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Unintended Consequences of Antismoking Pricing Policies: Insights from Smokers' Household Expenditure on Smoking Behavior and Public Health

Yael Kochan [1] and Stav Rosenzweig [1,2,*]

[1] The Department of Management, The Guilford Glazer Faculty of Business and Management, Ben-Gurion University of the Negev, Be'er Sheva 8410501, Israel
[2] The Goldman Sonnenfeldt School of Sustainability and Climate Change, Ben-Gurion University of the Negev, Be'er Sheva 8410501, Israel
* Correspondence: stavro@bgu.ac.il

Abstract: Despite e-cigarettes' increasing popularity, traditional cigarette smoking, particularly with roll-your-own (RYO) tobacco, persists as the predominant form of global tobacco consumption. We examine the effect of an antismoking pricing policy on smokers' behavior by assessing changes in their households' consumption of tobacco products. To do so, we use a pricing policy implemented in Israel that introduced significant tax increases on RYO tobacco and factory-made cigarettes as our research setting. We analyze data compiled by a national agency on 8000 households representing the smoking population, evaluating changes in smoking behavior through their expenditures on tobacco products. Our model assesses the policy's impact on tobacco and cigarettes consumed, as well as the probability of households consuming these products. We find that the policy reduced neither overall tobacco consumption nor cigarettes smoked, contrary to expectations. Instead, it was associated with an increased likelihood of households choosing RYO cigarettes and the number of RYO cigarettes consumed. The study emphasizes that anti-smoking pricing policies may inadvertently promote RYO tobacco use, potentially harming public health. To mitigate this, we recommend designing price policies that eliminate perceived gaps between RYO tobacco and factory-made cigarettes. This approach can discourage substitution and foster the deconsumption of both products.

Keywords: public policy; smoking; cigarettes; roll your own (RYO); tobacco; behavior

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1. Introduction

Tobacco-associated diseases pose a significant worldwide public health threat, resulting in the annual deaths of over 8 million individuals [1]. To mitigate the health risks and other consequences associated with smoking, numerous countries enact regulations against smoking [2,3]. One widely adopted approach to achieving these objectives involves imposing taxes on cigarettes and tobacco products, thereby raising their prices [4,5]. This pricing policy strategy aims to discourage smoking initiation, promote smoking cessation, and, most importantly, reduce consumption among the smoking population [6]. However, in addition to reducing smoking within this group, pricing policies also impact other smoking-related behaviors like substitution and increased engagement in activities like rolling cigarettes [7]. Consequently, despite numerous studies exploring the impact of such antismoking policies, much remains uncertain about how these measures affect smoker behavior.

With the introduction of new tobacco products to the market, studies indicate the necessity of adapting regulations to rapidly changing environments [8]. The need for regulatory adjustments arises, among other factors, from the fact that many tobacco manufacturers define young adults as a target audience for their products [9]. Despite the increase in e-cigarette usage, cigarette smoking is by far the most frequent form of tobacco

consumption worldwide [10,11], with roll-your-own (RYO) tobacco standing out as an alternative to factory-made cigarettes [12,13]. When imposing new pricing policies on tobacco products through taxation, RYO cigarettes remain more affordable than factory-made ones [14]. RYO cigarette smokers are prone to believe that RYO tobacco is less harmful, more natural, less synthetic, fresher, and contains fewer tar and chemicals than factory-made cigarettes [15,16]. These beliefs, however, are unsupported. In contrast to factory-made cigarettes, RYO tobacco carries higher aluminum concentrations [17], and its non-nicotinic components contribute to addiction [18]. Furthermore, a recent study suggests that tobacco products, especially those perceived as less harmful than others, may inadvertently lead to a significant imitation effect. Consequently, this could potentially contribute to an increase in smoking rates [19]. Accordingly, RYO cigarette users tend to report greater levels of addiction, reduced motivation to quit smoking, and a decreased likelihood of attempting to quit [13]. Consequently, the global rise in RYO tobacco usage, coupled with misconceptions about its comparative healthiness, increases the risk of its consumption and necessitates the examination of tobacco control measures and their effect on smokers in the dynamic tobacco products market.

In this paper, we examine the effect of an antismoking pricing policy on smokers' behavior by assessing changes in their households' consumption of tobacco products. To do so, we use a pricing policy implemented in Israel. While imposing substantial taxes on both RYO tobacco and factory-made cigarettes, this policy effectively accentuated a pre-existing price disparity between these tobacco products. It could, therefore, cause adverse consequences within smoking households by enhancing substitution for RYO tobacco, thereby increasing the negative results of RYO consumption while not decreasing factory-made cigarette consumption. Pricing policies are critical to reducing tobacco use, but countries rarely implement them appropriately [11,20]. While any solution is likely complex, raising awareness of this problem among policymakers is critical. Awareness would enable them to consider and potentially implement changes to create more balanced pricing policies as measures of tobacco control. The widespread adoption of comparable pricing policies across diverse countries enhances the generalizability of potential findings. We draw upon data from the Household Survey conducted by the Israel Central Bureau of Statistics (CBS) and investigate the tobacco consumption patterns of over 8000 households for two years before the introduction of the policy and three years after it. The sample is a formal survey representative of the population, conducted by a national agency to include a wide socio-economic, ethnic, and geographical spectrum of residents. We suggest that household spending can offer insights into behavioral changes resulting from antismoking pricing policies. These changes encompass substitution and other smoking-related actions, as we will describe later. Because RYO cigarettes are typically smaller than factory-made ones [21], this potential substitution suggests shifts not only in tobacco quantity consumption but also in cigarette count. Smokers' cigarette count has implications that surpass tobacco quantity for two reasons. First, it potentially affects their daily smoking frequency. Second, it influences the time spent smoking, given the additional task of rolling cigarettes. These dual implications carry social aspects (like group cigarette rolling and imitation) that likely impact spillover effects and cessation. These implications extend beyond personal health, affecting both smokers' well-being and public health externalities, and the latter is strongly related to sustainability, as we elaborate next.

2. Literature Review

2.1. The Regulation of Tobacco Products and Sustainability

In recent years, there has been an increasing focus on research related to the regulation of tobacco products, e.g., [19,22]. This interest stems, inter alia, from policymakers' understanding of the connection between reducing tobacco consumption and promoting sustainability. This connection between smoking cessation and sustainability is evident in societal health and environmental considerations [23]. At the societal level, smoking cessation contributes to healthier communities by reducing smoking-related illnesses and supporting

society's overall well-being. Governments promote anti-smoking campaigns and policies as part of their public health and sustainability agendas. These initiatives contribute to creating a healthier population and reducing the strain on healthcare systems [24,25]. Fewer smoking-related illnesses reduce healthcare costs, freeing up resources for sustainable healthcare practices and initiatives. In terms of environmental considerations, both the production and consumption of tobacco carry substantial consequences. Tobacco cultivation frequently leads to deforestation and the extensive use of pesticides [23,26]. Regarding consumption, while tobacco product smoke emissions are relatively lower than pollutants from, for example, energy consumption, they occur in close proximity to the population and are, therefore, profoundly harmful [27]. Moreover, cigarette butts pose a notable litter issue, with their improper disposal contributing to environmental pollution [28].

A recent collection of studies examined national and international initiatives that help local populations increase their health and welfare [29–34]. These studies, however, do not address the specific need to regulate tobacco products for public health promotion, nor do they address the potential increase in RYO tobacco consumption.

2.2. Roll-Your-Own Tobacco as Substitution

While various factors could prompt smokers to transition from factory-made cigarettes to RYO cigarettes [15], disparities in prices notably stand out as a meaningful contributing factor. The literature provides evidence that RYO tobacco becomes an attractive alternative after the implementation of policies that cause, preserve, or increase the price gap between RYO tobacco and cigarettes. Studies have reported an increase in RYO tobacco consumption over cigarettes in New Zealand, Ireland, and the US [13,15,35]. These studies suggested that RYO tobacco's lower cost was the driver of these changes. However, in some countries (e.g., the UK and New Zealand), RYO tobacco was a cheaper alternative even before the introduction of such policies [35,36], indicating that one cannot explain the increase in RYO tobacco consumption by the price gap alone. We will provide some examples next.

In Spain, a regulatory measure maintained an existing, substantial price difference between the two product types. RYO cigarettes were priced approximately 50% lower than regular cigarettes. The price adjustment did not change this disparity; instead, it elevated the lowest point in the cigarette price range. As a result, the tobacco industry effectively increased the sales of more affordable RYO tobacco brands [37]. Another study of Spain's policy estimated that the annual consumption of cigarettes decreased by 3%, whereas that of RYO cigarettes increased by 14.1% [38]. Additionally, a study investigating changes in pricing policies in New Zealand suggested that a 1% increase in cigarette prices led to a 0.87% increase in the demand for RYO tobacco. Importantly, however, overall tobacco demand decreased [39]. A study following a pricing policy on tobacco products in the UK revealed a decline in the proportion of smokers of expensive cigarettes and an increase in the proportion of smokers of cheaper tobacco products such as ultra-low-price cigarettes and RYO tobacco [36].

2.3. Implications of Switching to Roll-Your-Own Cigarettes

Switching from factory-made cigarettes to roll-your-own cigarettes has numerous consequences. From a health standpoint, RYO tobacco is typically perceived as more detrimental than factory-made cigarettes due to higher addiction levels and more harmful components [18,40]. However, this substitution has additional outcomes. One such consequence is the increased time commitment associated with rolling one's own cigarettes compared to smoking factory-made ones. The manual process of rolling RYO tobacco into a cigarette takes approximately 53 s [41]. Consuming 20 RYO cigarettes, which contain less tobacco than a factory-made cigarette, requires approximately 17 min. While rolling offers meditative advantages [15], it occupies both hands and restricts the smoker's ability to carry out other tasks.

Another significant factor is the social environment in which smokers operate, which meaningfully influences their smoking-related behavior. The RYO cigarette rolling process

has a distinctive social dimension. RYO cigarettes are more closely associated with social interactions than factory-made cigarettes due to the act of rolling cigarettes. These interactions encompass acquiring rolling skills, forming new meaningful connections during rolling and smoking, and reinforcing social bonds with fellow rolling smokers [15].

For certain smokers, the impetus to engage in smoking rituals is strongly connected to gaining social acceptance and a sought-after sense of belonging to a valued group. Consequently, such smokers could be more likely to smoke not only during social interactions but also when alone [42]. Analogous social consequences have been observed in the context of alcohol consumption—even those who dislike the taste of alcohol still consume it if they see this consumption as a way to foster social connections. In addition, failing to conform to group norms could result in individuals losing their group membership privileges [43].

Once integrated into a community of RYO cigarette smokers, participants often find it challenging to detach from their smoking peers, reinforcing their smoking habits. When contemplating quitting, their friends often dissuade them and even obstruct their cessation attempts [15]. Furthermore, research indicates that RYO cigarette smokers perceive smoking as normative, possess numerous smoking friends, exhibit deeper engagement in the smoking culture, and are less motivated to quit than factory-made cigarette smokers [13,40]. This social circle distinctly influences these consumers' smoking behavior.

3. Data and Method

3.1. Research Context

We focus on the smoking market in Israel, which resembles smoking markets in other countries. Smoking is a major contributor to morbidity and mortality in Israel. Smoking-related ailments claim nearly 8000 deaths each year, with passive smoking accounting for about 800 of those deaths [44]. Around 13% of the adult population (18+) are active smokers. Within this group, 83% opt for cigarettes, 13% use RYO tobacco, while the remaining portion engages with alternative tobacco products like hookah tobacco, cigars, and pipe tobacco [44,45]. Similar to other countries, a significant portion of smokers in Israel come from less-advantaged socio-economic backgrounds. This population experiences elevated unemployment levels, low incomes, and fewer material possessions. Lower educational levels are significantly associated with smoking. Additionally, the prevalence of smoking is greater among Arab men and male immigrants compared to men of Israeli-Jewish descent [46]. Over half of Israeli adolescents have tried smoking by the age of 13 or even earlier, and the median age at which smoking commences spans from 17 to 18 across various ethnic groups in Israel [47].

Policymakers in Israel consider pricing policies as one of the major methods for reducing tobacco use prevalence, the demand for tobacco products, and the effects of passive exposure to them, as well as for restricting the supply of these products [48]. Both governmental bodies and non-profit entities are actively involved in implementing tobacco control policies in Israel, with the shared goal of reducing smoking and minimizing its adverse effects. This commitment has resulted in the implementation of a range of policy measures. These measures include the designation of smoke-free zones, subsidized cessation services, restrictions on tobacco company advertising, and pricing regulation of tobacco products.

There is an ongoing discussion about the effectiveness of antismoking policies in Israel. For instance, it has been argued that over recent decades, a substantial surge in regulatory measures and cigarette taxes has aligned with a decrease in smoking prevalence in Israel [49]. However, policymakers argued that smoking prevalence among adults remained consistent between 2011 and 2016 [47] and that factory-made cigarette consumption declined, but the consumption of RYO cigarettes rose due to price differences between these products [50]. Notably, however, price differences clearly existed before a major tax policy was implemented in 2013. Table A1 in Appendix A summarizes pricing policies and price shifts over time for tobacco products in Israel. Figure 1 depicts the consumption of factory-made cigarette packs and RYO cigarette pack equivalents from 2011 to 2016.

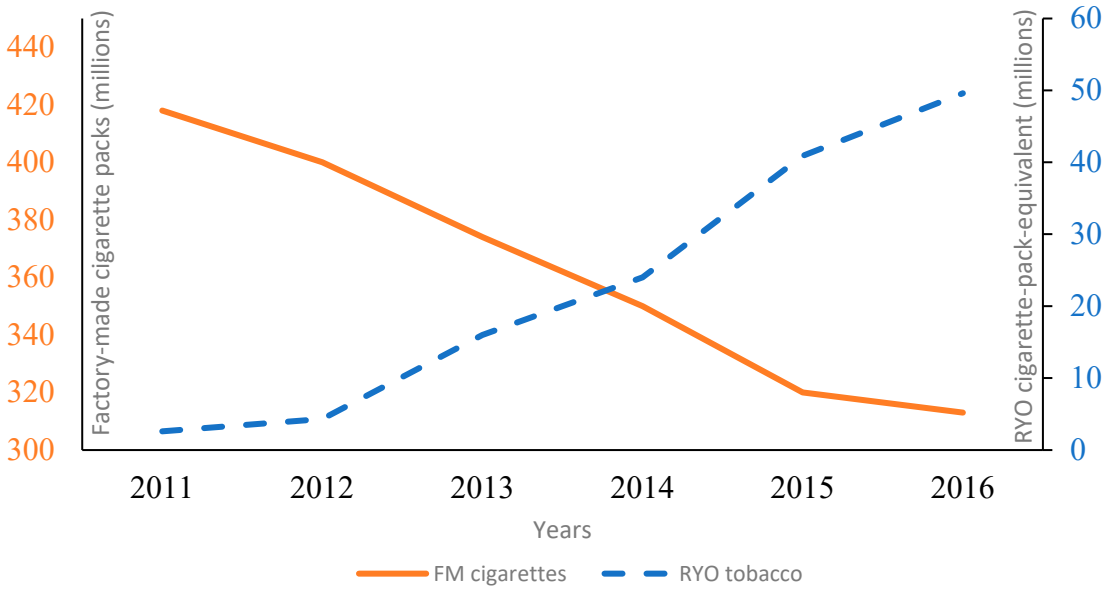


Figure 1. Consumption of factory-made cigarette packs and RYO cigarette pack equivalents, in millions [50].

During our study period, several additional smoking prevention policies were introduced. In July 2012, smoking was prohibited in outdoor spaces like bus stops and within 10 m of hospital and clinic entrances. Smoking rooms in government offices were also banned. By July 2014, smoking was forbidden in sports stadiums, and by February 2016, it was prohibited within a 10 m range of educational institution entrances [51,52]. We will factor in these policies in our analyses.

3.2. Data

We investigate a pricing policy introduced in Israel in 2013. This policy changed pricing structures and rates, which resulted in a more pronounced and, therefore, more noticeable price disparity between factory-made cigarettes and RYO tobacco. Our investigation relied exclusively on secondary data, with no acquisition of primary data undertaken by the authors. To assess the impact of this pricing policy on smoking households' consumption patterns, we examined the two-year period prior to the policy's implementation (2011–2012) and the subsequent three years (2014–2016). We used pooled cross-sectional household survey data from the Israel Central Bureau of Statistics (CBS) on monthly household tobacco expenditure (the data underwent anonymization and de-identification processes conducted by the CBS). The CBS household survey data are collected in accordance with The Statistics Ordinance and under a code of ethics. We excluded households with zero expenditure on cigarettes or RYO tobacco (exclusion criteria were expenses for (1) other tobacco products such as cigars, pipe tobacco, and hookah tobacco; (2) exclusively complementary RYO tobacco products such as rolling papers and filters; (3) smoking tools such as hookahs, pipes, lighters, and lighter refills; and (4) purchases of a single cigarette). We also excluded 379 households for which information regarding the place of residence was missing and households for which a negative monthly income was reported. The final sample included 8216 households: 3035 before and 5181 after the policy introduction. Each household was surveyed once, i.e., there is no overlap in the surveyed households across the two periods. Still, because we captured smoking households before and after the implementation of the policy, the data include households that potentially ceased smoking because of the policy and those that potentially started smoking because of the policy (Table 1). Combined with scanner data purchased from a market research firm regarding sales of tobacco products from the majority of retail stores across the country, we calculated the average price of a pack of local and imported cigarettes and RYO tobacco. We also retrieved data from

the Ministry of Health's smoking report regarding the average weight of a single factory-made RYO cigarette [47]. Using these data, we calculated the average household tobacco consumption, whether through RYO or factory-made cigarettes.

Table 1. Households included in the sample.

Year	Number of Households with Smoking Expenditure	Share of Households with Smoking Expenditure out of Households Surveyed by CBS
2011	1351	22.32%
2012	1684	19.26%
2014	1866	22.04%
2015	1699	19.86%
2016	1616	18.14%
Total	8216	

3.3. Variables

Because tobacco is consumed in both RYO cigarette and factory-made cigarette forms and this consumption is not mutually exclusive, we employ several dependent variables. Initially, we assess total *tobacco consumption* in grams and quantify the household's cigarette usage, encompassing both RYO and factory-made types. Subsequently, we analyze the household's *likelihood to consume RYO* and *factory-made cigarettes* before and after the introduction of the pricing policy. We also separately examine RYO and factory-made cigarette consumption due to potential insights into substitution dynamics and consumption patterns that bundling these types of tobacco consumption might obscure. Finally, considering the substantial difference in tobacco quantity between RYO and factory-made cigarettes, we also examine the cigarette count. This count bears relevance to smoking duration and social consequences, as indicated in the literature review. Therefore, the cigarette count carries meaning beyond tobacco quantity. We calculated the monthly average *number of RYO cigarettes* by dividing RYO tobacco consumption in grams by 0.5, which is the average weight of an RYO cigarette [47]. We calculated the monthly average *number of factory-made cigarettes* by multiplying the number of cigarette packs the household consumed each month by 20, which is the number of cigarettes per pack.

We controlled for the real average per-pack *price of RYO tobacco* and of factory-made cigarettes and for the household's real net *monthly income* in New Israeli Shekels (USD 1 = ~ILS 3.6) (the net household income in the three months preceding the date of the survey). We used the Consumer Price Index to adjust the nominal household income into 2011 real values as well as the *number of providers*. We do so because income has been continuously associated with smoking behavior [53,54] and because income and usage expenditure are key components in assessing the effect of a pricing policy on household behavior [55]. We also controlled for the following household characteristics: *number of individuals in the household under 15, 15–17, and over 18*. We do so because prior studies have indicated the inclination of youth and young adults to experiment with tobacco products by imitating other individuals in their vicinity [56,57]. We control for years of *education* of the household head because smoking behavior is closely related to the level of education [53]. Similarly, we use dummy variables if the household head had a *matriculation certificate*, an *academic degree,* was *self-employed*, had *no spouse*, was a *woman*, and the household *head and spouse were unemployed*, as these are standard control variables used in studies examining the effect of policy measures on households and that are likely to affect purchasing behavior [58,59]. We also control for the ethnicity of the household head—*Arab* or *Jewish* in the present case—because ethnicity is expected to affect household behavior, e.g., [58]. Finally, following prior studies indicating the effect of socio-economic status on smoking behavior, e.g., [23,51], we controlled for the location of the household in a peripheral area of the country (yes/no) and in a low-ranking socio-economic status area of residence (yes/no).

As we explain in Section 3.1, Israel implemented three extensions of smoking restrictions in public places during the examined period (July 2012, July 2014, and February 2016), which we also controlled for. Finally, we also interacted the variable representing the policy (*after pricing policy*) with the following variables: individuals under 15, individuals 15–17, individuals over 18, household periphery location, and low socio-economic location. Following prior research, e.g., [59,60], we introduce these interactions to assess the impact of the policy on these specific groups.

3.4. Empirical Modeling Approach

We used several econometric models and dependent variables because, taken together, they enabled a wholesome picture of the behavioral consequences of public policy measures, e.g., [61,62]. Because the dependent variables in the present study are of different natures (dichotomous, continuous, and count), we used the corresponding econometric model for each type of dependent variable. We used logistic regression models to examine the effect of the pricing policy on the probability that smokers would buy RYO tobacco and/or cigarettes. We used linear regression models to test the impact of the policy on the amount of tobacco consumed. Finally, we employed negative binomial regression models to estimate the effect of the policy on the number of cigarettes consumed. We estimated the coefficients of the following equations:

$$\left.\begin{array}{r} logit\ (P_i) \\ Y_i \\ Z_i \sim Negative\ Binomial \end{array}\right\} =$$

$$= \beta_0 + \beta_1 AfterPolicy_i + \beta_2 Price_i + \sum_{j=3}^{5} \beta_j Ages\ in\ HH_i + \beta_6 Periphery_i + \beta_7 LowSocio_i$$

$$+ \sum_{k=8}^{10} \beta_k Ages\ in\ HH\ X\ AfterPolicy_i + \beta_{11} Periphery\ X\ AfterPolicy_i + \beta_{12} LowSocio\ X\ AfterPolicy_i$$

$$+ \sum_{l=13}^{L} \beta_l C_i + \sum_{m=L+1}^{M} \beta_m D_i + \varepsilon_i$$

where i is the subscript for a household, *Price* is the average real price of RYO tobacco and/or factory-made cigarettes at the time household i was surveyed, *Ages in HH* is the number of individuals by age groups within household i (individuals under 15, individuals 15–17, and individuals over 18), and *Periphery* and *LowSocio* indicate the location of the household in a periphery or a low socio-economic area. C and D represent household control variables and control variables for other smoking policies in effect at the time household i was surveyed, respectively.

4. Results

4.1. Descriptive Findings

Table 2 presents the summary statistics of the main variables in our study. In 94.72% of smoking households, individuals smoked factory-made cigarettes, and 8.24% used RYO tobacco. The average monthly tobacco consumption was 332.37 g.

Table 2. Summary statistics.

	Panel A			
	Mean	**Std. Deviation**	**Min**	**Max**
Tobacco consumption (gr)	332.37	307.87	10.99	4303.05
Real price of RYO tobacco per pack of 40 gr (ILS) [a]	39.22	1.16	37.93	41.08
Real price of factory-made cigarette pack of 14 gr (ILS)	22.76	3.61	17.29	26.32
Monthly income of household (ILS) [a]	15,393.12	10,370.59	0.00	181,700.50
Number of providers in household	1.56	1.02	0.00	8.00
Number of individuals under 15 in household	0.91	1.27	0.00	9.00
Number of individuals 15–17 in household	0.19	0.47	0.00	3.00
Number of individuals over 18 in household	2.39	1.14	1.00	10.00
Head of household's years of education	12.64	3.42	0.00	37.00

Table 2. *Cont.*

	Panel B			
	Yes		No	
	Frequency	Percent	Frequency	Percent
RYO tobacco consumed in household (yes/no)	677	8.24	7539	91.76
Factory-made cigarettes consumed in household (yes/no)	7782	94.72	434	5.28
Head of household holds matriculation certificate (yes/no)	4435	53.98	3781	46.02
Head of household holds academic degree (yes/no)	1625	19.78	6591	80.22
Head of household is self-employed (yes/no)	884	10.76	7332	89.24
Head of household has no spouse (yes/no)	3377	41.10	4839	58.90
Head of household is a woman (yes/no)	2673	32.53	5543	67.47
Head and spouse are unemployed (yes/no)	597	7.27	7619	92.73
Head of household is Arab (yes/no)	1763	21.46	6453	78.54
Head of household is Jewish (yes/no)	6014	73.20	2202	26.80
Household located in periphery (yes/no)	1412	17.19	6804	82.81
Low socio-economic area (yes/no)	2936	35.74	5280	64.26

[a] USD 1 ≈ ILS 3.69.

Table 3 presents summary statistics of selected variables before and after the 2013 pricing policy introduction. One RYO tobacco pack of 40 g is equivalent to 2.86 packs of factory-made cigarettes, each containing 14 g. The difference in price between 40 g of cigarettes and 40 g of RYO tobacco increased significantly by about 138% (from a difference of ILS 13.82 before the policy to a difference of ILS 32.95 after the policy) ($t = -340$; $p < 0.01$).

Table 3. Summary statistics for households with smoking individuals before vs. after the introduction of the 2013 pricing policy.

	Panel A			
	2011–2012		2014–2016	
	Mean	Std. Deviation	Mean	Std. Deviation
Total tobacco consumption (gr)	347.00	311.13	323.81	305.64
Real price of RYO tobacco per pack of 40 gr (ILS) [a]	38.18	0.23	39.82	1.05
Real price of factory-made cigarette pack of 14 gr (ILS) [a]	18.18	0.80	25.44	0.92
Number of RYO cigarettes consumed in household per month	8.57	89.22	55.90	233.67
Number of factory-made cigarettes consumed in household per month	489.59	444.99	422.66	432.77
	Panel B			
	2011–2012		2014–2016	
	yes	no	yes	no
RYO tobacco consumed in household (yes/no)	1.78%	98.22%	12.02%	87.98%
Factory-made cigarettes consumed in household (yes/no)	98.95%	1.05%	92.24%	7.76%

[a] USD 1 ≈ ILS 3.69.

The average monthly tobacco consumption of both products declined by about 6.7% (from 347.00 g to 323.81 g, t = 3.28; $p < 0.01$), but the average monthly number of cigarettes for both products decreased by only 3.9% (from 498.16 units to 478.55 units, t = 1.91; $p < 0.10$). This is because one can smoke a greater number of RYO cigarettes than factory-made cigarettes using the same amount of tobacco. We delve into the meaning of this fact in the Section 5.

More importantly, Table 3 demonstrates remarkable substitution patterns. The real average price of factory-made cigarettes increased by about 40% (from ILS 18.18 to ILS 25.44), and the number of cigarettes smoked declined significantly by about 13.7% (from 489.59 units to 422.66 units, t = 6.65, $p < 0.01$). The proportion of households that consumed these cigarettes decreased significantly by 7%, down from 99% to 92% (z = 13.11, $p < 0.01$). By comparison, the real average price of RYO tobacco increased by about 4% (from ILS 38.18 to ILS 39.82). However, the average monthly number of RYO cigarettes skyrocketed by about 552% (from 8.57 units to 55.90 units, t = −13.05, $p < 0.01$), as did the proportion of households consuming RYO tobacco by about 500%, moving from 2% to 12% (z = −16.30, $p < 0.01$).

Figure 2 shows the real expenditure of smoking households on RYO tobacco, and Figure 3 shows the real expenditure of smoking households on factory-made cigarettes during the examined period. Factory-made cigarette expenditure demonstrates an increasing

trend (where expenditure in 2014 and 2016 was significantly higher than in 2012), but RYO tobacco expenditure demonstrates a very *large leap* after the policy introduction.

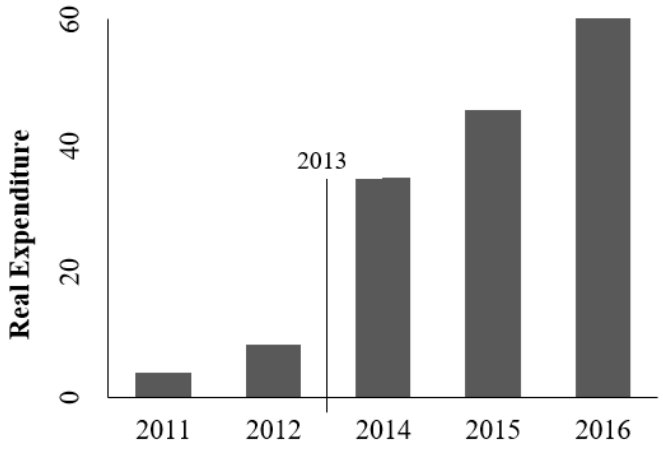


Figure 2. Real expenditure on RYO tobacco (thousands of ILS. USD 1 ≈ ILS 3.69).

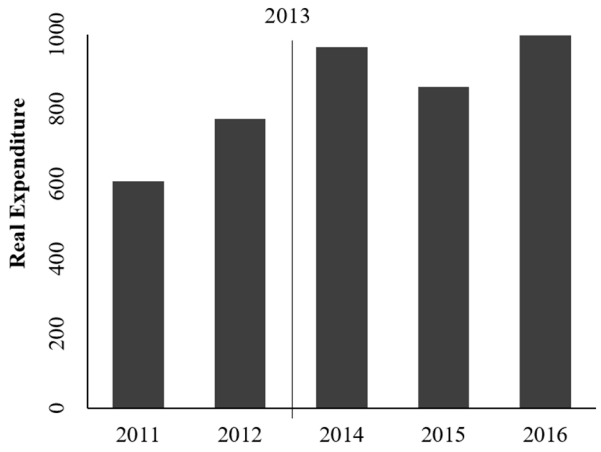


Figure 3. Real expenditure on factory-made cigarettes (thousands of ILS. USD 1 ≈ ILS 3.69).

4.2. Model Estimation

Table 4 presents the results of regression models examining the association between the pricing policy and tobacco consumption in grams and the number of cigarettes consumed (both RYO and factory-made) within smoking households. Whereas the policy was designed to decrease smoking, it was not significantly associated with a change in consumption, neither as measured with the amount of tobacco ($\beta = 3.32$; $p = 0.92$) nor with the number of cigarettes ($\beta = 0.016$; $p = 0.86$). No significant changes were observed for the other policies we controlled for, nor for the interactions of the pricing policy with different age groups in smoking households and with household locations in the periphery or low socio-economic areas.

The question remains whether and to what extent the policy was associated with shifts in demand and consumption patterns. RYO and factory-made cigarettes meet the same need: the consumption of nicotine via smoking. However, they differ in their product characteristics as well as the other needs that they fulfill, such as social needs. In addition, as opposed to factory-made cigarettes, the smoking of RYO cigarettes requires additional procurement of complementary products such as filters and rolling papers and time devoted to preparing the cigarettes by rolling them. The rolling activity does not allow engagement in other simultaneous activities that require the use of one's hands. This preparation takes time, prolonging the time spent on smoking activity. Therefore, we investigated the effect of the pricing policy on the consumption of each of the products.

Table 4. Model estimation: monthly consumption of tobacco and cigarettes within smoking households.

	Total Tobacco Consumption (gr) (Linear Regression Model)	Total Number of Cigarettes (Negative Binomial Regression Model)
After pricing policy (yes/no)	**3.32 (34.71)**	**0.01 (0.098)**
Real price of RYO tobacco per pack of 40 gr (ILS) [a]	−15.40 (6.95) *	−0.04 (0.019) *
Real price of factory-made cigarette pack of 14 gr (ILS) [a]	−3.99 (5.66)	−0.01 (0.016)
Number of individuals under 15 in household	−21.50 (4.49) **	−0.06 (0.012) **
Number of individuals 15–17 in household	−8.12 (12.33)	−0.02 (0.035)
Number of individuals over 18 in household	30.14 (5.66) **	0.06 (0.015) **
Household located in periphery (yes/no)	−7.64 (16.39)	−0.01 (0.046)
Low socio-economic area (yes/no)	37.94 (12.82) **	0.09 (0.036) *
Monthly income (natural log, ILS) [a]	49.00 (6.71) **	0.15 (0.019) **
Head of household's years of education	−1.83 (1.40)	−0.01 (0.004) +
Head of household holds matriculation certificate (yes/no)	−47.33 (8.36) **	−0.132 (0.023) **
Head of household holds academic degree (yes/no)	−36.17 (10.74)	−0.13 (0.031) **
Head of household is self-employed (yes/no)	11.98 (10.76)	0.01 (0.030)
Head of household has no spouse (yes/no)	26.36 (7.91) **	0.05 (0.022) **
Head of household is a woman (yes/no)	−0.12 (7.51)	−0.01 (0.021)
Head and spouse are unemployed (yes/no)	−51.70 (15.56) **	−0.16 (0.044) **
Head of household is Arab (yes/no)	99.65 (17.99) **	0.249 (0.051) **
Head of household is Jewish (yes/no)	−3.36 (14.83)	−0.03 (0.042)
Number of providers in household	−17.57 (5.33)	−0.05 (0.150) **
After July 2012 policy (yes/no)	12.62 (13.83)	0.03 (0.039)
After July 2014 policy (yes/no)	−2.35 (12.57)	−0.01 (0.035)
After February 2016 policy (yes/no)	22.91 (19.10)	0.07 (0.053)
Individuals under 15 × after pricing policy	4.79 (5.47)	0.00 (0.015)
Individuals 15–17 × after pricing policy	−6.55 (15.19)	−0.00 (0.043)
Individuals over 18 × after pricing policy	3.89 (6.30)	0.01 (0.017)
Household located in periphery × after pricing policy	−2.54 (19.63)	0.00 (0.055)
Low socio-economic area × after pricing policy	−25.88 (15.58) +	−0.07 (0.044)
Intercept	542.30 (251.01) *	6.87 (0.715) **
N	8216	8216

** $p < 0.01$; * $p < 0.05$; + $p < 0.10$; [a] USD 1 ≈ ILS 3.69.

Table 5 presents the odds ratios of the logistic regression models that examined the likelihood of consuming RYO and factory-made cigarettes within smoking households. The policy had a positive and significant association with the odds ratio of consuming RYO cigarettes ($\beta = 5.97$; $p < 0.01$). At the same time, it did not have the desired negative association with the odds ratio of smoking factory-made cigarettes ($\beta = 1.14$; $p = 0.85$). This analysis reveals a potentially meaningful change in consumption patterns, especially of RYO cigarettes.

Table 5. Model estimation: likelihood of RYO and factory-made cigarette consumption within smoking households (logistic regression models).

	Likelihood to Consume RYO Cigarettes (Odds Ratio)	Likelihood to Consume Factory-Made Cigarettes (Odds Ratio)
After pricing policy (yes/no)	**5.97 (2.51) ** **	**1.14 (0.83)**
Real price of RYO tobacco per pack of 40 gr (ILS) [a]	1.13 (0.08) +	
Real price of factory-made cigarette pack of 14 gr (ILS) [a]		0.67 (0.06) **
Number of individuals under 15 in household	0.93 (0.12)	1.35 (0.28)
Number of individuals 15–17 in household	1.24 (0.39)	0.61 (0.23)
Number of individuals over 18 in household	0.97 (0.13)	1.07 (0.18)
Household located in periphery (yes/no)	1.29 (0.55)	0.74 (0.41)
Low socio-economic area (yes/no)	0.54 (0.19) +	1.93 (0.93)
Monthly income (natural log, ILS) [a]	0.70 (0.05) **	1.41 (0.13) **
Head of household's years of education	1.06 (0.02) **	0.94 (0.02) **
Head of household holds matriculation certificate (yes/no)	1.22 (0.12) *	0.73 (0.09) *
Head of household holds academic degree (yes/no)	0.67 (0.08) **	1.51 (0.23) **
Head of household is self-employed (yes/no)	0.84 (0.11)	1.19 (0.20)
Head of household has no spouse (yes/no)	1.11 (0.11)	0.85 (0.10)
Head of household is a woman (yes/no)	0.62 (0.06) **	1.54 (0.18) **
Head and spouse are unemployed (yes/no)	1.24 (0.27)	0.71 (0.19)
Head of household is Arab (yes/no)	0.60 (0.13) *	1.57 (0.42) +
Head of household is Jewish (yes/no)	0.86 (0.14)	1.16 (0.22)
Number of providers in household	1.37 (0.10) **	0.72 (0.06) **
After July 2012 policy (yes/no)	1.79 (0.52) *	0.77 (0.29)
After July 2014 policy (yes/no)	1.15 (0.14)	1.13 (0.23)
After February 2016 policy (yes/no)	1.49 (0.27) *	1.21 (0.16)
Individuals under 15 × after pricing policy	1.08 (0.14)	0.71 (0.15)
Individuals 15–17 × after pricing policy	0.68 (0.23)	2.19 (0.90) +
Individuals over 18 × after pricing policy	0.76 (0.10) *	1.39 (0.24) +
Household located in periphery × after pricing policy	1.02 (0.45)	1.04 (0.59)
Low socio-economic area × after pricing policy	1.15 (0.43)	0.77 (0.38)
Intercept	10,747.94 (21,258.34) **	9.28 (1.98) **
N	8216	8216

** $p < 0.01$; * $p < 0.05$; + $p < 0.10$; [a] USD 1 ≈ ILS 3.69.

To test this potential change in smoking behavior, we used negative binomial regression models to estimate the effect of the policy on the number of RYO and factory-made cigarettes consumed by smoking households. Table 6 shows that the policy had a marginally significant positive association with the number of RYO cigarettes smoked (β = 1.49, p = 0.06) and had no negative association with the number of factory-made cigarettes smoked (β = 0.014; $p > 0.1$), again not demonstrating the desired negative effect on the consumption of cigarettes. Jointly, the results presented in Tables 5 and 6 are a strong indication that the policy, originally designed to decrease smoking, was counter-effective with regard to RYO cigarette smoking without the potentially predicted pattern of a decrease in the consumption of the more expensive factory-made cigarettes.

Table 6. Model estimation: monthly consumption of RYO and factory-made cigarettes within smoking households (negative binomial regression models).

	Number of RYO Cigarettes	**Number of Factory-Made Cigarettes**
After pricing policy (yes/no)	**1.49 (0.806) +**	**0.014 (0.126)**
Real price of RYO tobacco per pack of 40 gr (ILS) [a]	0.05 (0.185)	
Real price of factory-made cigarette pack of 14 gr (ILS) [a]		−0.05 (0.018) **
Number of individuals under 15 in household	0.03 (0.171)	−0.07 (0.016) **
Number of individuals 15–17 in household	−0.07 (0.507)	−0.03 (0.045)
Number of individuals over 18 in household	0.19 (0.221)	0.07 (0.020) **
Household located in periphery (yes/no)	1.33 (0.748) +	−0.01 (0.060)
Low socio-economic area (yes/no)	−2.05 (0.646) **	0.09 (0.047) *
Monthly income (natural log, ILS) [a]	−0.07 (0.267)	0.18 (0.024) **
Head of household's years of education	−0.05 (0.035) +	−0.01 (0.005) *
Head of household holds matriculation certificate (yes/no)	0.11 (0.293)	−0.15 (0.030) **
Head of household holds academic degree (yes/no)	−0.15 (0.323)	−0.10 (0.040) **
Head of household is self-employed (yes/no)	0.24 (0.367)	0.04 (0.039)
Head of household has no spouse (yes/no)	0.40 (0.275)	0.06 (0.028) *
Head of household is a woman (yes/no)	−0.67 (0.251) **	0.04 (0.027)
Head and spouse are unemployed (yes/no)	0.53 (0.547)	−0.17 (0.056) **
Head of household is Arab (yes/no)	−0.46 (0.646)	0.33 (0.066) **
Head of household is Jewish (yes/no)	−0.37 (0.484)	0.02 (0.054)
Number of providers in household	0.1 (0.175)	−0.07 (0.019) **
After July 2012 policy (yes/no)	1.26 (0.456) **	0.04 (0.050)
After July 2014 policy (yes/no)	0.11 (0.361)	−0.01 (0.045)
After February 2016 policy (yes/no)	0.61 (0.487)	0.14 (0.039) **
Individuals under 15 × after pricing policy	−0.06 (0.189)	0.01 (0.020)
Individuals 15–17 × after pricing policy	−0.28 (0.575)	0.01 (0.055)
Individuals over 18 × after pricing policy	−0.33 (0.221)	0.03 (0.022)
Household located in periphery × after pricing policy	−1.04 (0.818)	−0.02 (0.072)
Low socio-economic area × after pricing policy	1.37 (0.663) *	0.00 (0.057)
Intercept	1.02 (7.438)	5.43 (0.409) **
N	8216	8216

** $p < 0.01$; * $p < 0.05$; + $p < 0.10$; [a] USD 1 ≈ ILS 3.69.

5. Discussion

5.1. Summary and Discussion of Results

In this paper, we investigate the impact of an antismoking pricing policy implemented in Israel on smokers' behavior by assessing changes in their households' consumption of tobacco products. The pricing policy involved significant tax increases on both RYO tobacco and factory-made cigarettes, further amplifying an existing price gap between these tobacco products. We argue that by examining the change in smoking expenditures of these households, we can learn about meaningful shifts in smoking-related behavior.

Contrary to the desired effect, we found no negative association between the introduction of the policy and overall tobacco consumption, measured either in grams of tobacco or in the number of cigarettes. We also found a significant increase in the likelihood of households consuming RYO cigarettes, with no decrease in the likelihood of consuming factory-made ones. In this respect, the findings of the present study are in line with a study reporting no decrease in consumption but rather high levels of substitution between products [7]. Beyond substitution, a potential explanation for the lack of a decrease in consumption was suggested in a UK study, arguing that manufacturers raised their selling prices when tax increases were limited. However, they restrained their own price increases

during periods of tax increases [63], thereby smoothing price fluctuations to control shifts in demand. Another study identified a consumer strategy in the UK market where consumers increased their RYO tobacco consumption but decreased the amount of tobacco in each of their rolled cigarettes compared with the amount of tobacco used for RYO cigarettes in the US and Canada, where tobacco is less expensive [14].

We also found that the policy was positively associated with the number of RYO cigarettes, although it was only marginally significant. However, it was not associated with a desired decrease in factory-made cigarettes smoked. Studies in other countries with asymmetries in pricing policies between RYO tobacco and factory-made cigarettes, such as Australia, New Zealand, and the UK, also reported an increase in RYO tobacco consumption [39,64,65]. However, these studies reported a simultaneous decrease in factory-made cigarette consumption or in overall tobacco demand, which was not recorded in the present study. This discrepancy may be ascribed to varying substitution levels arising from disparate tax rates applied to RYO tobacco and factory-made cigarettes. Accordingly, a study examining European Union markets revealed pricing policies for both product categories, but these policies perpetuated the price gap between them [66].

The results presented in Table 6 illustrate a strong association between income and the tobacco product of choice, such that there is a significant association between income and the number of factory-made cigarettes ($\beta = 0.18$; $p < 0.01$), but not with RYO cigarettes ($\beta = -0.07$; $p > 0.1$). These findings are in line with prior research conducted in Australia, where no significant association between socio-economic indicators and RYO tobacco was evident [64].

The meaning of an increase in RYO cigarette consumption has bearings on the time spent smoking because rolling a cigarette is estimated at 53 s [41]. Before the pricing policy, the estimated time spent rolling the average number of RYO cigarettes per household per month (8.57 cigarettes) was 7.57 min. After the introduction of the policy, the average number of cigarettes increased to 55.9, and the time spent rolling these cigarettes increased to almost 50 min per month, an increase of approximately 553%. Rolling prevents consumers from engaging in other, less negative activities and pushes them to spend more time in smoking areas. The literature suggests that time spent in smoking areas contributes to the formation of smoking-related social connections, which negatively affect smoking cessation attempts and consequently has a considerable damaging effect on smokers. Based on prior studies that accentuate the social consequences of RYO rolling and smoking, we argue that this increased time spent rolling cigarettes creates a vicious cycle that is more difficult to exit than to quit smoking factory-made cigarettes. In other words, not only did the policy not decrease total tobacco consumption and factory-made cigarette smoking, it seems to have had counter-effective consequences by nudging individuals to experiment with RYO cigarette smoking that is harder to quit because of social consequences. Such social consequences include belonging to a group and taking part in social rituals associated with RYO tobacco smoking that are particularly engaging [15,42,43].

5.2. Policy Implications

The research findings offer public policy implications. Policymakers must consider changes in consumer behavior resulting from tobacco pricing policy changes. Specifically, changes in tobacco taxation should be such that they do not accentuate existing gaps between tobacco products. Such pricing gaps encourage consumers to buy cheaper products, which may be no less, and perhaps more, harmful to their health. As previous research has shown, price differences in tobacco products significantly influence purchasing patterns [20]. Therefore, taxation on RYO tobacco should be structured to ensure that consumers do not perceive any price disparities. Policymakers should also consider establishing a liability and compensation fund to which tobacco companies must allocate funds derived from sales of their highly popular tobacco products. Such a policy has two advantages. First, tobacco companies that must allocate capital to the fund will likely raise the prices of these

products, making them less affordable. Second, the accumulated contributions can help alleviate healthcare expenses resulting from smoking-related health hazards.

5.3. Limitations

Our research has several limitations. First, tobacco product markets are complex and encompass multiple stakeholders; the latter also vary in interests and market behavior across countries [20]. As such, a holistic analysis of these markets to avoid biases poses a considerable challenge that cannot be fully addressed in the present study. For example, we excluded some households from the analyses because of missing values (see Section 3.2). Furthermore, the available data did not allow us to examine the effect of the pricing policy on the same household before and after the introduction of the policy. Information regarding the specific brands procured by the households was unavailable, preventing us from investigating to what extent households replaced expensive cigarette brands with cheaper brands. Additionally, we had no data on tobacco consumption by minors under 18 years old or by soldiers. Minors under 18 years old and soldiers might be more sensitive to price changes and social influences. If included in our sample, the introduction of the policy might have had a more substantial impact on the number of RYO and factory-made cigarettes consumed and on the time devoted to RYO cigarette rolling.

5.4. Future Research Opportunities

The limitations in this study create opportunities for future research. First, recent studies have used machine learning to cope with global tobacco product markets' complexity. Future research can utilize machine learning and artificial intelligence cutting-edge techniques to address complex issues and markets, e.g., [18,67] and to improve inter- and intra-state tobacco control. Second, given that youth and young adults are specifically targeted by tobacco companies [9], and given their limited income, the susceptibility of these populations to pricing policies should be further investigated. Finally, RYO tobacco remains popular among smokers [12], even in the face of the growing popularity of heated tobacco products. Future research should investigate the factors influencing sustained RYO tobacco use, particularly among more vulnerable low-socio-economic groups. Given the heightened likelihood of imitation behavior and social smoking, particularly prevalent within low-socio-economic populations, future research should focus on developing effective intervention strategies to address these specific patterns of RYO tobacco use.

6. Conclusions

The present research illustrates that a pricing policy aimed at reducing tobacco consumption had an unforeseen impact on households with smoking individuals. The results indicate that the pricing policy did not lead to an expected decrease in overall tobacco consumption by smokers or in the total number of cigarettes smoked. However, it was positively linked to the likelihood of smoking households choosing to smoke RYO cigarettes and the number of RYO cigarettes consumed. This increase in RYO tobacco consumption was not accompanied by a decrease in the likelihood of smoking factory-made cigarettes or the number of factory-made cigarettes consumed.

We argue that the act of rolling cigarettes has a notably adverse impact. This is due to its role in increasing the daily time allocated to smoking-related activities and the duration spent within the social circles of RYO cigarette smokers. Consequently, a policy that effectively encourages consumers to transition from factory-made cigarettes to RYO cigarettes could potentially worsen the issues associated with smoking rather than alleviate them.

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Data Availability Statement: Publicly available datasets were analyzed in this study. These data can be requested from the Israel Central Bureau of Statistics here: https://www.cbs.gov.il/en/Surveys/Pages/Household-Survey.aspx.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Tobacco products' pricing policies and major price shifts by tobacco companies, 2011–2016 (in ILS [a]). Authors' summary based on data from the Israel Ministry of Finance (2018) and the Israel Ministry of Health (2018).

Date	Cigarettes					RYO Tobacco	
	Pricing Policies [b]				Tobacco Firms	Pricing Policies [b,c]	Tobacco Firms
	Ad Valorem Tax [d]	Specific Tax [e]	Total Tax [f]	Minimum Tax [g]	Price Increase	Specific Tax	Price Increase
Before December 2011	260.60%	4.29	4.29 + 2.61 WP	9.50	-	3.66	-
December 2011	-	-	-	-	-	3.91	-
February 2012	-	-	-	-	-	4.01	-
July 2012	278.60%	5.49	5.49 + 2.79 WP	12	-	-	-
January 2013	-	-	-	-	-	4.07	-
May 2013	270.00%	7.83	7.83 + 2.70 WP	15	-	6.30	-
December 2013	-	-	-	-	1	-	-
January 2014	-	-	-	-	-	6.42	-
December 2014	-	-	-	-	2	-	-
January 2015	-	-	-	-	-	6.41	-
July 2015	-	-	-	-	1	-	-
May 2016	-	-	-	-	1	-	2

[a] USD 1 ≈ 3.69 ILS. Per pack of 14 gr for cigarettes and 40 gr of RYO tobacco. [b] Excluding VAT because the VAT is equal for all tobacco products. [c] Equivalent to a pack of cigarettes. [d] Calculated as a percentage of the wholesale price (WP), as determined by the importer or by the local manufacturer. [e] The fixed tax rate per pack. [f] The total tax is a sum of the specific tax and the AD valorem tax. For example, if the wholesale price (WP) is 10 ILS, then the total tax of a cigarette pack in 2013 was 34.83 ILS (7.83 + 2.70 × 10). [g] The total tax cannot be under the minimum tax per pack.

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