarter. For low-strength cigarettes, sales was increasing at a rate of 0.5% per quarter, but it declined to -1.6% per quarter following the ban. As for the analysis of the flavour ban, these results are summarized in Table 20.

Since the sales of full-strength cigarettes seem to be growing over time following the ban while those of the other two categories are declining, this explains the shift in the distribution of different strength categories, as seen in Figure 11. As for the flavour ban, Table 22 shows the own-price elasticity of demand of the total market as well as the different strength categories. These fall within the expected range as found in the literature, with full-strength cigarettes being the most responsive to changes in price.

5 Discussion

Immediately after it obtained regulatory authority over the tobacco market, the US FDA imposed bans on the sale of flavoured cigarettes and on the use of descriptors on packaging that imply reduced harm levels in cigarettes. While the impact of these bans have been studied before, none of the existing literature evaluates both the short- and long-term impacts. This chapter uses an interrupted time series model to evaluate the both the short- and the long-term impacts of the flavour and descriptor bans, taking into account any underlying trends in sales prior to these policies.

I find that immediately after the flavour ban came into effect, there was a 15% jump in the overall level of cigarette sales, but no long-lasting impact in the form of a change

Table 20: Summary of slope and level changes in sales of cigarettes and little cigars following the flavour and descriptor bans

	Flavour ban:	Total market	Tobacco	Menthol	Exotic
Cigarettes	Pre-ban growth rate	0.000365	-0.00332	0.00811	-0.386
	Post-ban growth rate	-0.00558	-0.00496	-0.00859	-0.198
	Jump in level (%)	0.152	0.105	0.236	-2.219
Little cigars	Pre-ban growth rate	-0.014	-0.00236	0.00804	-0.0385
	Post-ban growth rate	-0.0291	-0.03276	-0.02866	-0.03471
	Jump in level (%)	0.618	0.725	1.015	0.331
	Descriptor ban:	**Total market**	**ZUL**	**Low**	**Full**
Cigarettes	Pre-ban growth rate	0.0101	-0.00472	0.00524	0.0238
	Post-ban growth rate	-0.004	-0.01512	-0.01606	0.0077
	Jump in level (%)	0.117	0.0535	0.214	0.175

Pre- and post-ban growth rates are expressed as % per quarter
Post-ban growth rate is given by the sum of the pre-ban slope (coefficient of the time variable) and the change in slope following the ban (coefficient of the interaction term)

Table 21: Own- and cross-price elasticities of demand for cigarettes and little cigars

		Cigarettes		Little Cigars	
		Own	Cross	Own	Cross
By flavour	Total market	-1.388***	0.128**	-1.871***	1.176**
	Tobacco	-1.368***	0.106*	-1.910***	0.930*
	Menthol	-1.216***	0.195***	-1.784***	1.329
	Exotic	-0.134	2.098	-1.061***	2.263***
By strength	Total market	-1.235***	-	-	-
	ZUL	-1.248***	-	-	-
	Low	-1.256***	-	-	-
	Full	-1.305***	-	-	-

in growth of sales. Although I find no significant impact on the market for tobacco- and exotic-flavoured cigarettes, there is a significant impact on the menthol cigarettes market in both the short- and the long-term, with an immediate jump in sales by just under 24% and a long-term decline in the sales by 1.7% per quarter, even after price increases have been controlled for.

Along with the jump in the sales of menthol cigarettes, there is a jump in the sales of the overall market for little cigars, as well as for the individual tobacco- and menthol-flavoured little cigars markets. Much like the trend for menthol cigarettes, these impacts don't last in these markets, with sales declining over time to negative rates. I find no significant impact on the market for exotic-flavoured little cigars. This is likely to be related to the rising popularity of electronic cigarettes which became widely available and accepted right around the time the bans came into effect.

Moving on to the analysis of the descriptor ban, much of the literature suggests that the tobacco industry evaded the descriptor ban for the most part. I find that there is a significant impact on the low- and full-strength cigarettes markets, both in the short- and the long-term, but none on the market for zero- and ultra-low-strength cigarettes. Following the ban on descriptors, the sales of both low- and full-strength cigarettes jump up. Over time, the sales of both these categories started to decline at a significant rate, resulting in a permanent decline in the sales of low-strength cigarettes (negative slope) and a slower growth in the sales of full-strength ones (positive slope, but smaller than before the ban). My results add to the knowledge base by suggesting that the descriptor ban may have permanently slowed down sales of some cigarettes, therefore making the ban not entirely ineffective.

The findings of this chapter have significant policy implications: bans that target specific attributes such as flavour and nicotine strength can have significant lingering impacts, even if they are not immediately apparent. While a naïve look at the levels of little cigar sales shows that little cigar sales goes up immediately following the ban on flavoured cigarettes, over time the ban does have lingering effects on overall sales of both cigarettes and little cigars. Also, the descriptor bans may not have been quite as ineffective, because the sales of full-strength cigarette sales grow at a slower rate compared to pre-ban levels, while those of low-strength cigarettes decline permanently. An area of further exploration would be to include the impacts of the bans on the electronic cigarettes market, since these became wildly popular around the same time as the bans came into effect and there was little to no regulation of that market until much later. These results are timely and aim to inform the policy discourse as the FDA is discussing new bans on the sales of all flavoured tobacco products, including menthol cigarettes, and the regulation of nicotine levels in cigarettes.

Chapter V

CONCLUSION

Products can be thought of as a bundle of characteristics. When a smoker buys a cigarette, s/he chooses what comprises that bundle – the flavour, nicotine strength, the kind of packaging, whether the cigarette has a filter tip or not, etc. Once we begin to look at a product as a bundle of attributes rather than a single object, we can begin to tweak different attributes to affect the overall desirability of the product. The underlying theme of this dissertation is the targeting of tobacco control policy towards specific attributes of three different nicotine delivery devices – electronic cigarettes (e-cigarettes), traditional cigarettes and little cigars.

In the second chapter, I break down disposable and rechargeable e-cigarettes into individual attributes and estimate users' valuation of attributes in exact dollar amounts. For disposable e-cigarettes, I find that users value exotic flavour (flavours other than menthol) the most, with tobacco flavour being the second most-preferred. Preferences are similar for buyers of rechargeable starter kits, but for vapers who buy refills for rechargeable e-cigarettes, I find that both exotic and menthol flavours are valued more than tobacco. Next, I look at the valuation of nicotine strength. I find that vapers who use both disposables and rechargeable starter kits value low strength e-cigarettes the most. However, once again, the results are different for buyers of individual refills, who value full-strength the most. Finally, for rechargeables, I estimate the valuation of other features such as extra refill cartridges, batteries and chargers. I find that vapers value all three of these positively and would pay to have them included.

In the third chapter, I do the same exercise for cigarettes and little cigars, which are very similar by design and in use. Because a lot more information about particulars of cigarettes is available compared to little cigars or e-cigarettes, I am able to break down a cigarette into five different attributes – flavour, nicotine strength, size/length, type of packaging and inclusion of a filter tip. I find that smokers are willing to pay a positive premium for menthol cigarettes over tobacco-flavoured ones. They also pay a premium for low-nicotine cigarettes, but value cigarettes of the regular 80-90mm length more highly than either shorter or longer variants. Smokers are willing to pay a little extra to have a non filter tip cigarette, as well as to buy an individual pack rather than a carton of multiple packs. For little cigars, I estimate the valuation of flavour and filter tip only, and find that smokers value tobacco-flavoured little cigars more than any other flavour, and non filter tips more than filter tips. I also conduct this analysis by store type – food, drug and mass (FDM) stores like K-Mart or Walgreens, versus convenience stores such as 7-Eleven or Shell. I find that valuation varies according to store type, suggesting differences in the demographics of patrons of different store types.

Estimating users' valuation of different attributes of these three products goes towards informing future policy. Knowing which attributes are most highly valued will contribute towards more effective policy-making. It will also help policymakers get an estimate of how smokers or vapers may react to specific interventions. Finally, it can contribute towards tax policy by giving a measure of just how large the magnitude of a tax change should be. To the best of my knowledge, this is the first time that users' willingness-to-pay (WTP) for different attributes were estimated using the revealed preferences method of hedonic pricing.

Having formed a sense of vapers' and smokers' valuation of different attributes, I move on to evaluating the impact of two policies implemented by the Food and Drug Administration (FDA) that target specific attributes – a ban on the sales of flavoured cigarettes, implemented in 2009, and a ban on the use of any descriptors on cigarette packaging that may imply reduced harm, implemented in 2010. I use an interrupted time series model that estimates both the short-term and long-term impacts of the two policy interventions. I find that the flavour ban had no significant impact on overall cigarette sales or on the sale of tobacco-flavoured cigarettes in particular. However, immediately following the ban, the sales of menthol cigarettes shot up while that of exotic cigarettes dropped. This effect on menthol cigarette sales is not long-lasting though, as sales decline over time. The flavour ban did not extend to the little cigars market, and I find the impact on this market to be similar to that on menthol cigarettes. Sales of tobacco and menthol flavour categories shoot up immediately following the ban on exotic cigarettes, but the effects do not linger as sales begin to decline over time. This is most likely due to one of two factors: firstly, tobacco control policy has been getting more and more stringent, so the decline may be the result of some other policies; and more importantly, the e-cigarettes market was flourishing rapidly in the period following the ban, so much of the substitution was possibly towards e-cigarettes than little cigars or menthol cigarettes. With respect to the descriptor ban, I find an interesting result showing unintended consequences. While there is no impact on overall cigarette sales or on that of ultralow nicotine strength cigarettes, sales of low- and full-strength cigarette seem to increase following the ban. Their rate of growth of sales does slow down following the ban, causing a decline in the sales of low-strength cigarettes and a positive, but slower, growth in sales of full-strength ones in the long-term.

This research is timely because the FDA is now considering further flavour bans on e-cigarettes and has proposed an extension of the flavour ban on cigarettes to include menthol cigarettes as well. Furthermore, there are talks of regulating the nicotine levels in cigarettes. Flavoured and low-strength products have long been proven to be associated with use by youth and novice users. While the flavour and descriptor bans on cigarettes are a step in the right direction, their effectiveness is diluted by the continued availability in the little cigars and electronic cigarettes market. E-cigarettes, which were initially marketed as smoking cessation devices and have been shown to be safer than conventional cigarettes, are a beneficial tool for curbing the tobacco epidemic as long as they are used by current smokers. However, the rapid and unprecedented growth seen in the e-cigarette market shows that many non-smokers are turning to vaping, leading to concerns both over e-cigarettes being a gateway into smoking as well as the risks associated with vaping itself, much of which are unknown at this point in time. The decades of work in tobacco control are at a risk of being less effective and a whole new generation led into nicotine dependence. Under these circumstances, the regulatory policy environment has to respond quickly in an attempt to ensure that tobacco and nicotine dependence can be kept in check.

Appendices

APPENDIX A: SUMMARY OF STATE REGULATIONS ON E-CIGARETTE PRODUCTS

Level	Status	Year*	Regulation Types†	Legal Citations of Statutes, Acts, Rules, and Bills
Federal: DHHS, FDA	P	2011	UPS (in aircrafts on all domestic and international flights to or from the US) .	49 USC §41706, 41702; 14 CFR Part 252; Docket No. DOT-OST-2011-0044
Federal: DOT	P	2014	SBM MA P	21 CFR Parts 1100, 1140, 1143; Docket No. FDA-2014-N-0189
AL	E	2013	SBM-UPM	Ala. Code §28-11-2
AZ	E	2010	SBM	Ariz. Rev. Stat. Ann. §13-3622
AR	E	2013	SBM	Ark. Stat. Ann. §5-27-233
	E	2013	UPL (school district property)	Ark. Code. Ann. §§4-16-101, 6-21-609
CA	E	2011	SBM	Cal. Code §119405
	P	2013	UPL (public buildings, schools, and day care center) MAM (restrict television advertisements and prohibit marketing to minors)	Cal. SB 648
CO	E	2011	SBM	Colo. Rev. Stat. §§18-13-121, 24-35-501 et seq., 25-14-30, 22-32-109, 25-14-204
	E	2011	UPL (school property, unless approved by FDA as cessation devices)	Colo. Code Regs. §2509-8

CT	S	2014	SBM (Effective 10/01/2014)	Conn. SB 24, Pub. Act No. 14-76
DC	E	2013	UPL (public libraries)	19-810 D.C. Code Mun. Regs §810.5
	E	2013	UPL (playgrounds, public recreational facilities and bus stops, in parity with the District of Columbia Smoking Restriction Act of 1979)	D.C. Law 3-22; D.C. Code Ann. §§7-1701 et seq.
DE	E	2013	UPL (state workplace property, indoor and outdoor)	State of Delaware Tobacco-Free Workplace Policy
	S	2014	SBM (signed by governor 06/12/2014)	Del. HB 241
	P	2014	UPC (in parity with Delaware's 2002 Clean Indoor Air Act)	Del. HB 309
FL	E	2014	SBM	Fl. Rev. Stat. §569.14, §322.056; Fl. Stat. §877.112
GA	E	2014	SBM	Georgia HB 251, Georgia §16-12-171.1
HI	E	2013	SBM	Haw. Rev. Stat. §709-908
	E	2014	UPL (Department of Health property)	Haw. Department of Health, Intra-Departmental Directives, no. 13-03.01 et seq.
	P	2013	UPC (in parity with Hawaii's anti-smoking statute, including workplaces and public places)	Haw. SB 2495
	P	2013	MAM (requires that e-cigarettes be stored for sale behind a counter, advertisements to be placed four feet off the floor)	Haw. SB 652
	P	2014	L	Haw. SB 2495
ID	E	2012	SBM-UPM	Idaho Code Ann. §39-5702 et seq.

IL	E	2013	SBM	Ill. Stat. Ann 720 ILCS 675/1.5
	S	2015	P (effective 01/01/2015)	Ill. HB 5689, III. Pub. Act 098-1021
IN	E	2013	SBM-UPM	Ind. Code §§35-46-1-1.5, 35-46-1-10, 35-46-1-10.2, 7.1-3-18.5-8
	P	2014	T (OTP rate of 24% of wholesale)	Ind. HB 1174
IA	S	2014	SBM (signed by governor 05/23/2014, effective 07/01/2014)	Iowa HB 2109
	S	2014	L (signed by governor 05/23/2014, effective 07/01/2014)	Iowa HB 2109
KS	E	2012	SBM-UPM	Kan. Stat. Ann. §§79-3301, 3303, 3321
	E	2010	UPL (Department of Corrections property and grounds, by both employees and inmates)	Kan. Admin. Regs. §123-2-111
KY	S	2014	SBM-UPM (signed by governor 04/10/2014)	Ken. SB 109, Ken. Rev. Stat. §§438.30-438.340, 438.350
	P	2014	T (defines e-cigarettes as tobacco products, 15% OTP tax)	Ken. HB 319
LA	S	2014	SBM-UPM (signed by governor 05/29/2014)	Lou. SB 12, Lou. Rev. Stat. §§14 :91.8, 26 :910, 910.1(A), 14 :91.6(B)(6)(7), 26 :901(28)
MD	E	2011	UPL (MARC commuter rail system trains)	Md. Code Regs. 13A.02.04.01-.07
	E	2012	SBM	Md. Code Ann. Health-Gen. §24-305
MA	P	2013	UPL (public school grounds, public areas and workplaces) SBM	Mass. HB 3726
MI	S	2013	SBM-UPM	Mich. HB 4997

MN	E	2010	SBM	Minn. Stat. §609.6855
	E	2013	T (95% of the wholesale cost of any product containing or derived from tobacco)	Minn. Stat. §297F.01, subd. 19
	S	2014	UPL (agency building, state colleges and universities, day care facilities, health care facilities and clinics) (signed by governor 05/21/2014) MA (bans retail sales of the products from mail kiosks, requires them to be kept behind store counter) P	Minn. HB 2402
MS	E	2013	SBM	Miss. Code Ann. §97-32-51
NE	S	2014	SBM-UPM (effective 04/09/2014)	Neb. LB 863
NH	E	2010	SBM UPL (public educational facilities)	N.H. Rev. Stat. Ann. §126-K:2 et seq.
NJ	E	2010	SBM	N.J. Stat. Ann. §2A :170-51.4
	E	2010	UPC (workplaces and indoor public areas, in parity with New Jersey's Smoke-Free Air Act of 2006)	N.J. Stat Ann §§26-3D-55 et seq., 2C :33-13.1, 26 :3A2-20.1, N.J. Admin. Code §§10 :128-4.6, 10 :122C-7.2
NY	E	2011	SBM	N.Y. Code §1399-aa, §1399-cc
	P	2013	UPC (public areas including bars, restaurants, offices, and other public indoor spaces, in parity with New York State's Clean Indoor Air Act)	N.Y. AB 8178

	P	2014	T (classifies e-cigarettes as tobacco products; 75% excise tax on e-cigarettes)	N.Y. AB 8594
	P	2014	UPL (certain indoor areas)	N.Y. AB 10182
NC	E	2013	SBM	N.C. Gen. Stat. Ann. §14-313
	S	2014	T (5 cents per milliliter tax on e-cigarette liquid) (signed by governor on 05/29/2014)	N.C. HB 1050
ND	E	2012	UPC (public areas, including non-hospitality workplaces, restaurants, bars, and gambling facilities, in accordance with North Dakota's smoke-free law)	N.D. Cent. Code §23-12-09
OH	S	2014	SBM-UPM (signed by governor 03/04/2014, effective 08/02/2014)	Ohio HB 144, Ohio Rev. Code §§2151.87, 2927.02, 2927.021, and 2927.022
OK	E	2014	UPL (state properties, including Department of Corrections facilities, vehicles, and grounds)	Okla. Exec. Order No. 2013-43, 31, Okla. Reg. 340
	S	2014	SBM-UPM (Effective 11/01/2014)	Okla. SB 1602
OR	E	2009	SB (Department of Justice settlement prohibits sale of e-cigarettes until they are FDA approved, or until court rules FDA cannot regulate them and scientific research can prove them safe)	Or. Judicial order
	E	2013	UPL (State agency buildings and grounds, university-owned or controlled properties)	Or. Admin. R. 571-050-0005, 576-040-0010—0015, 576-015-0020; Exec. Order No. 12-13, 51 No.9 Or. Bull. 4
RI	S	2014	SBM-UPM (signed by governor 06/30/2014, effective 07/01/2014)	R.I. HB 7021, R.I. Rev. Stat. §§11-9-13 et seq., 11-9-14, Chap. 11-9

			L (signed by governor 06/30/2014, effective 01/01/2014)	
SC	E	2013	SBM	S.C. Code Ann. §§16-17-500 et seq.
SD	E	2014	SBM-UPM	S.D. §§34-46-2 et seq. Chap 34-46
	E	2014	UPL (Department of Corrections facilities and on grounds thereof, by both employees and inmates)	S.D. Department of Corrections Policy, 1.3.C.7 – Tobacco Products and Electronic Cigarettes – Use and Possession
TN	E	2011	SBM-UPM	Tenn. Code Ann. §39-17-1501 et seq.
TX	E	2013	UPL (to be eligible to receive CPRIT funding, a CPRIT-funded entity shall certify that the entity has adopted and enforces Tobacco-Free Workplace policy, including e-cigarettes)	Tex. Admin. Code §703.20
UT	E	2010	SBM-UPM	Ut. Code Ann. §§77-39-101, 76-8-311.3, 76-10-101 et seq, 53A-11-908, 26-38-1 et seq., 58-37-8, 10-8-41.6, 17-50-333, 41-6a-1717
	E	2012	UPC (non-hospitality workplaces, restaurants, bars, and gambling facilities, in parity with Utah Indoor Clean Air Act)	Ut. Admin. Code r. 392-510-2—17
VT	E	2012	SBM-UPM	Vt. Stat. Ann. Tit. 7, §1001 et seq.
	E	2014	UPL (school grounds and at child care facilities, both indoors and outdoors)	Vt. Act No. 135 (H. 217)
	E	2015	P (effective 01/01/2015)	Vt. Act No. 0188
VA	E	2014	SBM-UPM	Vir. §18.2-371.2 Chapter 357

	E	2014	UPL (school property)	Vir. §22.1-79.5 – Chapter 326
WA	E	2013	SBM-UPM	Wash. Rev. Code §26.28.080
	E	2014	UPL (community colleges and universities)	Wash. Admin. Code §§132Q-30-231, 132L-136-010, 132E-120-410, 172-122-310
WV	E	2014	SBM-UPM	W.V. Code Ann. §16-9A-2
WI	E	2012	SBM	Wis. Stat. Ann. §134.66
WY	E	2013	SBM-UPM	Wyo. Stat. §14-3-301(a)(i)

[Source: Tremblay et al (2015)]

*In the case of planned regulation, year of introduction to legislature. In the case of an enacted regulation or signed regulation, year of enactment.

† Regulations explicitly addressing e-cigarettes, electronic smoking devices, electronic nicotine delivery devices and vapor products (not nicotine containing or tobacco-derived products, unless explicitly including e-cigarettes in these products).

Abbreviations: E = enacted regulation, P = planned regulation (bill or proposed rule), S = regulation (bill) signed into law, but not yet codified, UPC = use prohibited comprehensively in indoor public places, SBM = Sale to minors ban, UPL = use prohibited in limited venues, UPM = use by minors prohibited.

State Abbreviations: AZ = Arizona, AL = Alabama, AR = Arkansas, CA = California, CO = Colorado, CT = Connecticut, DC = District of Columbia, DE = Delaware, FL = Florida, GA = Georgia, HI = Hawaii, ID = Idaho, IL = Illinois, IA = Iowa, IN = Indiana, KS = Kansas, KY = Kentucky, LA = Louisiana, MA = Massachusetts, MD = Maryland, MI = Michigan, MN = Minnesota, MS = Mississippi, NE = Nebraska, NH = New Hampshire, NJ = New Jersey, New Mexico, NY = New York, NC = North Carolina, ND = North Dakota, OH = Ohio, OK = Oklahoma, OR = Oregon, Pennsylvania, RI = Rhode Island, SC = South Carolina, SD = South Dakota, TN = Tennessee, TX = Texas, UT = Utah, VT = Vermont, VA = Virginia, WA = Washington, WV = West Virginia, WI = Wisconsin, WY = Wyoming.

APPENDIX B: CALCULATION OF FULL IMPACTS OF FLAVOUR AND STRENGTH INTERACTION TERMS

From Equation 6,

$logprice_{ijkl} = \alpha_0 + \alpha_{11} menthol_i + \alpha_{12} exotic_i + \alpha_{21} ZUL_i + \alpha_{22} low_i +$

$\alpha_{31}(menthol \cdot ZUL)_i + \alpha_{32}(menthol \cdot lowL)_i + \alpha_{33}(exotic \cdot ZUL)_i +$

$\alpha_{34}(exotic \cdot low)_i$

For the reference flavour category of tobacco, the equation boils down to

$$logprice_{ijkl} = \alpha_0 + \alpha_{21} ZUL_i + \alpha_{22} low_i$$

Thus, the impact of a full-strength tobacco-flavoured product on *logprice* is α_0 because ZUL and low both take a value of 0.

Similarly, the impact of a ZUL-strength tobacco-flavoured product on *logprice* is $\alpha_0 + \alpha_{21}$ as $ZUL = 1$ and $low = 0$. The coefficient α_{21} therefore shows the impact of a ZUL-strength tobacco-flavoured product relative to that of a full-strength tobacco-flavoured product. By the same logic, the coefficient α_{22} shows the impact of a low-strength tobacco-flavoured product relative to that of a full-strength tobacco-flavoured one.

Turning now to menthol-flavoured products, Equation (6) boils down to

$$logprice_{ijkl} = \alpha_0 + \alpha_{11} menthol_i + \alpha_{21} ZUL_i + \alpha_{22} low_i + \alpha_{31}(menthol \cdot ZUL)_i +$$
$$\alpha_{32}(menthol \cdot low)_i$$

The sum of the coefficients $\alpha_0 + \alpha_{11}$ represents the impact of a full-strength menthol-flavoured product on price, while that of a ZUL-strength menthol-flavoured one is given by $(\alpha_0 + \alpha_{11}) + (\alpha_{21} + \alpha_{31})$ as $ZUL = 1$ and $low = 0$, and that of a low-strength menthol-flavoured one is given by $(\alpha_0 + \alpha_{11}) + (\alpha_{22} + \alpha_{32})$ as $ZUL = 1$ and $low = 0$. The following table shows the impacts of each flavour by strength:

	Tobacco	Menthol	Exotic
Full	α_0	$\alpha_0 + \alpha_{11}$	$\alpha_0 + \alpha_{12}$
ZUL	$\alpha_0 + \alpha_{21}$	$\alpha_0 + \alpha_{11} + \alpha_{21} + \alpha_{31}$	$\alpha_0 + \alpha_{12} + \alpha_{21} + \alpha_{33}$
Low	$\alpha_0 + \alpha_{22}$	$\alpha_0 + \alpha_{11} + \alpha_{22} + \alpha_{32}$	$\alpha_0 + \alpha_{12} + \alpha_{22} + \alpha_{34}$

Now, if we want to compare a full-strength menthol product to a full-strength tobacco product, the impact is given by the difference between the coefficients of full-strength tobacco- and menthol-flavoured products, i.e. $\alpha_0 + \alpha_{11} - \alpha_0 = \alpha_{11}$. Similarly, if we were to compare a ZUL-strength menthol product to a ZUL-strength tobacco product, the impact is again given by the difference between the two, i.e. $\alpha_0 + \alpha_{11} + \alpha_{21} + \alpha_{31} - \alpha_0 - \alpha_{21} = \alpha_{11} + \alpha_{31}$. The following table shows the impacts of each flavour profile relative to tobacco-flavoured products of the same strength:

	Menthol	Exotic
Full	α_{11}	α_{12}
ZUL	$\alpha_{11} + \alpha_{31}$	$\alpha_{12} + \alpha_{33}$
Low	$\alpha_{11} + \alpha_{32}$	$\alpha_{12} + \alpha_{34}$

The same exercise can be done for the different strength profiles. For full-strength products, Equation (6) boils down to $logprice = \alpha_0 + \alpha_{11} menthol + \alpha_{12}$ exotic, while for ZUL- and low-strength products it is $logprice = \alpha_0 + \alpha_{11} menthol + \alpha_{12} exotic + \alpha_{21} ZUL + \alpha_{31}(menthol * ZUL) + \alpha_{33}(exotic * ZUL)$, and $logprice = \alpha_0 + \alpha_{11} menthol + \alpha_{12} exotic + \alpha_{22} low + \alpha_{32}(menthol * low) + \alpha_{31}(exotic * low)$ respectively.

The coefficients representing full impacts of each strength profile for each flavour are shown in the following table:

	Full	ZUL	Low
Tobacco	α_0	$\alpha_0 + \alpha_{21}$	$\alpha_0 + \alpha_{22}$
Menthol	$\alpha_0 + \alpha_{11}$	$\alpha_0 + \alpha_{21} + \alpha_{11} + \alpha_{31}$	$\alpha_0 + \alpha_{22} + \alpha_{11} + \alpha_{32}$
Exotic	$\alpha_0 + \alpha_{12}$	$\alpha_0 + \alpha_{21} + \alpha_{12} + \alpha_{33}$	$\alpha_0 + \alpha_{22} + \alpha_{12} + \alpha_{34}$

The next table shows how ZUL- and low-strength products compare to full-strength ones for each flavour profile:

	ZUL	Low
Tobacco	α_{21}	α_{22}
Menthol	$\alpha_{21} + \alpha_{31}$	$\alpha_{22} + \alpha_{32}$
Exotic	$\alpha_{21} + \alpha_{33}$	$\alpha_{22} + \alpha_{34}$

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