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Do e-cigarette sales reduce the demand for nicotine replacement therapy (NRT) products in the US? Evidence from the retail sales data

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Abstract

Despite mixed evidence, many smokers use e-cigarettes to quit smoking. With the substantial growth of e-cigarette sales in recent years, it is important to understand how it may affect FDA-approved nicotine replacement therapy (NRT) products in the US. This study aims to investigate the impact of e-cigarette prices and TV advertising on the demand for NRT products. Quarterly (2010 Q1 – 2017 Q4) retail sales and price data of e-cigarettes and NRT gum and patch, compiled from Nielsen retail store scanner database, were linked with contemporaneous quarterly television rating data for e-cigarettes and NRT products, compiled from Kantar Media, using

state and county identifier. Market, year, and quarter fixed effects models were used to estimate the impact of NRT price and TV advertising, as well as e-cigarette price and TV advertising, on the demand for NRT gum and patch. NRT gum price elasticity was estimated to be -0.91. Higher patch price was found to decrease gum sales (cross-price elasticity -0.96). Higher e-cigarette prices were found to decrease NRT gum sales. Higher cigarette prices were found to increase NRT gum sales. NRT patch price elasticity was estimated to be -2.05. Higher gum price was found to increase patch sales (cross-price elasticity 0.97). E-cigarette TV advertisement was positively associated with NRT gum sales. NRT gum appeared to be complements for e-cigarettes. Recent growth in e-cigarette sales may have increased the demand for NRT gum. More studies are needed to understand the differential behavioral patterns of NRT gum users and NRT patch users.

1. Introduction

Smoking is one of the leading preventable causes of mortality and morbidity, responsible for about half a million deaths annually in the US (US Department of Health and Human Services, 2014). Smoking leads to more than \$300 billion economic loss every year in the US, including \$170 billion on direct medical care and \$150 billion on lost productivity (US Department of Health and Human Services, 2014; Xu et al., 2015). In 2018, about 55% of adult smokers in the US reported that they had made at least one quit attempt in the past 12 months, however, only 7.5% quit successfully (US Department of Health and Human Services, 2020). There are a variety of behavioral and medical interventions to help smokers quit, including individual or group counseling programs, prescription medications, and FDA-approved over-the-counter nicotine replacement therapy (NRT) products (Stead et al., 2016). NRT products deliver nicotine to reduce smokers' cravings for smoking but do not contain most toxins found in combustible tobacco products (West and Shiffman, 2001). They help smokers remain abstinent by reducing the withdrawal symptoms that smokers usually experience while attempting to quit (Hartmann-Boyce et al., 2018). There are a variety of NRT products, including chewing gum, skin patch, lozenges, tablets, inhalators, and spray. Evidence has demonstrated that NRT products are effective in aiding smoking cessation (Hartmann-Boyce et al., 2018).

In the past decade, the US tobacco and nicotine market has experienced substantial changes due to the emergence of e-cigarettes (Huang et al., 2019; US Department of Health and Human Services, 2014). E-cigarettes refer to “any device with a heating element that produces an aerosol from a liquid the users can inhale” (National Academies of Sciences and Medicine, 2018). E-cigarettes come in many different shapes and sizes. Depending on whether one is able to refill or replace e-liquids and whether a device has a rechargeable power source, e-cigarettes can be grouped into two broad mutually exclusive categories: single use disposable e-cigarettes and reusable e-cigarettes (National Academies of Sciences and Medicine, 2018). Regulations towards e-cigarettes vary by country (Klein et al., 2020). For example, although the US FDA has not approved e-cigarettes as smoking cessation products, other countries, such as the UK, New Zealand, and Canada have taken more pragmatic stances towards them, with their public health authorities encouraging smokers to switch to e-cigarettes (Klein et al., 2020).

Scientific evidence on the effectiveness of e-cigarettes in promoting smoking cessation is rapidly growing. Several randomized controlled trials (RCT) found that e-cigarettes are more or as effective as NRT products in helping smoking cessation (Bullen et al., 2013; Carpenter et al., 2017; Hajek et al., 2019; Hatsukami et al., 2020; Holliday et al., 2019; Walker et al., 2020). Evidence of e-cigarette’s effectiveness in aiding smoking cessation from real-world studies are mixed (Beard et al., 2016, 2020; El Dib et al., 2017; Kalkhoran and Glantz, 2016; Weaver et al., 2016; Zhu et al., 2017). However, some recent population-level studies suggest that e-cigarettes increased smoking cessation (Abraham et al., 2018; Beard et al., 2020; Zhu et al., 2017). The most up-to-date Cochrane systematic review also suggested “moderate-certainty evidence” that e-cigarettes with nicotine could increase quit rates compared to NRT products (Hartmann-Boyce et al., 2020). Research on the health risks of e-cigarettes is also rapidly growing. Although the long-term health consequences of e-cigarette use are largely unknown, some recent evidence shows e-cigarette use was associated with cellular malfunction, short-term lung damage, and an elevated risk of cardiovascular disease (Glantz and Bareham, 2018; National Academies of Sciences and Medicine, 2018). Nevertheless, overall, e-cigarettes appear to produce fewer toxins compared with combustible cigarettes (National Academies of Sciences and Medicine, 2018).

E-cigarettes emerged in the US market around 2006/07, the awareness and use of e-cigarettes have grown rapidly since then, particularly among adolescents and young adults (US Department of Health and Human Services, 2014). As the technology improves, newer generations of e-cigarette products have become more discreet, aesthetically appealing, and can deliver a large amount of nicotine at a speed comparable to combusted cigarettes (Grana et al., 2014). The growth of e-cigarettes was driven, in part, by tobacco and vaping industry's aggressive marketing (Huang et al., 2019; Kornfield et al., 2015). Unlike cigarette advertisements, which have long been banned from airing on television or radio (Eckard Jr, 1991), e-cigarette advertising, until very recent FDA's enforcement actions, was largely unregulated. Social media played an important role in promoting e-cigarettes in recent years, however, TV remains one of the primary media channels on which e-cigarette advertisers reach their audience (Seidenberg et al., 2017). Previous studies showed that from 2011 to 2013, exposure to e-cigarette advertisements on TV increased more than 250% for youth and more than 300% for young adults (Duke et al., 2014). Evidence from several randomized control trials showed that youth who were exposed to e-cigarette TV advertisements exhibited stronger intentions to use and more positive attitude toward e-cigarettes (Duke et al., 2015; Farrelly et al., 2015). In addition to advertising, prices also play an important role in determining the demand for e-cigarettes. Previous studies, for example, have shown that the declining in e-cigarette costs over time increased sales of e-cigarettes in the US (Huang et al., 2018; Huang et al., 2014).

To help quit smoking is the most commonly reported reason for using e-cigarettes among US adult smokers (Patel et al., 2016). The rapid growth of e-cigarette sales in recent years likely diverted some smokers from using NRT products for quitting. Unfortunately, despite its important policy and public health implications, research on this topic is surprisingly scarce. Two studies using self-reported survey data from England found that e-cigarette use was not associated with the decline of overall NRT products use, however, e-cigarette use was found to be negatively associated with use of NRT products obtained from prescription (Beard et al., 2015; Beard et al., 2016). One study utilized e-cigarette sales and advertising data in the US and found that e-cigarette advertising was negatively associated with NRT sales (Tuchman, 2019). Unfortunately, this study data ended in 2015, the year when Juul e-cigarettes entered the US market and subsequently transformed the e-cigarette market. Our study contributes to this nascent research by

extending the analysis to include 8 years of e-cigarette and NRT sales data from 2010 to 2017. Importantly, our analyses take into account key determinants of demand for e-cigarettes and NRT products, including their own prices, the price of cigarettes, and the televised advertising for e-cigarettes and NRT products.

2. Methods

2.1. Data

Quarterly sales and price data for reusable and disposable e-cigarettes, NRT gum and patch, and cigarettes were compiled from the Nielsen (The Nielsen Company, US, LLC) Retail Store (NRS) database from 2010 to 2017. The NRS data included UPC (universal product code)-level sales and price data for e-cigarettes and NRT products sold in 52 Nielsen-defined retail markets. A Nielsen market consists of a group of geographically adjacent counties centered around a major city. Those 52 retail markets cover 44 states and the District of Columbia in the continental US. NRS data were collected from Nielsen participating retailers, which include convenience stores, food, drug, and mass stores.

E-cigarette, NRT gum and patch TV advertising data from 2010 to 2017 were compiled from the StrategyTM of Kantar Media using keyword searches. Product-level TV advertising was measured by TV ratings, the gross rating points (GRPs), which is the multiplication of the percentage of households covered and the average watched times of these households for a specific product advertisement within a specific timeframe (quarterly) and in a given designated media market (DMA). Our ratings data cover 210 DMAs in the US. Like Nielsen retail markets, each DMA also consists of a number of counties, however, DMAs are smaller than Nielsen retail markets. This study did not involve human subjects and was exempted from IRB review.

2.2. Measurements

2.2.1 Per smoker NRT sales volume:

Two main categories of NRT products, gum and patch, were analyzed. These two categories represent over 70% of total NRT sales in the NRS data. Sales volumes of gum (in pieces) and patch (in patches) were constructed by aggregating sales units (first converted to pieces for gum and patches for patch) in a given year, quarter and Nielsen retail market using UPC level sales data. Total

sales volume in a given year, quarter and retail market was subsequently divided by the estimated number of smokers in that specific year, quarter and retail market to obtain per smoker sales volume, to account for high sales volume in a market due to its large smoking population size. The population for each Nielsen retail market was constructed by summing up the population of all counties comprising this market. Quarterly county population data was extrapolated using the annual county population data, measured at the mid-point of each year, from the US Census Bureau (US Census Bureau, 2019). The smoking prevalence for each Nielsen retail market was based on prevalence data from the Behavioral Risk Factor Surveillance System (BRFSS) (US Centers for Disease Control and Prevention, 2019, 2020).

2.2.2 Inflation-adjusted NRT gum and patch, e-cigarette and cigarette prices:

E-cigarette prices were constructed separately for reusable and disposable e-cigarettes. Specifically, the average disposable e-cigarette price for a given year, quarter and retail market was calculated by dividing the total disposable e-cigarette sales dollars by the total disposable e-cigarette sales volume of that year, quarter and retail market. Prices were inflated adjusted using the consumer price index (CPI), obtained from the Bureau of Labor Statistics (Bureau of Labor Statistics, 2019). Prices for reusable e-cigarette, NRT gum and patch, and cigarette were constructed using the same method.

2.2.3. E-cigarette and NRT gum and patch television advertisement ratings:

DMA level household GRPs for e-cigarette TV advertisement, NRT gum and patch advertisement were retrieved from Kantar Media using a comprehensive list of keywords that include both generic product types (e.g. electronic cigarettes, vaping, NRT) and specific brand names (e.g. Njoy, Juul, Nicorette, Nicoderm). E-cigarette advertisement TV ratings for a given year, quarter and DMA was calculated by summing up the GRPs for all e-cigarette advertisements in that year, quarter and DMA. The same method was used to construct the TV ratings for NRT gum advertisement and patch advertisement. Product specific DMA level ratings were then linked with each Nielsen retail market using state and county identifiers, as well as year/quarter indicators. A product specific Nielsen retail market level rating was then calculated using the DMA population weighted average ratings for all DMAs contained in the same retail

market. TV ratings were further transformed to the natural log form for the ease of presentation and interpretation. TV ratings less than one, including zero, were recoded to 1 before regression analyses.

2.3. Statistical analyses

All analyses were conducted using Stata version 15. Fixed-effect models were used to estimate the own- and cross-price elasticities, and the impact of advertising on sales. Market fixed effects accounted for time-invariant retail market specific factors that influence NRT sales. Year fixed effects accounted for year specific factors that influence NRT sales. Quarter fixed effects accounted for seasonality in NRT sales. Heteroscedasticity-robust standard errors were reported to account for the different variance across observations (Cameron et al., 2011).

Models

$$\text{Model 1: } \ln(\text{NRT Sales})_{m,y,q} = \beta_0 + \beta_1 \ln(\text{NRT Prices})_{m,y,q} + M + Y + Q + \varepsilon_{m,y,q}$$

The dependent variable is the natural log of per smoker sales volume of NRT gum (or patch) sold in each market/year/quarter. The key independent variable is the natural log of inflation-adjusted average prices of NRT gum (or patch) sold in the same market/year/quarter. The log transformation of both sales volume and sales price enable us to obtain the estimates of own price elasticities directly from $\hat{\beta}_1$. M, Y, and Q are market, year, quarter fixed effects, respectively.

To estimate cross price impact and the impact of advertising on NRT sales, we sequentially added the following variables to Model 1: gum (patch) TV ratings (Model 2), patch (gum) price (Model 3), cigarette and e-cigarette prices (Model 4 and 5), patch (gum) TV ratings (Models 6-8), and e-cigarette TV ratings (Model 9 and 10). Because year fixed effects and quarter fixed effects alone explained a large proportion of variations of reusable e-cigarette prices ($r^2=0.63$) and disposable e-cigarettes ($r^2=0.53$), in the models (Model 4-10) including e-cigarette prices, only market fixed effects were added. In Models 1-3, a three-way fixed effects model (market, year, and quarter) was used.

3. Results

Quarterly NRT and e-cigarette prices and sales data are presented in **Figure 1**. From 2010 Q1 to 2017 Q4, the average inflation adjusted NRT gum price decreased from \$0.39/per piece to \$0.36/per piece, and gum sales increased from about 189 million pieces to about 232 million pieces. During the same period, patch prices decreased from \$3.07/per patch to \$2.77/per patch. Patch sales showed strong seasonality, with significantly higher sales during the first quarters, and lower sales in the third/fourth quarters. Average reusable e-cigarette prices decreased from \$38.11 to \$13.53 from 2010 to 2017, and not surprisingly, its quarterly sales increased substantially from a merely a few thousands to more than 6 million pieces by the end of 2017. Average disposable e-cigarette price decreased from \$17.68 to \$7.53 during the same period. Its quarterly sales increased exponentially between 2010 and 2014 (from about 30,000 in 2010 to about 11 million in early 2014), but have since declined to approximately 4 million pieces per quarter by the end of 2017.

Descriptive statistics for key variables in our analysis are presented in **Table 1**. Average per smoker quarterly NRT gum and patch sales was 1.55 and 0.07 pieces in the study period. Average inflation-adjusted retail price for gum and patch was \$0.38 per piece and \$2.99 per patch, respectively. Average reusable e-cigarette price was \$20.31, significantly higher than that of disposable e-cigarettes (\$9.33). On average, patch TV advertisement GRPs were higher than those for gum, which in turn higher than those for e-cigarettes. This indicates higher amount of patch TV ads, compared with those for NRT gum and e-cigarettes.

Results from the fixed effects models for NRT gum sales were presented in **Table 2**. The estimated own-price elasticity was -0.91 (model 1), indicating that a 10% increase in gum price would result in an 9.1% decrease in gum sales. The estimated cross price elasticity with regard to patch was estimated to be -0.96 (model 3), indicating that a 10% increase in patch price would result in an 9.6% decrease in gum sales. The cross-price elasticity with regard to e-cigarettes was estimated to -0.21 for reusable e-cigarettes (model 4), and -0.47 for disposable e-cigarettes (model 5). These results indicate that a 10% increase in reusable e-cigarette price would result in a 2.1% decrease in gum sales, and a 10% increase in disposable e-cigarette price would result in a 4.7% decrease in gum sales. Interestingly, although gum TV ratings were not significantly associated with gum sales, patch and e-cigarette TV ratings were found to be positively and significantly associated with gum sales.

Results from the fixed effects models for NRT patch sales were presented in **Table 3**. The estimated own-price elasticity was -2.05 (model 1), indicating that a 10% increase in patch price would result in a 20.5% decrease in per smoker patch sales. The estimated cross price elasticity with regard to gum was estimated to be 0.97 (model 3), indicating that a 10% increase in gum price would result in 9.7% increase in patch sales. The cross-price elasticity with regard to e-cigarettes was not statistically different from 0 (model 4 & 5). Patch TV ratings were positively and significantly associated with patch sales in models that controlled e-cigarette and cigarette prices with an estimated coefficient around 0.02, indicating that a 10% increase in patch TV ratings would result in a 0.2% increase in patch sales. No significant relationships were detected between gum TV ratings, e-cigarette TV ratings, and patch sales.

4. Discussion

This paper contributes to the nascent research on the impact of e-cigarettes on the demand for NRT products by examining how e-cigarette price and televised e-cigarette advertising, two key determinants of e-cigarette sales, influence NRT sales. Four important findings emerged from the analysis conducted in this paper. First, we found that one of the key determinants of NRT product sales was their own prices. Both patch and gum sales respond to changes in their own prices, but the demand price elasticity is larger for patch (2.05) than that for gum (0.91), indicating patch demand is more sensitive to its price changes. This suggests that lowering the costs that smokers pay for the NRT products could result in an increase in use of these products, and that the impact would be more pronounced for NRT patch. Our finding that NRT product demand responds to price changes is consistent with the results from previous studies (Huang et al., 2018, Tauras et al., 2005).

Second, our analysis revealed an important, yet not previously reported, one-way relationship between NRT gum and patch. Specifically, we found that when patch price increases, which reduces the demand for patch, the demand for gum would also decrease (with cross-price elasticity -0.96), indicating gum may be a complement for patch. However, when gum price increases, which reduces the demand for gum, the demand for patch would increase (with cross-price elasticity 0.97), indicating patch may be a substitute for gum. This one-way relationship appears to be counter-intuitive as it is generally believed that the relationship should be two-ways. However, if the characteristics of patch users differ from those of gum users, then one-way substitution/complementarity could exist.

For example, patch users were widely recommended to add a fast-acting product like gum to help combat acute urges (UK National Health Service, 2019; Wadgave and Nagesh, 2016). If patch users were predominantly dual product users (either simultaneously or sequentially), then it is conceivable that an increase in the price of patch would result in a decrease in demand for both products. However, if gum users were predominantly single product users, then it is also conceivable that an increase in the price of gum would result in an increase in demand for patch. Studies are needed to better understand the potential differences in the characteristics of patch users and gum users, as well as the differences in their motivations to quit and product use behaviors. These differences could shed light on this peculiar one-way relationship between NRT patch and gum.

Third, our analysis also revealed the existence of cross product impact between e-cigarettes and NRT products. Specifically, our results show that NRT gum appeared to be complementary with e-cigarettes, i.e. when e-cigarette price increases, it depresses the demand for both products. During our study period, the average price of reusable e-cigarettes decreased by 64.5%. Based on our estimate of the cross-price elasticity between reusable e-cigarette and gum (-0.21), this price decrease implies a 13.5% increase in gum sales over our study period, which was approximately 25.6 million additional pieces of gum sales per quarter. NRT patch sales appeared to have no statistically significant association with e-cigarette price changes. Our findings indicate that the ways gum was used in combination with e-cigarettes are different from that for patch. NRT gum appeared more likely to be used either simultaneously or sequentially with e-cigarettes, or used in ways complementing vaping, i.e. using gum to reduce cravings or maintain nicotine intake in locations/times where/when vaping is not allowed. Patch, on the contrary, appeared to be used independently from e-cigarettes. In addition, cigarettes appeared to be a substitute for NRT gum, but cigarettes were neither a substitute nor a complement with NRT patch, which also suggested that the behavioral patterns of gum users and patch users are different. More individual-level quantitative and qualitative studies are needed to better understand the underlying mechanisms of different behavioral patterns between gum users and patch users.

Finally, we found a small impact of televised NRT advertising on NRT product sales. Specifically, televised patch advertising has a small but positive impact on patch sales (own product advertising elasticity=0.02) and gum sales (cross product advertising

elasticity=0.01). We did not find any significant impact of gum TV advertising on either patch or gum sales. Televised e-cigarette advertising has a small positive effect on gum sales (cross product advertising elasticity=0.01), suggesting again that e-cigarettes and gum may be complements. However, the estimated cross product advertising elasticities between e-cigarettes and patch were not significant. Our NRT advertising results are consistent with those from a previous study. Tauras et al. (2005) analyzed retail sales data from 1996-2002 and found that advertising for NRT patch was significantly and positively associated with its sales, with elasticity ranging from 0.030 to 0.163; however, the impact of NRT gum advertising was not significant (Tauras et al., 2005).

4.1. Limitations

Our study has limitations. First, our sales data were limited to product sales in retail stores tracked by Nielsen, which excluded sales occurred online, in specialty stores, or in other retail outlets not tracked by Nielsen. Based on a report from the Wells Fargo Securities, in 2018, about 35% of e-cigarette/vapor products sales (\$2.3 billion vs. \$6.6 billion) in the US were through Nielsen tracked channels (Wells Fargo Securities, 2018). Consequently, our estimates reflect only a subset of total e-cigarette and NRT products sold in the US. As such, our price elasticity estimates are likely to be larger than the true price elasticity for each product category. Additionally, NRT products and other smoking cessation medications through prescription, which were more likely to be obtained by smokers with more serious quit intentions, were not included in the Nielsen scanner database. This data limitation might lead to weak associations between NRT products and e-cigarettes. Furthermore, due to the nature of our data, we were not able to examine the potential differential price and advertising impact across subpopulations, such as youth/young adults, minorities, or low-income people. More research is warranted to better understand how use of NRT products may differ across subpopulation groups due to the growth of e-cigarettes.

5. Conclusion

Our study discovered several important relationships within the NRT products and provided new insight into how e-cigarette sales affect the demand for NRT products. Our results suggest that NRT gum may be a complement with e-cigarettes. Recent growth in e-cigarette sales may have increased the demand for NRT gum. Several important policy implications emerging from our study include:

reducing the cost of NRT products could be one of the most effective policy tools to increase NRT use; differential pricing between NRT patch and gum may lead to substitution within the NRT products; and policies that regulate e-cigarettes, be it pricing or advertising, may have secondary impact on the demand for NRT gum.

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Declaration of competing interest:

The authors have no conflicts of interest relevant to this article to disclose.

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Table 1. Descriptive Statistics: Sales volume, inflation-adjusted unit prices, and TV ratings for NRT and e-cigarette products

Variables	Mean	SD	Min	Max
NRT Gum sales volume per smoker	1.55	2.00	0.00	10.01
NRT Gum sales volume per smoker (in log)	-0.50	1.51	-5.26	2.30
NRT Patch sales volume per smoker	0.07	0.09	0.00	0.41
NRT Patch sales volume per smoker (in log)	-3.62	1.17	-9.14	-0.89
NRT Gum price (\$ per piece)	0.38	0.06	0.20	0.71
NRT Gum price (in log)	-0.97	0.16	-1.60	-0.35
NRT Patch price (\$ per piece)	2.99	0.47	1.83	4.40
NRT Patch price (in log)	1.02	0.16	0.60	1.48
Reusable e-cigarette price (\$ per piece)	20.31	11.59	2.06	87.98
Reusable e-cigarette price (in log)	2.87	0.51	0.72	4.48
Disposable e-cigarette price (\$ per piece)	9.33	1.97	4.14	29.94
Disposable e-cigarette price (in log)	2.22	0.18	1.42	3.40
Cigarette price (\$ per stick)	0.30	0.07	0.21	0.53
Cigarette price (in log)	-1.22	0.20	-1.58	-0.64
NRT Gum TV rating	668.61	589.75	0.00	3741.21
NRT Patch TV rating	1098.92	668.36	0.00	4001.61
E-cigarette TV rating	522.82	505.92	0.00	2553.59

Table 2. Estimated own- and cross-price elasticities, as well as the impact of TV advertising, for NRT gum

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Gum price (in log)	-0.906*** (0.198)	-0.905*** (0.198)	-0.783*** (0.184)	-0.508*** (0.179)	-0.815*** (0.226)	-1.030*** (0.177)	-0.497*** (0.179)	-0.810*** (0.226)	-0.507*** (0.180)	-0.823*** (0.226)
Gum TV rating (in log)		0.001 (0.004)	0.002 (0.004)	0.003 (0.003)	0.002 (0.003)	0.001 (0.003)	0.003 (0.003)	0.001 (0.003)	0.001 (0.003)	-0.001 (0.003)
Patch price (in log)			-0.960*** (0.195)	-1.091*** (0.174)	-1.399*** (0.158)	-1.706*** (0.160)	-1.068*** (0.175)	-1.402*** (0.159)	-1.028*** (0.179)	-1.377*** (0.160)
Cigarette price (in log)				0.172 (0.189)	0.560*** (0.193)	0.308* (0.171)	0.130 (0.189)	0.535*** (0.193)	0.139 (0.184)	0.535*** (0.190)
Reusable e-cig price (in log)				-0.211*** (0.016)			-0.209*** (0.016)		-0.201*** (0.016)	
Disposable e-cig price (in log)					-0.470*** (0.065)			-0.453*** (0.065)		-0.393*** (0.070)
Patch TV rating (in log)						0.011** (0.005)	0.016*** (0.004)	0.011* (0.006)	0.016*** (0.004)	0.013** (0.006)
E-cigarette TV rating (in log)									0.011*** (0.004)	0.015*** (0.004)
Market Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	No	No	No	No	No	No	No
Quarter Fixed Effects	Yes	Yes	Yes	No	No	No	No	No	No	No
Observations	1,652	1,652	1,652	1,366	1,429	1,652	1,366	1,429	1,366	1,429
R-squared	0.969	0.969	0.970	0.978	0.970	0.962	0.978	0.970	0.978	0.971

Notes: The outcome is per smoker NRT gum sales volume measured by piece.

***p<0.01, **p<0.05, *p<0.1.

Robust standard errors in brackets.

Table 3. Estimated own- and cross-price elasticities, as well as the impact of TV advertising, for NRT patch

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Patch price (in log)	-2.052*** (0.248)	-2.051*** (0.248)	-2.250*** (0.254)	-2.266*** (0.281)	-2.347*** (0.239)	-1.776*** (0.211)	-2.272*** (0.286)	-2.360*** (0.246)	-2.250*** (0.290)	-2.351*** (0.247)
Patch TV rating		0.003	0.000	0.022***	0.024***	0.008	0.022***	0.024***	0.022***	0.025***

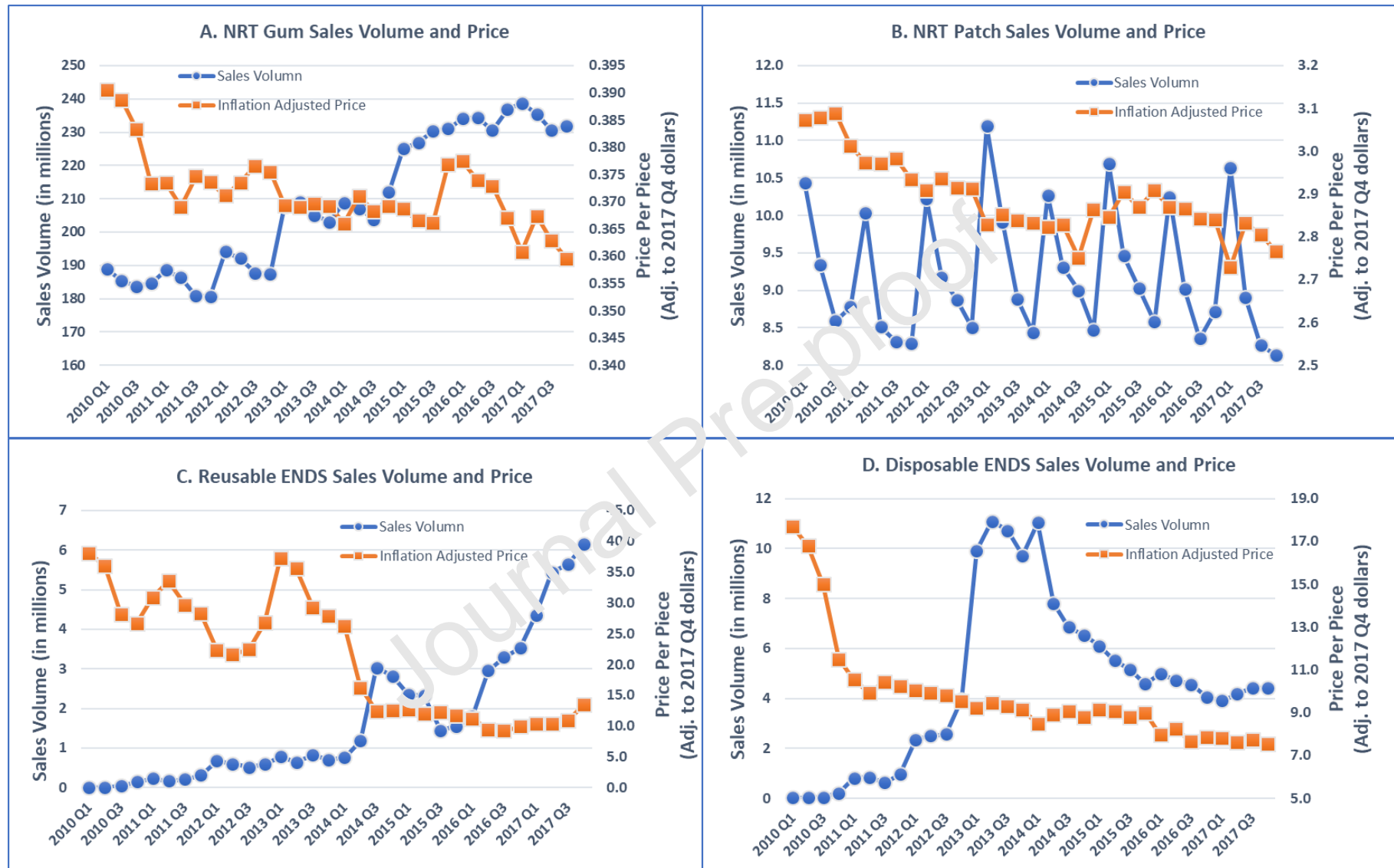
(in log)	(0.007)	(0.006)	(0.005)	(0.007)	(0.006)	(0.005)	(0.007)	(0.005)	(0.007)
Gum price		0.972***	1.326***	1.155***	1.174***	1.324***	1.151***	1.318***	1.146***
(in log)		(0.230)	(0.319)	(0.284)	(0.244)	(0.318)	(0.284)	(0.317)	(0.283)
Cigarette price			-0.164	-0.175	-0.229	-0.150	-0.151	-0.145	-0.151
(in log)			(0.198)	(0.167)	(0.159)	(0.204)	(0.170)	(0.199)	(0.167)
Reusable e-cig price			-0.002			-0.003		0.001	
(in log)			(0.020)			(0.020)		(0.019)	
Disposable e-cig price				0.042			0.044		0.065
(in log)				(0.066)			(0.066)		(0.068)
Gum TV rating					-0.005	0.002	0.003	0.001	0.003
(in log)					(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
E-cigarette TV rating								0.006	0.005
(in log)								(0.004)	(0.004)
Market Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	No	No	No	No	No	No
Quarter Fixed Effects	Yes	Yes	Yes	No	No	No	No	No	No
Observations	1,652	1,652	1,552	1,366	1,429	1,652	1,366	1,429	1,366
R-squared	0.962	0.962	0.965	0.969	0.966	0.957	0.969	0.966	0.969

Notes: The outcome is per smoker NRT patch sales volume measured by piece.

***p<0.01, **p<0.05, *p<0.1.

Robust standard errors in brackets.

Figure 1. Retail Sales Volume and Inflation-adjusted Average Price for NRT Gum, NRT Patch, Reusable E-Cigarettes, and Disposable E-Cigarettes in the US, 2010 - 2017. (Color should be used for this figure in print)



Credit authorship contribution statement

Jidong Huang: Conceptualization, Methodology, Supervision, Project administration, Funding acquisition, Writing – review & editing. Yu Wang: Formal analysis, Writing – original draft. Zongshuan Duan: Formal analysis, Writing – review & editing. Yoonsang Kim: Project administration, Writing – review & editing. Sherry L. Emery: Project administration, Writing – review & editing. Frank J. Chaloupka: Project administration, Writing – review & editing.

Highlights

- The growth of e-cigarette sales may have increased the demand for NRT gum.
- NRT patch appeared to be used independently from e-cigarettes.
- E-cigarette advertising was positively associated with NRT gum sales.