

**Global demand for cigarettes: a cross-country analysis of consumption, income,
and price elasticity; 2008-2012**

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A thesis

submitted in partial fulfillment of the
requirements for the degree of

Master of Public Health

University of Washington

2015

Committee:

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Program Authorized to Offer Degree:

School of Public Health – Department of Global Health

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Abstract

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Background: Tobacco taxation remains an effective but under-utilized means to reduce the burden of smoking-related diseases globally. Estimates of price elasticity of demand (PED, or price sensitivity) for cigarettes vary widely across countries and studies, and recent reports suggest that variations in the intensity of cigarette consumption influence price sensitivity. I sought to explore cross-country variations in PED accounting for variations in the relationship between smoking intensity, price, and income level.

Methods: I obtained Global Burden of Disease 2013 estimates of per capita cigarette consumption in 181 countries over five years (2008 – 2012). I obtained data on average price per pack of cigarettes in each country-year. I included, as controls, per capita gross domestic product (GDP) as a proxy for income as well as data on other tobacco policies. I used quantile regression to model PED for cigarettes across varying levels of cigarette consumption, and I assessed statistical significance using robust standard errors. I

visualized the results using simulation techniques and generated “predicted” elasticities for individual countries based on the model.

Results: I estimated that the PED for cigarettes was -0.15 on average over 2008 – 2012, though it was smaller in low- and high-consumption settings. I found a synergistic negative impact of price and country income on demand. Hence low income countries were expected to be less price sensitive as the intensity of smoking increased, while high income countries were expected to be more price sensitive. The countries in the dataset with the weakest predicted PED were predominantly in sub-Saharan Africa, where smoking intensity low-to-moderate as compared with other regions. My results were robust to the exclusion of an interaction between price and income, and the model produced similar results when applied to individual years within the dataset.

Conclusions: Globally, there is significant heterogeneity in PED for cigarettes. Countries where the intensity of smoking is very high or low are less price-sensitive than moderate-consumption countries. Furthermore, wealthier countries are more price-sensitive than poorer countries. These findings raise concerns about the relative effectiveness of raising cigarette prices in lower income settings in the absence of robust non-tax tobacco policies.

INTRODUCTION

Exposure to tobacco smoke is the second most important risk factor for morbidity and premature mortality worldwide. In 2010, smoking accounted for 5.7 million direct deaths, with an additional 601,000 deaths attributed to secondhand smoke.¹ One study recently reported that despite 10% absolute reduction in the prevalence of smoking between 1980 and 2013, the number of regular smokers increased by 246 million, driven in large part by population growth in South and East Asia.² Another recent forecasting study estimated that, if current trends continue, most countries will not meet tobacco control goals by 2025, disparities in smoking rates between high-income and low- and middle-income countries will persist, and large increases in tobacco use will be observed, particularly in the African and eastern Mediterranean regions.³

The Framework Convention on Tobacco Control (FCTC), which was adopted in May 2003 and came into effect in February 2005, established a supranational legal structure for reducing tobacco consumption in UN Member States through a combination of taxation, regulation, and bans, among other measures.⁴ Building on the FCTC, the World Health Organization released the MPOWER tool in 2008 to guide policymakers in scaling up tobacco control measures in several key domains. MPOWER policy domains include (1) Monitoring the burden of smoking and policy implementation; (2) Protecting the public from smoking (e.g., by banning smoking in public places); (3) Offering assistance for smokers to quit; (4) Warning about the dangers of smoking, e.g., through media campaigns; (5) Enforcing tobacco regulation, particularly through advertising restrictions; and (6) Raising the price of tobacco to 70% above the final retail price using excise taxes. Of the MPOWER components, taxation is widely regarded as the single most effective policy approach to reducing demand for tobacco products.⁵

Unfortunately, in low- and middle-income countries, taxation is often under-utilized,⁶ and one recent analysis found that cigarettes are actually becoming more affordable in many settings.⁷ To date, only 32 countries have met the MPOWER price target, and 95

countries have minimal or no taxation policies in place.⁴ In some countries, financial arrangements between governments and the tobacco industry – including state ownership of tobacco production – may be barriers to tax increases.⁸ In others, concerns about the regressiveness of taxation are sometimes cited as reasons not to increase cigarette prices.⁹ Regressiveness, in the context of tobacco taxation, refers to the possibility that poorer individuals are less able to cope with price increases and bear more of the burden associated with increased tobacco taxation. While individuals of all income groups may continue to smoke after an increase in prices or taxes, the increase will be larger, relative to one's income, for the poor, and they are more likely to experience undue financial hardship.¹⁰

In order to understand the true health gains and the potential regressiveness of an increase in tobacco prices, the price elasticity for the demand (PED) of cigarettes must be known. A relatively "elastic" demand for cigarettes would indicate that changes in prices have substantive effects on the change the demand for cigarettes, and rather than imposing undue financial hardship, the price increase would improve health. Alternatively, a relatively "inelastic" demand for cigarettes would indicate that individuals are not responsive to changes in prices of cigarettes and that a price increase or tax will not affect smoking prevalence, not affect health outcomes, and that the poor will face financial hardship as the cost of smoking will, in relative terms, be paid mostly by them.

A commonly-cited meta-analysis by Gallet and List assessed studies of PED for cigarettes and concluded that a 10% increase in price is, on average, associated with a 4.8% lower prevalence of smoking.¹¹ Similarly, an analysis by Blecher and colleagues compared prices across a range of country income levels and found that a 10% increase in price was associated with 5.3% fewer cigarettes consumed per capita.⁷ However, one aspect that is missing in the existing literature is whether and how price elasticity differs across consumption levels. Studies on PED on cigarettes have historically focused on high-income countries, where consumption levels are generally high. In recent years, an

increasing number of studies have focused on developing nations, though these studies have also been conducted in countries with high consumption, such as China,^{12,13} Ukraine,¹⁴ and India.¹⁵ Although these results appear to suggest that the magnitude of PED is comparable across high-, middle- and low- income countries,^{8,10} other studies have demonstrated heterogeneity in price elasticity of demand according to intensity of tobacco consumption.^{16,17}

Understanding the variation in PED across different consumption levels is pertinent to developing context-specific fiscal policies. In this study, I take a closer look at the association between intensity of tobacco consumption and price across different levels of consumption and national income across 181 countries. I apply quantile regression techniques to the largest contemporary analysis of cigarette consumption to reveal the heterogeneity in global PED for cigarettes.

METHODS

Data sources

I compiled a dataset on tobacco consumption, price trends, and policies using three major data sources. First, I obtained country-level time series data on cigarette consumption. Ng and colleagues² recently estimated trends of smoking prevalence and cigarette consumption in 187 countries over 1980 – 2013. I extracted from this dataset the average number of cigarettes consumed per capita per day in a given country-year. Per capita consumption was calculated using estimates of total consumption and the size of the population 10 years and older in each country-year. This age cutoff was selected since the number of cigarettes smoked in children under 10 years is very small, and including children in the population at risk of smoking might bias per capita estimates downward depending on a given country's population structure.

Second, I obtained data on cigarette sales from work done by a former master of public health candidate at the University of Washington.¹⁸ These price data were derived from the Euromonitor database of aggregate cigarette sales¹⁹ and converted into 2012 international (purchasing power parity, PPP) dollars. In addition to using PPP prices to adjust for buying power across countries, I incorporated per-capita GDP (2012 international dollars) in my models as a proxy for country income level. The latter data were obtained from a series that was developed for the Global Burden of Disease 2010 study.²⁰

Finally, to detect more accurately the unique influence of price on consumption amidst the multitude of concurrent tobacco control efforts, I used data from a recent WHO tobacco control report²¹ to determine whether a given country at a given time had achieved “highest-level” status⁴ on one or more of the Protect, Offer, Warn, or Enforce policy areas described in the MPOWER report. For instance, if a country had legislated “strong” health warnings on cigarette packaging (i.e., a graphic warning covering at least 50% of the package), that country would be coded “yes” for the Warn covariate in that year and every year thereafter; however, a country that had only legislate weak warnings (or no warnings at all) on cigarette packaging would be coded as “no” for the Warn covariate in that year. We chose not to include Monitor policies (i.e., those policies related to tracking and surveying tobacco use) in my models, because they, in theory, should not be causally and independently associated with lower cigarette consumption. Although all of these variables are an imperfect measure of the policy environment in a given country, they serve as proxies for the intensity of other, non-price tobacco policies.

Modeling approach

My model of PED for cigarettes had the following form:

$$\ln(\text{consumption}_{it}) = \beta_0 + \beta_1 \ln(\text{price}_{it}) + \beta_2 \ln(\text{GDP}_{it}) + \beta_3 \ln(\text{price}_{it}) * \ln(\text{GDP}_{it}) + \beta_4 P_{it} + \beta_5 O_{it} + \beta_6 W_{it} + \beta_7 E_{it} + \sum_{k=1}^4 \gamma_k I_k + \epsilon_{it}$$

where consumption_{it} refers to cigarettes per capita per day for country i at year t , price_{it} is the average price of cigarettes per pack, GDP_{it} is per capita gross domestic product, and P_{it} , O_{it} , W_{it} , and E_{it} are the four indicator variables for whether a country had achieved “highest-level” status on the related MPOWER measure in the given year. I_t are year indicators representing the year (with 2008 as the reference) to capture secular trends in tobacco consumption. Of particular interest to this analysis is the quantity $\beta_1 + (\beta_3 * \ln(\text{GDP}))$, which is the PED specific to each level of GDP. To facilitate interpretation, I centered $\ln(\text{GDP}_{it})$ around the mean value in the dataset so that β_1 can be interpreted as the PED for a country at the mean GDP.

I then used quantile regression (QR) to estimate my model at five quantiles of cigarette consumption (denoted as values of τ),^{16,17} namely the 10th, 25th, 50th, 75th, and 90th, i.e., $\tau = 0.10, 0.25, 0.50, 0.75, \text{ and } 0.90$. The advantage of QR over subgroup analysis is that the former uses information from the full sample to generate estimates for conditional quantiles of the dependent variable; in this case, cigarette consumption. Hence there is no loss of degrees of freedom that would result from splitting the sample into various quantiles.¹⁶ For comparison purposes, I also fitted a more general model using ordinary least squares (OLS). For both QR and OLS results, I used heteroskedasticity-consistent standard errors to test the statistical significance of coefficients.

Because I found that PED varied widely across consumption levels and that interpretation of the quantity $\beta_1 + (\beta_3 * \ln(\text{GDP}))$ was cumbersome, I used simulation techniques to visualize my model results and provide country-specific predictions of PED.²² First, to visualize the interaction between price and income, I estimated PED across the 5th – 95th quantiles of consumption in four scenarios: the average per-capita GDP of low income, lower-middle income, upper-middle income, and high income countries. I otherwise held all non-price covariates at their global means.

Second, I predicted PED for 179 countries in the year 2012 using observed GDP and non-tax policy levels in that year. (I excluded two countries for which I did not have cigarette price data for 2012.) In both the region- and country-level simulations, I used global maximum vs. minimum cigarette prices to estimate (counterfactual) consumption levels, then I calculated the slope between these values, which I interpreted as the region's or country's PED, respectively. I incorporated model uncertainty by repeating this analysis over 1000 draws from the Multivariate Normal distribution using the mean regression coefficients and their heteroskedasticity-consistent variance-covariance matrix.²²

Ethical considerations

The use of these published datasets was self-certified as "not human subjects research" on October 15th, 2014 according to the criteria of the University of Washington's Institutional Review Board (Human Subjects Division).

Table 1. Descriptive statistics of the countries in the dataset, according to World Bank income group.

	Country-years of observation	Mean (95% CI) consumption*	Range	Mean (95% CI) price**	Range
Total sample	900	2.8 (2.73, 2.99)	0.1 – 8.7	3.44 (3.25, 3.63)	0.12 – 18.17
Low income countries	170	0.9 (0.80, 1.20)	0.1 – 3.2	1.51 (1.41, 1.61)	0.12 – 3.55
Lower middle income countries	220	2.4 (2.16, 2.60)	0.1 – 7.1	2.37 (2.14, 2.61)	0.43 – 9.83
Upper middle income countries	250	3.3 (3.07, 3.53)	0.4 – 7.6	3.16 (2.90, 3.44)	0.17 – 12.07
High income countries	260	4.1 (3.91, 4.33)	1.1 – 8.7	5.87 (5.47, 6.29)	0.64 – 18.17

* Consumption: daily number of cigarettes consumed per person aged 10+ years

** Prices are in 2012 international (PPP) dollars

95% confidence intervals (CI) of the mean obtained by bootstrap resampling (n = 100,000)

RESULTS

Main findings

My final dataset (Table 1) contained information on 181 countries measured over five years, and it was complete except for missing price value for Libya (2012), and Argentina (2008 – 2010 and 2012), so these data points were excluded.

Table 2. Results of the main model of price elasticity of demand for tobacco in the entire sample (OLS) and across quantiles (τ) of consumption.

	OLS	Quantile Regression				
		$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$
ln(price)	-0.15 (0.04)	0.13 (0.09)	-0.11 (0.04)	-0.22 (0.05)	-0.12 (0.04)	-0.11 (0.08)
ln(GDP)	0.55 (0.04)	0.56 (0.06)	0.60 (0.04)	0.57 (0.04)	0.44 (0.03)	0.45 (0.02)
ln(price) * ln(GDP)	-0.04 (0.03)	0.00 (0.06)	-0.04 (0.02)	-0.09 (0.02)	-0.14 (0.03)	-0.13 (0.01)
"P" policy	-0.26 (0.09)	-0.57 (0.22)	-0.29 (0.13)	-0.13 (0.08)	-0.03 (0.10)	0.04 (0.03)
"O" policy	0.13 (0.08)	0.04 (0.22)	0.29 (0.15)	0.11 (0.07)	0.02 (0.07)	-0.17 (0.04)
"W" policy	-0.05 (0.08)	-0.22 (0.20)	0.06 (0.16)	-0.03 (0.06)	-0.21 (0.07)	-0.21 (0.03)
"E" policy	-0.17 (0.08)	0.23 (0.14)	-0.06 (0.06)	-0.32 (0.05)	-0.22 (0.06)	-0.41 (0.03)
year 2009	0.02 (0.08)	0.06 (0.17)	0.02 (0.06)	0.02 (0.08)	0.00 (0.08)	0.01 (0.05)
year 2010	0.03 (0.08)	0.06 (0.18)	0.03 (0.07)	0.02 (0.09)	0.02 (0.08)	0.03 (0.05)
year 2011	0.05 (0.08)	0.06 (0.18)	0.01 (0.09)	0.03 (0.09)	0.03 (0.08)	0.02 (0.06)
year 2012	0.05 (0.08)	0.07 (0.19)	0.01 (0.08)	0.03 (0.08)	0.04 (0.08)	0.03 (0.05)
Intercept	0.88 (0.07)	-0.41 (0.13)	0.37 (0.08)	1.09 (0.09)	1.53 (0.07)	1.81 (0.05)

OLS = ordinary least squares; GDP = per capita gross domestic product
Robust standard errors given in parentheses, **bolded** values indicate $p < 0.05$

My main findings are provided in Table 2. Using OLS, I estimated the global average PED to be -0.15. This means that a 10% increase in price per pack is associated, on

average, with a 1.5% reduction in cigarettes consumed per capita. However, the OLS results do not take into consideration how countries with different levels of cigarette consumption might respond differently to changes in prices. Hence I used QR to estimate the variation in PED across five important quantiles: the 10th, 25th, 50th, 75th, and 90th.

In general, the QR results demonstrated that increasing intensity of consumption was associated with greater price sensitivity, as is indicated by the trend in the coefficients on $\ln(\text{price})$, though countries at the highest quantiles of consumption were less price-sensitive than those of moderate consumption. In addition, the model estimated a synergistic effect of increasing price and income on PED, as is indicated by the trend in the coefficients on $\ln(\text{price}) * \ln(\text{GDP})$. These results suggest that, all else being equal, wealthier countries are slightly more responsive to changes in price. Both the main effect of price and the price-GDP interaction were statistically significant at all but the lowest quantile of consumption. Appendix 1 displays, in graphical form, the trends in these coefficients across all quantiles.

Four counterfactual simulations (Figure 1) demonstrate the substantive significance of the relationship between price, income, and consumption intensity as well as the interaction of price and income. Holding other policies constant, there are countervailing trends in the relationship between price elasticity and consumption intensity at different levels of income. Most importantly, a typical low income country is expected to be less price-sensitive at high levels of smoking intensity, whereas a typical high income country is expected to be more price-sensitive at high levels of smoking intensity. Furthermore, low income countries have positive (and often non-significant) elasticity estimates, which suggests that increases in price could be less effective at reducing smoking in these settings. Lower-middle and upper-middle countries have less variation in price elasticity across levels of consumption.

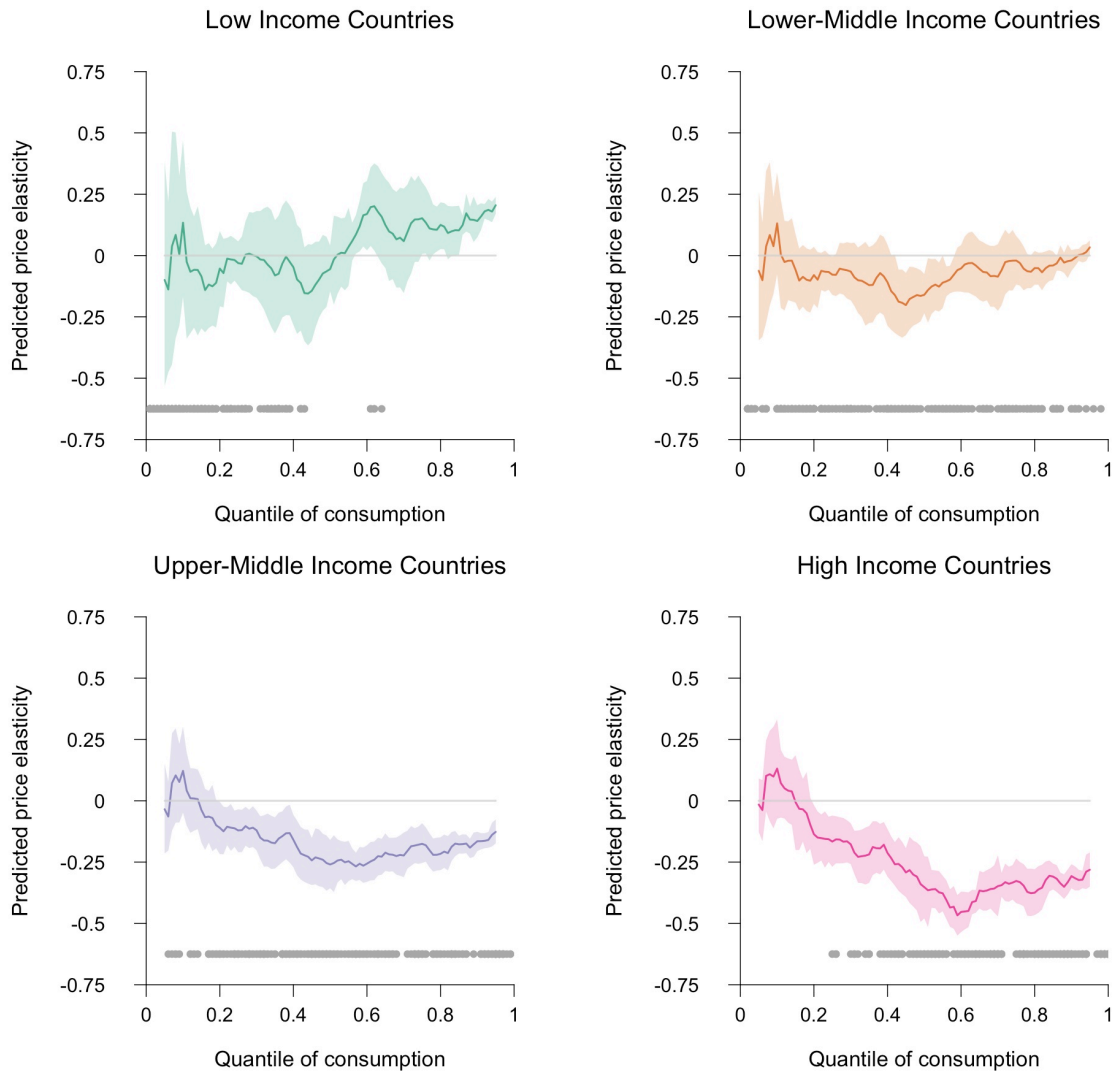


Figure 1. Visualization of the relationship between price elasticity of demand and smoking intensity in hypothetical countries at mean per-capita GDP in each of the four World Bank income groups. 95% confidence intervals of elasticity estimates are shaded. Individual country quantiles of smoking intensity in the countries included in the dataset are provided as grey points below each graph.

I also used my model to predict country-specific price elasticity estimates using observed data from 2012 (Figure 2). Again, I found a high degree of heterogeneity in price elasticity estimates depending on intensity of consumption and per capita income.

Generally, the least price-sensitive nations were low and lower-middle income countries, with the most extreme estimates in very poor sub-Saharan African nations. Conversely, the most price-sensitive nations were high income countries, especially those in central and northern Europe, the United States, and a few of the wealthy Middle Eastern nations. Appendix 2 provides the predicted elasticities for all countries and includes their uncertainty intervals.

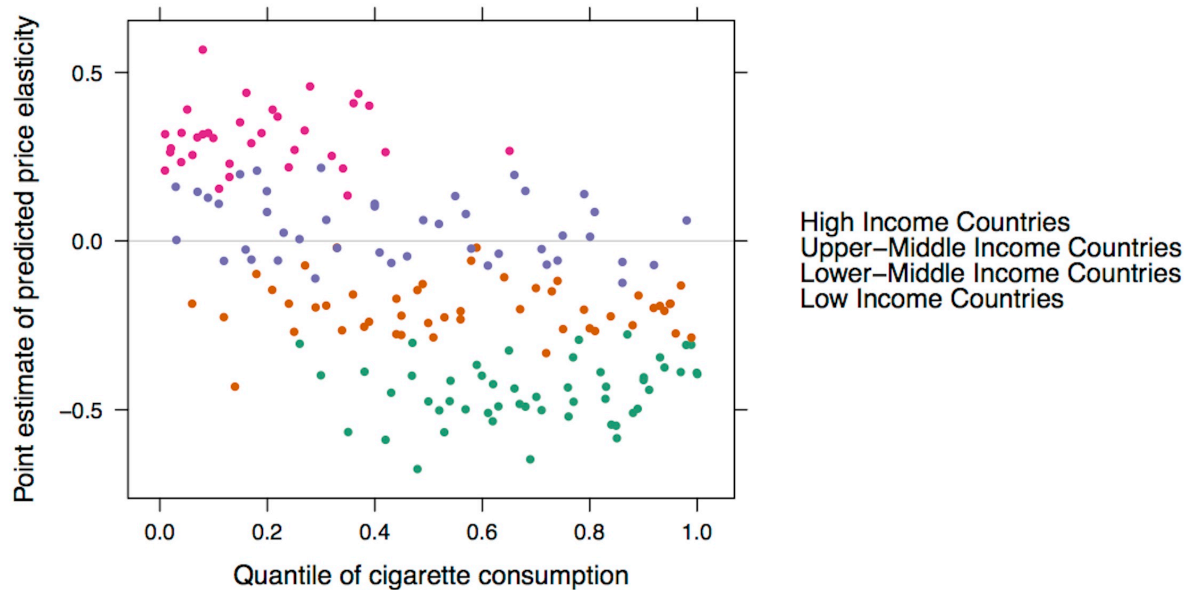


Figure 2. Predicted price elasticity of demand for 179 countries in 2012, clustered by the four World Bank income groups. The numerical estimates for each country, including 95% confidence intervals, are provided in Appendix 2.

Robustness checks

I conducted two additional analyses to assess the robustness of my findings. I first fit a model similar to the one described above, except it did not include an interaction term. I then fit QR models on cross-sectional data from 2008 and 2012. The results of these robustness checks were similar to those in the main model and did not substantively alter my conclusions about the data. More details of these models are given in Appendix 3.

DISCUSSION

I have conducted the first cross-national analysis of the variation in price elasticity of demand for cigarettes according to intensity of smoking. My modeling strategy not only measures PED at various levels of consumption, but it also accounts for the complex relationship between price and country income and its effect on price sensitivity. I found that the inter-relatedness of price, income, and smoking intensity explains much of the observed heterogeneity in PED globally. I was able to make use of the largest and most comprehensive set of estimates of global tobacco consumption patterns to explore variations in PED across nearly all countries. Three important findings emerge from the analysis.

First, I estimated the PED for cigarettes to be comparable to but lower than prior studies. At average income and policy coverage level, price elasticity was -0.15 (OLS). This estimate varies substantially according to intensity of consumption, with moderate consumption countries being the most elastic (-0.22 at $\tau = 0.50$) compared to low consumption countries (0.13 at $\tau = 0.10$) or high consumption countries (-0.11 at $\tau = 0.90$) at average income. By comparison, Gallet and List¹¹ report a mean elasticity of -0.53 in their meta-analysis, while Jha²³ in his review of the elasticity literature reports a range of -0.25 to -0.80, depending on country income level. There are several explanations for the discrepancies. For one, as noted earlier, many prior studies focus on high consumption countries, which do have greater PED than low consumption countries on average. Also, previous studies have typically not taken into account the presence of other non-tax tobacco control interventions, which if not adjusted for would (in principle) result in higher measured PED. Finally, by including an interaction term in my model, I assumed elasticity for any given country will also depend on its income level, and in fact, for wealthier countries that have been extensively studied, my predicted elasticities were generally higher (e.g., -0.28 to -0.68 in high income countries, Appendix 2).

Second, my results contribute substantially to the two prior studies that employed quantile regression to estimate cigarette PED. First, Goel and Ram¹⁶ estimated price elasticity using state-level per capita cigarette consumption across multiple cross-sectional surveys in the United States. They reported a 33% more negative elasticity in the 25th percentile of consumption as compared to the 75th percentile. In other words, they found that low-consumption states were more price-sensitive than high-consumption states. In contrast to this study, Chen and colleagues¹⁷ in Taiwan used individual-level survey data to estimate elasticity, employing a selection model to identify smokers first. They reported a 100% less negative elasticity in the 25th percentile of consumption as compared to the 75th percentile. In other words, they found that low-consumption individuals were less price-sensitive than high-consumption individuals. My analysis identified a modest reverse “j-shaped” trend in price sensitivity at mean GDP (Appendix 1, panel a) that argues that both prior studies may be capturing part of a larger, perhaps quadratic, trend at a global level.

Third, and possibly most importantly, I identified a synergistic interaction between the price per pack of cigarettes and per-capita GDP (income) in a given country (Appendix 1, panel b) such that, all else equal, wealthier countries are expected to be more price-sensitive than poorer countries. This interaction explains the differences in PED, e.g., between heavier-consumption, less-developed countries and heavier-consumption, more-developed countries. By contrast, lighter-consumption low- and middle-income countries all demonstrated relatively similar PED (Figure 1). The interaction term was found to be statistically significant in nearly all quantiles of consumption, and the elasticity estimates were similar in a model that did not include such an interaction (Appendix 3), suggesting that its inclusion is justified.

My results also have relevance to tobacco taxation policy in low- and middle-income countries. It is of particular concern that 59 of the 179 countries for which I predicted elasticity had “positive” estimates (Appendix 2). All of these were low income or lower-middle income nations, and most were in sub-Saharan Africa. For these countries, the

results suggest that additional increases in price would not be effective at reducing cigarette consumption. While these results need to be validated by more individual-level studies within low- and middle-income countries, they do suggest that tax policy should be more judiciously applied in low-income countries, many of which are not particularly high-consumption settings (Figure 2). In such countries, the economic side effects of taxation – particularly among the poor – may be more pronounced than they would in moderate-consumption countries. Hence, in very poor countries and lower-consumption middle income countries, non-tax intervention may be more urgent and effective relative to taxation. To this end, I found some statistical evidence that achievement of highest-level MPOWER policies was associated with significantly lower consumption (Table 2; Appendix 3). However, these non-tax policies were incorporated as crude controls and were not the focus of my analysis.

This study has several important limitations. I used aggregate cross-sectional data pooled over several years, hence my analysis is ecological by design, and individual-level trends among smokers may be different than those I measured. Also, my approach could not fully address concerns over endogeneity. QR estimates have been demonstrated to be biased in the presence of lagged dependent variable regressors and fixed effects,²⁴ which are techniques commonly used in panel data analyses to reduce the potential for endogeneity. Because of these concerns, I chose to pool the data and incorporate indicator variables for each year to account for secular trends. Finally, there were several sources of uncertainty in the dataset, including 1) reliance on fully modeled (imputed) estimates of tobacco consumption for some countries,² 2) potential measurement error in both the consumption estimates and the Euromonitor tobacco sales data, and 3) relatively crude control variables for the presence of non-price tobacco policies.

I have identified a few next steps in this research. First, the overall model fit may be improved by additional covariates. A major unobserved confounder in this model may in fact be age. Younger smokers are generally thought to be more price-sensitive than older

smokers,⁸ so I hope to obtain data that can reflect the average age of smokers in each of these countries. This variable would also need to be interacted with price, making the model more complex. Second, I hope to check the accuracy of my simulated (predicted) PED for each country by reading more about QR theory. The fact that several countries had positive predicted PED raises concern over a coding error in my simulations or perhaps model misspecification. Thirdly, I acknowledge that the legal market for cigarettes (the focus of this analysis) is only one aspect of the global tobacco burden; black market cigarettes and non-cigarette tobacco products (e.g., bidis in India) may be important confounders in particular settings but are outside the scope of this analysis. Finally, although this is primarily a study of taxation, more granular data on the non-tax policy environment would likely improve the fit of this model. Ongoing multi-country evaluations are attempting to measure the effectiveness of non-tax tobacco policies and their relative impact compared to taxation in a handful of less-developed nations.²⁵

CONCLUSIONS

This preliminary analysis found that PED for cigarettes varies substantially across the world and is influenced, not only by levels of price and income, but also by the intensity of smoking in a given country. Price and income exert synergistic negative effects on demand at all levels of consumption, with wealthier countries being much more price-sensitive than poorer countries. My results suggest that, at current price levels, further increases in tobacco taxes will be most effective in upper-middle and high income countries. Hence poor countries may wish to place a particular emphasis on non-tax policies such as bans, warnings, and cessation programs. The next steps for my model will be to incorporate data on average smoker age in each country to ensure that age is not a confounding variable. Future studies on the impact of tobacco policies should also include low income settings, which have historically not been the focus of tobacco economics research.

ACKNOWLEDGEMENTS

I would like to acknowledge Ruben Conner, who gathered the data on cigarette prices for a separate analysis of PED. I would also like to thank the members of my masters thesis committee (Marie Ng, Joe Dieleman, and Rachel Nugent) for providing invaluable guidance during this project and for their helpful comments on earlier drafts of this thesis.

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