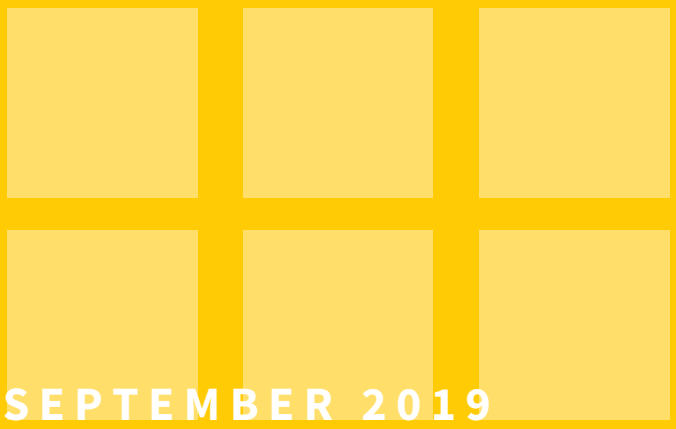
WILLIAM DAVIDSON INSTITUTE
AT THE UNIVERSITY OF MICHIGAN

Revenue Estimates from Taxing "Bads" in 16 Low- and Middle-Income Countries



SEPTEMBER 2019

Ben Davis, ***William Davidson Institute at the University of Michigan***
William Savedoff, ***Center for Global Development***
Pascale R. Leroueil, ***William Davidson Institute at the University of Michigan***

wdi.umich.edu

Background

There is strong support in the literature for an inverse relationship between taxes on "bads", such as tobacco and alcohol, and consumption of these products.[1,2] Although taxes on "bads" are often present in low- and middle-income country (LMIC) tax codes, low tax rates limit the potential benefits of decreased consumption, reduced product-related morbidity and mortality, and additional government revenue.

Several researchers have estimated the health and revenue benefits of raising tax rates on "bads" in LMICs. For tobacco, Chapters 4 and 5 of *The Economics of Tobacco and Tobacco Control* provide a comprehensive review of the literature related to health and revenue benefits of tobacco taxation.[3] As an example, Goodchild, Perucic, and Nargis estimate that an excise tax increase of one international dollar (I$) per 20-cigarette pack worldwide would lead to an 18% reduction in cigarette consumption and a I$ 190 billion increase in excise tax revenue.[4] For alcohol and sugar-sweetened beverages (SSBs), Stacey *et al.* estimate that an excise tax on beer of 27% and on SSBs of 20% in South Africa could lead to a total gain of approximately 1.26 million life years over a 30-year period and generate total additional revenue of 19.4 billion ZAR per year.[5] More recently, Summan and Laxminarayan estimated that a tax on tobacco, alcohol, and SSBs that increases retail price by 50% will "avert over 50 million premature deaths while raising over US$20 trillion of additional revenues worldwide over the next 50 years."[6]

Concerning the revenue benefits of raising tax rates on "bads", we identified three outstanding issues with existing studies and reports. First, country-level estimates are often based on a small number of data points specific to the target country. If these data points are consistently over- or under-estimated relative to their true values, there will be a negative impact on the accuracy of the final revenue estimate. Second, these studies rely on a "bottom up" calculation method that starts with product consumption. This approach, while valid, does not incorporate available data on current excise tax rates and revenues. Third, these studies provide country-level revenue estimates for only a limited set of LMICs. An expanded set of country-level estimates could facilitate discussions with policymakers in LMICs about the potential benefits of increased excise taxes on "bads."

This white paper is a modest contribution to the existing body of knowledge on potential revenue benefits from taxation of "bads" in LMICs. We seek to provide orders-of-magnitude responses to the questions, "For 16 LMICs, what amount of additional government revenue could have been generated in 2016 if higher excise tax rates had been imposed on tobacco, alcohol, and SSBs?", and "How does this additional government revenue compare to select national economic indicators?" while addressing the outstanding issues mentioned above.

To address the first two issues, we apply a novel approach for "triangulating" each tax revenue estimate. We pool parameter estimates from the target country and scaled parameter estimates from comparable countries and then select a median value to use for subsequent calculations. This process can increase the accuracy of excise tax revenue estimates by reducing reliance on the inputs from any single target country. We then apply both "bottom up" and "top down" calculation methods for each product type and each country. Finally, we report median additional excise tax revenue that is chosen from the full set of estimates from "bottom up" and "top down" calculations.

To address the third issue, we perform calculations for a set of 16 LMICs that span world regions and levels of "bads" consumption.

Our outputs are a set of estimates for additional excise tax revenue under three scenarios and a comparison of these estimates to select economic indicators. Because our method neither accounts for income and cross-substitution effects nor adjusts outputs based on historical experience in raising tax revenues, our most restrictive scenario may still represent an upper bound.

Methods

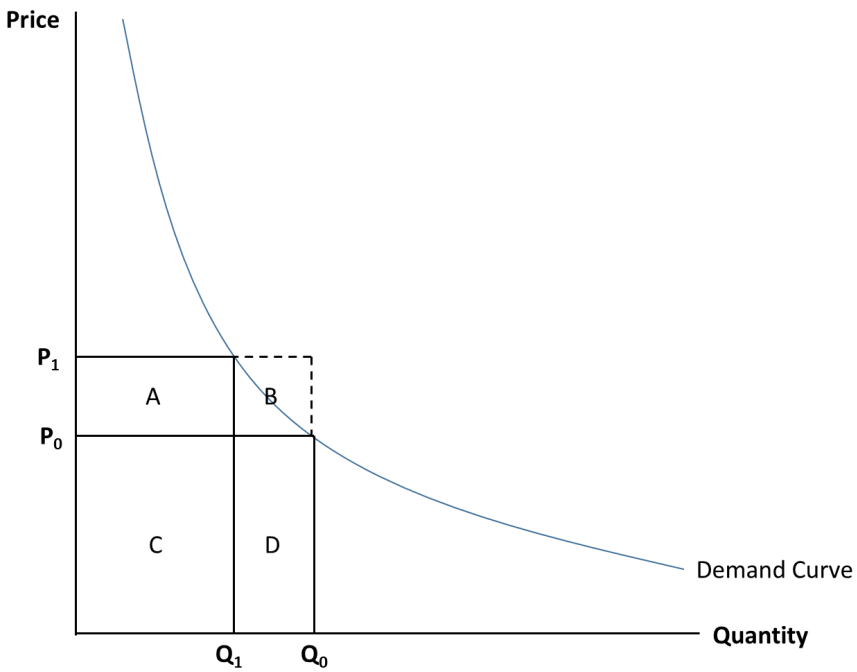
Equations

We first created a set of equations for estimating the additional excise tax revenue that could have been generated in 2016 if higher excise tax rates had been imposed on tobacco, alcohol, and SSBs. Equations rely on basic economic theory and assume that for each product type there is an underlying demand curve characterized by a value for price-elasticity of demand. Price elasticity of demand is used to estimate changes in quantity and revenue, including tax revenue, given changes in price. The equations and variable definitions used for an ad valorem excise tax are provided in Table 1. Figure 1 illustrates the relationship between price, quantity, and revenue for a single product category and country when using the ad valorem equations. The equations and variable definitions used for a specific excise tax are provided in Table 2.

Table 1 Equations and variable definitions for an ad valorem excise tax

Equations		
$R_0 = P_0*Q_0 = V_0 + V_0*T_0 + V_0*M$		
$R_1 = P_1*Q_0 = V_0 + V_0*T_1 + V_0*M$		
$R_2 = P_1*Q_1 = V_1 + V_1*T_1 + V_1*M$		
$E = [(Q_1-Q_0) / Q_0] / [(P_1-P_0) / P_0]$		
Variable Definitions		
R_0	Total sales revenue from products in 2016, in 2016 USD	Output
P_0	Average retail price per unit in 2016, in 2016 USD	Input
Q_0	Total number of units sold in 2016	Output
V_0	Total value of products subject to excise tax in 2016, in 2016 USD	Input
T_0	Current excise tax rate as a percentage on declared value of products during import or when leaving the manufacturing facility (if produced locally)	Input
M	Any taxes (apart from excise tax) and markup added between (a) the moment of import or exit from manufacturing facility and (b) sale to the final customer, applied as a percentage on declared value of products during import or when leaving the manufacturing facility. It is assumed that M does not change with changes in excise tax rate.	Output
R_1	Total sales revenue from products in 2016 using alternative excise tax, not taking into account elasticity of demand, in 2016 USD	Output
P_1	Average retail price per unit with alternative excise tax rate, in 2016 USD	Output
T_1	Alternative excise tax rate as a percentage on declared value of products during import or when leaving the manufacturing facility.	Input
R_2	Total sales revenue from products in 2016 using alternative excise tax, taking into account elasticity of demand, in 2016 USD	Output
Q_1	Total number of units sold in 2016 if the alternative excise tax rate had been in place, taking into account elasticity of demand	Output
V_1	Total value of products subject to excise tax in 2016, if the alternative excise tax rate had been in place, taking into account elasticity of demand, in 2016 USD	Output
E	Price elasticity of demand	Input
Y_0	Excise tax as a percentage of the retail price, based on T_0 and P_0	Input

Figure 1 Relationship between price, quantity, and revenue for a single product category and country



$R_0 = C + D$

$R_1 = A + B + C + D$

$R_2 = A + C$

Table 2 Equations and variable definitions for a specific excise tax

Equations		
$P_1 = P_0 - T_0 + T_1$		
$E = [(Q_1-Q_0) / Q_0] / [(P_1-P_0) / P_0]$		
Variable Definitions		
P_1	Average retail price per unit with alternative excise tax rate, in 2016 USD	Output
P_0	Average retail price per unit in 2016, in 2016 USD	Input
T_0	Current excise tax per sales unit, in 2016 USD	Input
T_1	Alternative excise tax per sales unit, in 2016 USD	Input
E	Price elasticity of demand	Input
Q_1	Total number of units sold in 2016 if the alternative excise tax rate had been in place, taking into account elasticity of demand	Output
Q_0	Total number of units sold in 2016	Input

Target Countries

After defining the equations, we selected “target” countries for analysis. Target countries are those for which we calculated excise tax revenue estimates.

To select low-income countries, we created a data set that included product use statistics for “bads” in all low-income countries and calculated quartiles for each statistic. We then chose a set of ten low-income target countries that included (a) all quartile values for prevalence of tobacco use and alcohol consumption, (b) all quartile values for share of tax in retail price of cigarettes, to capture different starting points for tobacco taxation, and (c) different regions of Sub-Saharan Africa and of the world.

To this set of ten low-income countries, six lower-middle-income countries were added based on the preferences and priorities of stakeholders at the Center for Global Development and the Global Fund to Fight AIDS, Tuberculosis and Malaria.

The 16 target countries included in the analysis are Côte d'Ivoire, Democratic Republic of the Congo (DRC), Ethiopia, Haiti, India, Lao PDR, Moldova, Myanmar, Niger, Papua New Guinea, Rwanda, Senegal, Sierra Leone, Tajikistan, Tanzania, and Togo.

Inputs

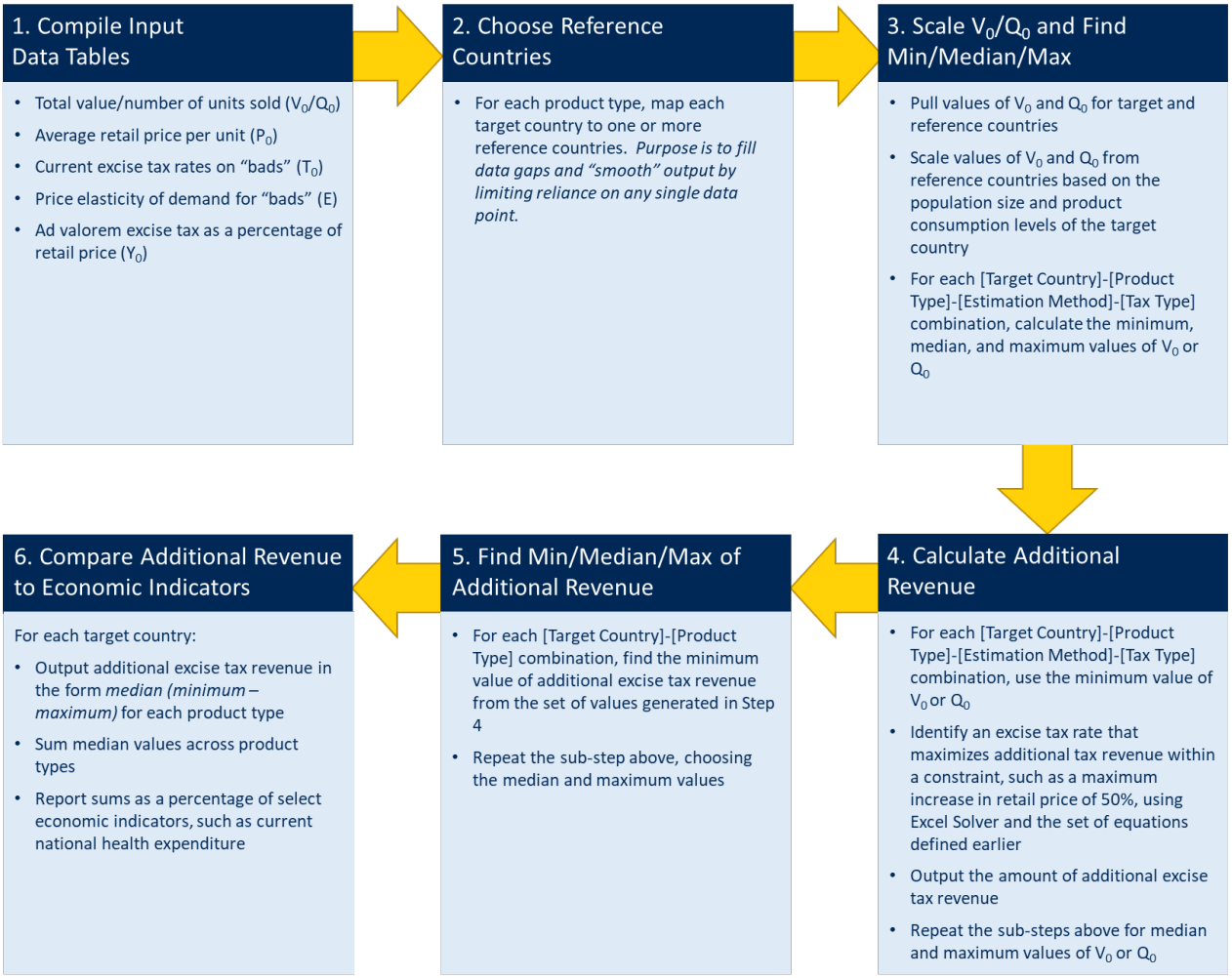
We performed a desk review to identify data for the variables listed as inputs in Table 1 and Table 2. Our desk review included searches for both input variable values as well as values of “upstream” statistics that could be used to calculate input variable values. We identified a number of relevant sources including databases such as the World Bank Databank[7] and OECD Global Revenue Statistics database[8], journal articles such as Blecher, Liber, Drope, Nguyen, and Stoklosa 2017[9] and Stacey, Tugendhaft, and Hofman 2017[10], and national tax codes such as the Code Général des Impôts 2013[11] from Senegal.

The scope of the three product categories included was adjusted based on data availability. For tobacco, cigarettes serve as a proxy for all tobacco consumption. For alcohol, we treat beer, wine, and spirits separately. We also included an “All Alcohol” category for countries with sufficient data. The scope of SSBs is based on the definition provided in Singh *et al.* 2015: “beverages containing over 50 kcal/8oz serving, including sodas, fruit drinks, sports/energy drinks, pre-sweetened iced tea, and homemade sugar-sweetened beverages such as frescas."[12]

Calculations and Outputs

We developed a model in Microsoft Excel that uses the equations and input data defined previously to estimate excise tax revenue given alternative excise tax rates. The model is structured as a set of input tables, several analysis worksheets, and a set of output tables. The six steps for generating excise tax revenue estimates using the model are listed in Figure 2.

Figure 2 Steps for generating excise tax revenue estimates using the model



1. Compile Input Data Tables

Input data tables were compiled using relevant data identified during desk review. Available data were mapped to one of two estimation methods, "top down" or "bottom up". For the "top down" method, reported excise tax revenue and country excise tax rates were used to estimate V_0, the total dollar value of a product category in 2016 at import or when leaving the manufacturing facility (if produced locally). For the "bottom up" method, product consumption data were used to estimate Q_0, the total number of units of a product category sold in 2016.

Out of the possible 24 [Product Type]-[Estimation Method]-[Tax Type] combinations, 15 were included. Other combinations were excluded due to a lack of data. Table 3 summarizes the combinations available in the model and the number of data points available for each. One data point is an estimate of V_0 or Q_0 for one country.

Table 3 Combinations of products, estimation methods, and tax types included in the model

Product Type	Sub-Product	Estimation Method	Tax Type	Data Points[a]
Tobacco		Top Down	Ad Valorem	7
Tobacco		Top Down	Specific	56
Tobacco		Bottom Up	Specific	52
Alcohol	All	Top Down	Ad Valorem	3
Alcohol	Beer	Top Down	Ad Valorem	2
Alcohol	Spirits	Top Down	Ad Valorem	1
Alcohol	Beer	Top Down	Specific	5
Alcohol	Wine	Top Down	Specific	3
Alcohol	Spirits	Top Down	Specific	5
Alcohol	Beer	Bottom Up	Specific	171
Alcohol	Wine	Bottom Up	Specific	166
Alcohol	Spirits	Bottom Up	Specific	157
SSB		Top Down	Ad Valorem	2
SSB		Top Down	Specific	1
SSB		Bottom Up	Specific	185

2. Choose Reference Countries

We considered two different approaches for selecting the value of V_0 or Q_0 for each country, product type, estimation method, and tax type. The first approach is to select only values of V_0 or Q_0 from the target country. This approach requires that each target country have at least one data point for each product type. In addition, this approach assumes that the values of V_0 or Q_0 from the target country are the best estimates for these parameters, without taking into account the uncertainty of the inputs. The second approach is to use the values of V_0 or Q_0 from the target country and the values of V_0 or Q_0 from reference countries. For reference countries, values of V_0 or Q_0 are scaled to the population size and product consumption of the target country. Assuming that some data points are overestimates of the true value and some are underestimates, pooling these values would allow us to improve the accuracy of the final parameter estimate.

For example, Ethiopia is a target country, and Ethiopia has one data point (Q_0) for tobacco. Using the first approach, we would estimate additional excise tax revenue from tobacco in Ethiopia with this one data point and no data from reference countries. The final estimate for additional excise tax revenue from tobacco would be based only on the bottom up estimation method for a specific tax. Using the second approach, we would include both the Ethiopia data point and data points from reference countries, scaled to the population and tobacco consumption of Ethiopia. The final estimate for additional excise tax revenue from tobacco would be the median value of three separate estimates: a top down ad valorem tax estimate, a top down specific tax estimate, and a bottom up specific tax estimate. The model uses this second approach.

[a] Includes upper-middle and high-income countries if these data were "packaged" in the same data set as information for low- and middle-income countries.

We selected reference countries for each [Target Country]-[Product Type] combination. For target countries in the regions Sub-Saharan Africa and East Asia & Pacific, reference country matches were made based on region, income group, and the presence of at least one data point (e.g., reference country has data for at least one of the three tobacco estimation methods). For target countries in the regions Europe & Central Asia, Latin America & Caribbean, and South Asia, matches were made based only on region and presence of at least one data point. This difference is due to the small number of reference countries for these regions that match on region and income group and have at least one data point.

3. Scale V_0/Q_0 and Find Min/Median/Max

Values of V_0 and Q_0 for reference countries are scaled to the population size and product consumption of the target country. As an example, DRC is the target country and Benin is the reference country. The Q_0 estimate for tobacco is scaled up first by a factor of 6.80 to account for the larger population ages 15+ in DRC and then again by a factor of 1.85 to account for higher smoking prevalence in DRC compared to Benin. When this approach is applied to the target country and all reference countries, the result is one scaled value of V_0 or Q_0 for each country and estimation method for which data are available.

Then, for each target country and each combination of [Product Type]-[Estimation Method]-[Tax Type], a minimum, median, and maximum are calculated from the set of target country and scaled reference country values of V_0 and Q_0. Carrying forward the DRC tobacco example:

- Top down estimation method and ad valorem tax type: 1 value of V_0 from DRC and 4 scaled values of V_0 from reference countries.
- Top down estimation method and specific tax type: 6 scaled values of Q_0 from reference countries.
- Bottom up estimation method and specific tax type: 1 value of Q_0 from DRC and 19 scaled values of Q_0 from reference countries.

A minimum, median, and maximum are calculated for the five values of V_0 for top down ad valorem. Then, a minimum, median, and maximum are calculated for the six values of Q_0 for top down specific. Finally, a minimum, median, and maximum are calculated for the 20 values of Q_0 for bottom up specific.

4. Calculate Additional Revenue

For each target country and each [Product Type]-[Estimation Method]-[Tax Type] combination, the minimum, median, and maximum values of V_0 or Q_0 serve as inputs to the equations defined previously. Using Excel solver, the alternative excise tax rate (T_1) is adjusted until the revenue-maximizing rate is found. The model also allows for adjustment of T_1 within a constraint, such as a 50% maximum increase in the retail price of a sales unit (e.g. pack of 20 cigarettes).

We assume that any change in the excise tax rate is fully passed through to the retail price. For example, a $0.10 increase in the specific excise tax per sales unit will increase the retail price per sales unit by $0.10.

5. Find Min/Median/Max of Additional Revenue

For each target country and product type, the minimum, median, and maximum values of additional revenue are calculated using the set of estimates for additional revenue created in the previous step. It is at this step that "triangulation" through different estimation methods is achieved. For example, some of the values for additional revenue may have been calculated using the top down estimation method and an ad valorem tax type, while other values for additional revenue may have been calculated using the bottom up estimation method and a specific tax type. Values from all estimation methods are grouped together when calculating the minimum, median, and maximum for each target country and product type.

6. Compare Additional Revenue to Economic Indicators

For each target country and product type, the model outputs the minimum, median, and maximum values of additional excise tax revenue from all estimation methods and tax types available. Median values are added

across product types, providing an estimate of total additional revenue from tobacco, alcohol, and SSBs (assuming no substitution between products). These sums are then expressed as a percentage of select economic indicators, such as current national health expenditure.

Results

Using the Excel model, we generated three sets of estimates for additional excise tax revenue in the 16 target countries.

Table 4 provides estimates for the additional excise tax revenue that could have been generated in 2016 if excise tax revenue-maximizing rates had been applied (“Hypothetical Revenue-Maximizing” scenario). These estimates provide the theoretical upper bound of additional revenue through excise taxes on “bads”. Table 5 presents the sum of the median values across product categories (excluding “All Alcohol”) from Table 4 as a percentage of select economic indicators.

Table 6 provides estimates for the additional excise tax revenue that could have been generated in 2016 if excise tax revenue-maximizing rates had been applied, with the constraint that the retail price per sales unit must not increase more than 50% (“Constrained Revenue-Maximizing” scenario). Table 7 presents the sum of the median values across product categories (excluding “All Alcohol”) from Table 6 as a percentage of select economic indicators.

Table 8 provides a third set of estimates for a scenario in which target countries are limited in their ability to collect excise taxes at the increased rates (“Pragmatic Revenue Estimates” scenario). In this scenario, each country implements excise tax revenue-maximizing rates, under the constraint that the retail price per sales unit must not increase more than 50%. However, weak tax administration results in the application of these higher excise tax rates to only to 1/3 of eligible products. The value of 1/3 is for illustrative purposes only and is not based on a tax administration capacity metric. Because we assume a linear demand curve, we can obtain reasonable estimates for this scenario by modifying the constraint used for Table 6 such that retail prices must not increase more than 16.7% (i.e. 50%*1/3). Table 9 presents the sum of the median values across product categories (excluding “All Alcohol”) from Table 8 as a percentage of select economic indicators.

Figure 3, Figure 4, and Figure 5 present additional excise tax revenue as a percentage of current health expenditure, total tax revenue, and GDP, respectively, for all three scenarios.

Table 4 Hypothetical Revenue-Maximizing: Additional excise tax revenue that could have been generated in 2016 using excise tax revenue-maximizing rates

	Additional excise tax revenue by product category, in million 2016 USD *Median (Minimum - Maximum)*						
Country	Tobacco	All Alcohol	Beer	Wine	Spirits	Sugar-Sweetened Beverages	Sum of median values for all product categories* in million 2016 USD
Congo, Dem. Rep.	150 (0 - 951)	109 (65 - 298)	82 (38 - 1,021)	50 (3 - 1,101)	35 (1 - 1,299)	276 (120 - 1,567)	593
Côte d'Ivoire	71 (4 - 133)		2,038 (423 - 4,515)	187 (15 - 3,095)	123 (2 - 328)	347 (153 - 482)	2,766
Ethiopia	74 (0 - 670)	307 (182 - 841)	222 (57 - 1,539)	24 (2 - 533)	53 (2 - 1,998)	688 (257 - 2,237)	1,061
Haiti	47 (0 - 290)		317 (15 - 529)	42 (2 - 514)	542 (126 - 1,280)	377 (71 - 503)	1,325
India	8,293 (3,895 - 10,665)		14,219 (757 - 41,520)	1,890 (82 - 40,227)	25,758 (348 - 95,322)	10,425 (3,746 - 17,050)	60,585
Lao PDR	82 (10 - 142)		491 (156 - 844)	61 (8 - 1,598)	567 (36 - 1,245)	51 (30 - 209)	1,252
Moldova	49 (7 - 126)		312 (86 - 615)	151 (4 - 345)	116 (22 - 656)	18 (5 - 37)	646
Myanmar	299 (37 - 517)		943 (300 - 1,622)	296 (41 - 7,805)	2,229 (143 - 4,894)	436 (251 - 1,783)	4,203
Niger	27 (0 - 78)	8 (5 - 23)	6 (3 - 82)	2 (0 - 52)	2 (0 - 61)	85 (44 - 382)	122
Papua New Guinea	742 (91 - 1,282)		46 (15 - 79)	10 (1 - 260)	75 (5 - 164)	155 (89 - 633)	1,028
Rwanda	16 (0 - 73)	153 (91 - 420)	101 (19 - 524)	47 (3 - 1,021)	20 (1 - 755)	94 (30 - 263)	278
Senegal	25 (0 - 59)	9 (5 - 24)	6 (3 - 118)	2 (0 - 41)	1 (0 - 42)	57 (24 - 326)	91
Sierra Leone	18 (0 - 40)		77 (15 - 404)	10 (1 - 213)	18 (0 - 227)	43 (18 - 158)	166
Tajikistan	87 (10 - 222)		43 (12 - 85)	81 (2 - 184)	50 (10 - 286)	34 (10 - 70)	295
Tanzania	151 (1 - 345)		799 (154 - 4,181)	131 (8 - 2,859)	227 (3 - 2,929)	311 (130 - 1,132)	1,619
Togo	11 (0 - 113)	13 (8 - 37)	10 (5 - 245)	6 (0 - 138)	4 (0 - 162)	29 (12 - 164)	60

A value of 0 indicates that additional excise tax revenue is greater than 0 USD but less than 0.5 million USD

**Excluding "All Alcohol"*

Table 5 Hypothetical Revenue-Maximizing: Sum of median values for additional excise tax revenue as a percentage of select economic indicators

Country	Tax Revenue	Current Health Expenditure	Out-of-Pocket Expenditure	Domestic General Government Health Expenditure	External Health Expenditure	Taxes on Income, Profits, and Capital Gains	GDP
Congo, Dem. Rep.		40%	106%	241%	101%		1.7%
Côte d'Ivoire	50%	140%	388%	641%	531%	462%	7.6%
Ethiopia		36%	95%	134%	235%		1.5%
Haiti		242%	667%	2 267%	495%		16.6%
India		69%	105%	268%	7 715%		2.7%
Lao PDR	61%	282%	622%	802%	1 665%	383%	7.9%
Moldova	49%	93%	202%	205%	1 283%	446%	9.5%
Myanmar	104%	134%	182%	584%	4 350%	801%	6.6%
Niger		22%	43%	106%	87%		1.6%
Papua New Guinea	38%	137%	2 378%	193%	591%	76%	5.2%
Rwanda	22%	42%	160%	194%	94%	99%	3.3%
Senegal	3%	16%	35%	49%	133%	14%	0.6%
Sierra Leone	54%	25%	67%	284%	48%	193%	4.7%
Tajikistan		62%	98%	220%	734%		4.2%
Tanzania	29%	56%	213%	158%	152%		3.4%
Togo	6%	21%	40%	73%	135%	54%	1.4%

Values are blank if the economic indicator of interest was not available for any year from 2014-2016

Table 6 Constrained Revenue-Maximizing: Additional excise tax revenue that could have been generated in 2016 using excise tax revenue-maximizing rates, with the constraint that the retail price per sales unit must not increase more than 50%

	Additional excise tax revenue by product category, in million 2016 USD *Median (Minimum - Maximum)*						
Country	Tobacco	All Alcohol	Beer	Wine	Spirits	Sugar-Sweetened Beverages	Sum of median values for all product categories* in million 2016 USD
Congo, Dem. Rep.	117 (0 - 738)	99 (59 - 272)	64 (28 - 765)	48 (3 - 1,053)	33 (1 - 1,242)	276 (120 - 1,567)	538
Côte d'Ivoire	53 (3 - 100)		1,529 (317 - 3,386)	179 (15 - 2,959)	117 (1 - 314)	347 (153 - 482)	2,225
Ethiopia	55 (0 - 526)	281 (167 - 769)	175 (42 - 1,154)	23 (1 - 509)	51 (2 - 1,910)	688 (257 - 2,237)	992
Haiti	35 (0 - 217)		238 (11 - 397)	40 (2 - 492)	518 (121 - 1,223)	377 (71 - 503)	1,208
India	6,803 (3,196 - 8,750)		11,432 (609 - 33,382)	1,866 (81 - 39,705)	24,622 (332 - 91,118)	10,425 (3,746 - 17,050)	55,148
Lao PDR	63 (8 - 109)		368 (117 - 633)	58 (8 - 1,528)	542 (35 - 1,190)	51 (30 - 209)	1,082
Moldova	41 (6 - 105)		239 (66 - 471)	149 (4 - 339)	113 (22 - 640)	18 (5 - 37)	560
Myanmar	253 (31 - 437)		707 (225 - 1,217)	283 (39 - 7,461)	2,131 (136 - 4,678)	436 (251 - 1,783)	3,810
Niger	20 (0 - 62)	8 (5 - 21)	5 (2 - 61)	2 (0 - 49)	2 (0 - 58)	85 (44 - 382)	114
Papua New Guinea	611 (75 - 1,057)		34 (11 - 59)	9 (1 - 248)	71 (5 - 157)	155 (89 - 633)	880
Rwanda	13 (0 - 59)	140 (83 - 384)	79 (14 - 393)	45 (3 - 975)	19 (1 - 722)	94 (30 - 263)	250
Senegal	19 (0 - 48)	8 (5 - 22)	5 (2 - 88)	2 (0 - 41)	1 (0 - 42)	57 (24 - 326)	84
Sierra Leone	13 (0 - 30)		60 (12 - 313)	10 (1 - 208)	17 (0 - 224)	43 (18 - 158)	143
Tajikistan	66 (8 - 168)		34 (9 - 67)	78 (2 - 178)	49 (9 - 276)	34 (10 - 70)	261
Tanzania	121 (0 - 275)		635 (122 - 3,326)	128 (8 - 2,790)	222 (3 - 2,864)	311 (130 - 1,132)	1,417
Togo	8 (0 - 86)	12 (7 - 34)	7 (3 - 184)	6 (0 - 131)	4 (0 - 155)	29 (12 - 164)	54

A value of 0 indicates that additional excise tax revenue is greater than 0 USD but less than 0.5 million USD

**Excluding "All Alcohol"*

Table 7 Constrained Revenue-Maximizing: Sum of median values for additional excise tax revenue as a percentage of select economic indicators

Country	Tax Revenue	Current Health Expenditure	Out-of-Pocket Expenditure	Domestic General Government Health Expenditure	External Health Expenditure	Taxes on Income, Profits, and Capital Gains	GDP
Congo, Dem. Rep.		36%	96%	218%	92%		1.5%
Côte d'Ivoire	40%	113%	312%	516%	427%	371%	6.1%
Ethiopia		34%	89%	125%	219%		1.4%
Haiti		221%	608%	2 067%	451%		15.2%
India		62%	96%	244%	7 022%		2.4%
Lao PDR	53%	244%	538%	693%	1 439%	331%	6.8%
Moldova	43%	81%	175%	178%	1 112%	386%	8.2%
Myanmar	94%	122%	165%	529%	3 944%	726%	6.0%
Niger		21%	40%	99%	81%		1.5%
Papua New Guinea	33%	117%	2 036%	165%	506%	65%	4.4%
Rwanda	20%	37%	144%	175%	85%	89%	2.9%
Senegal	3%	14%	33%	45%	123%	13%	0.6%
Sierra Leone	47%	22%	57%	245%	42%	166%	4.0%
Tajikistan		55%	87%	194%	649%		3.8%
Tanzania	25%	49%	187%	138%	133%		3.0%
Togo	6%	19%	36%	66%	122%	49%	1.2%

Values are blank if the economic indicator of interest was not available for any year from 2014-2016

Table 8 Pragmatic Revenue Estimates: Additional excise tax revenue that could have been generated in 2016 using excise tax revenue-maximizing rates, with the constraint that the retail price per sales unit must not increase more than 16.7%

	Additional excise tax revenue by product category, in million 2016 USD *Median (Minimum - Maximum)*						
Country	Tobacco	All Alcohol	Beer	Wine	Spirits	Sugar-Sweetened Beverages	Sum of median values for all product categories* in million 2016 USD
Congo, Dem. Rep.	49 (0 - 305)	45 (27 - 124)	26 (11 - 312)	23 (1 - 504)	16 (1 - 594)	175 (78 - 990)	289
Côte d'Ivoire	22 (1 - 41)		623 (129 - 1,380)	86 (7 - 1,416)	56 (1 - 150)	219 (97 - 304)	1,006
Ethiopia	23 (0 - 218)	128 (76 - 350)	73 (17 - 470)	11 (1 - 244)	24 (1 - 914)	444 (162 - 1,414)	575
Haiti	14 (0 - 89)		97 (5 - 162)	19 (1 - 235)	248 (58 - 585)	238 (45 - 318)	616
India	2,880 (1,353 - 3,704)		4,792 (255 - 13,993)	952 (41 - 20,254)	11,780 (159 - 43,593)	6,588 (2,367 - 10,775)	26,992
Lao PDR	26 (3 - 45)		150 (48 - 258)	28 (4 - 731)	259 (17 - 569)	32 (19 - 132)	495
Moldova	17 (2 - 45)		98 (27 - 194)	75 (2 - 172)	56 (11 - 317)	11 (3 - 23)	257
Myanmar	109 (13 - 188)		288 (92 - 496)	135 (19 - 3,570)	1,020 (65 - 2,238)	276 (159 - 1,127)	1,828
Niger	8 (0 - 26)	4 (2 - 10)	2 (1 - 25)	1 (0 - 24)	1 (0 - 28)	54 (28 - 241)	66
Papua New Guinea	259 (32 - 448)		14 (4 - 24)	5 (1 - 119)	34 (2 - 75)	98 (56 - 400)	410
Rwanda	5 (0 - 24)	64 (38 - 175)	33 (6 - 160)	21 (1 - 467)	9 (0 - 345)	61 (19 - 166)	129
Senegal	8 (0 - 20)	4 (2 - 10)	2 (1 - 36)	1 (0 - 21)	1 (0 - 24)	36 (16 - 206)	48
Sierra Leone	5 (0 - 12)		25 (5 - 129)	5 (0 - 103)	9 (0 - 114)	27 (11 - 100)	71
Tajikistan	27 (3 - 69)		14 (4 - 28)	38 (1 - 87)	24 (5 - 135)	21 (6 - 44)	124
Tanzania	50 (0 - 115)		265 (51 - 1,387)	63 (4 - 1,383)	110 (2 - 1,425)	196 (82 - 715)	684
Togo	3 (0 - 35)	6 (3 - 15)	3 (1 - 75)	3 (0 - 63)	2 (0 - 74)	18 (8 - 104)	29

A value of 0 indicates that additional excise tax revenue is greater than 0 USD but less than 0.5 million USD

**Excluding "All Alcohol"*

Table 9 Pragmatic Revenue Estimates: Sum of median values for additional excise tax revenue as a percentage of select economic indicators

Country	Tax Revenue	Current Health Expenditure	Out-of-Pocket Expenditure	Domestic General Government Health Expenditure	External Health Expenditure	Taxes on Income, Profits, and Capital Gains	GDP
Congo, Dem. Rep.		19%	52%	117%	49%		0.8%
Côte d'Ivoire	18%	51%	141%	233%	193%	168%	2.8%
Ethiopia		19%	51%	72%	127%		0.8%
Haiti		113%	310%	1 054%	230%		7.7%
India		31%	47%	119%	3 437%		1.2%
Lao PDR	24%	112%	246%	317%	658%	151%	3.1%
Moldova	20%	37%	80%	82%	510%	177%	3.8%
Myanmar	45%	58%	79%	254%	1 892%	349%	2.9%
Niger		12%	23%	58%	47%		0.9%
Papua New Guinea	15%	55%	949%	77%	236%	30%	2.1%
Rwanda	10%	19%	74%	90%	44%	46%	1.5%
Senegal	2%	8%	19%	26%	70%	7%	0.3%
Sierra Leone	23%	11%	29%	122%	21%	83%	2.0%
Tajikistan		26%	41%	92%	309%		1.8%
Tanzania	12%	24%	90%	67%	64%		1.4%
Togo	3%	10%	20%	35%	65%	26%	0.7%

Values are blank if the economic indicator of interest was not available for any year from 2014-2016

Figure 3 Median values for additional excise tax revenue as a percentage of current health expenditure in 2015

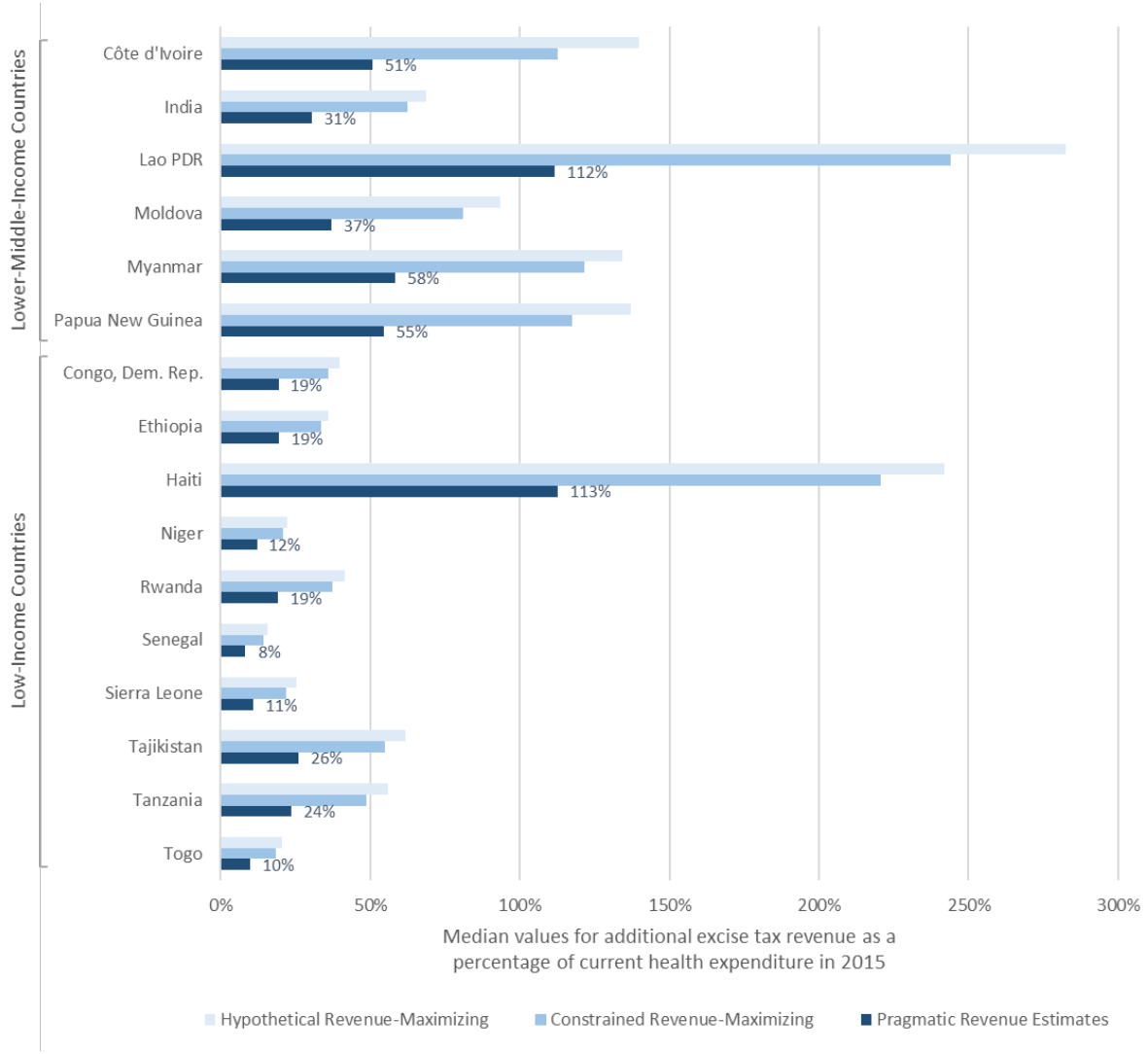


Figure 4 Median values for additional excise tax revenue as a percentage of total tax revenue in 2016 (2014 for Sierra Leone and Tanzania)

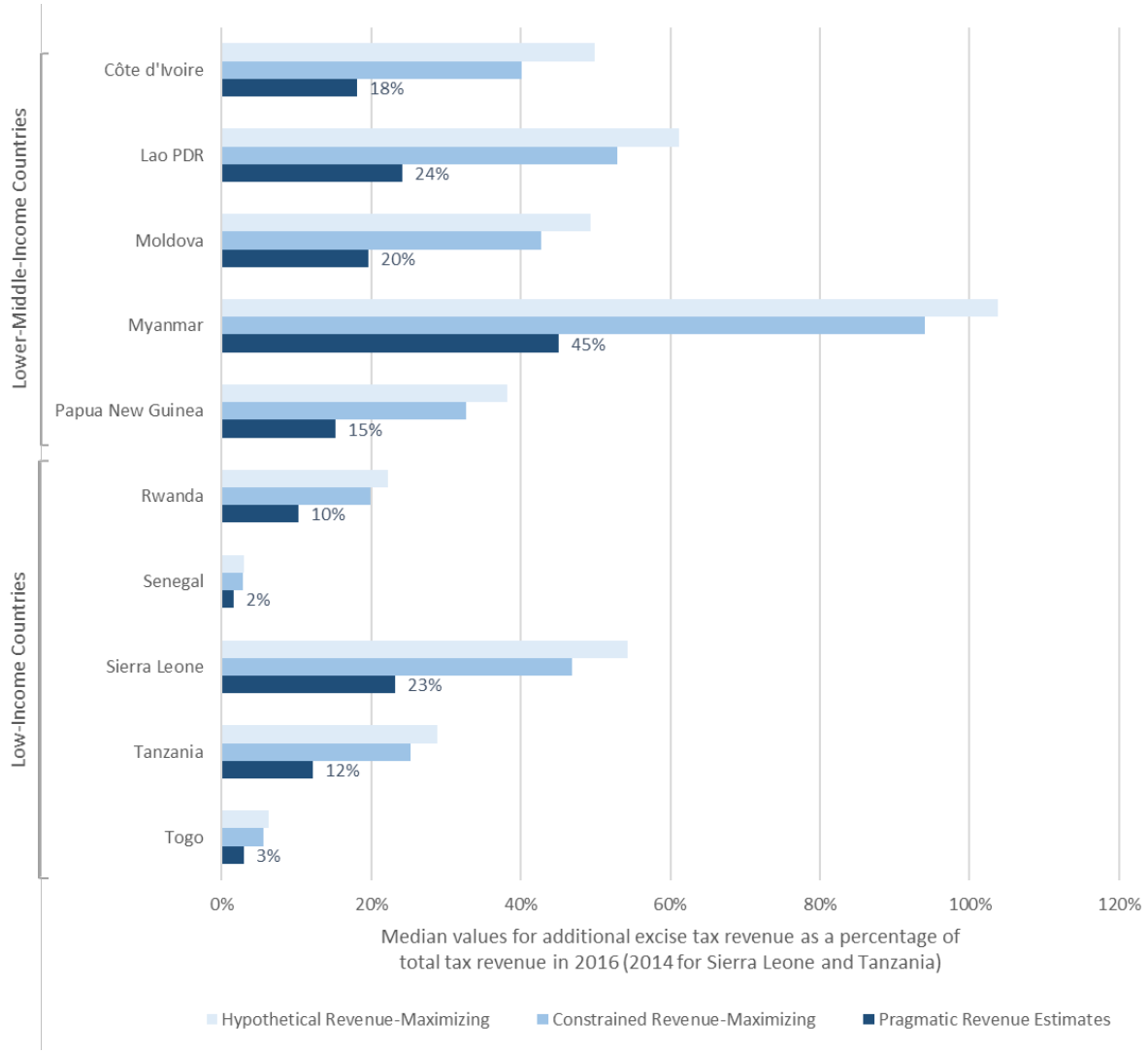
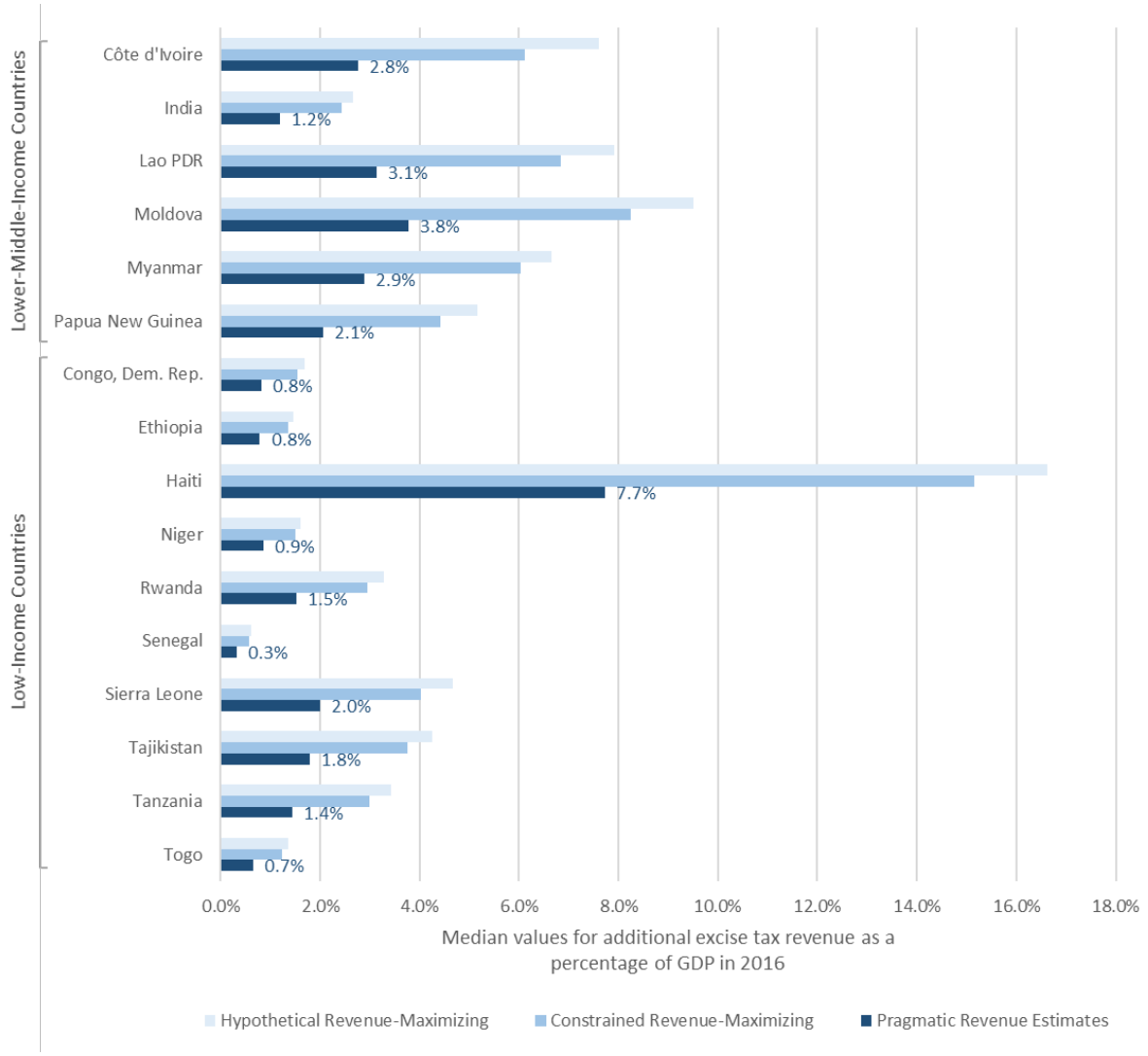


Figure 5 Median values for additional excise tax revenue as a percentage of GDP in 2016



Discussion

The primary conclusion drawn from the modeling exercise is that for most of the target countries, the amount of additional revenue possible through increased taxation of "bads" is important relative to select economic indicators. Even in the most restrictive scenario (Table 9), additional excise tax revenue as a percentage of domestic general health expenditure is greater than 50% for 14 of the 16 target countries and greater than 100% for 7 of the 16 target countries. Moreover, additional excise tax revenue as a percentage of current health expenditure is greater than 10% for 14 of the 16 target countries.

Figure 3 illustrates that additional excise tax revenue as a percentage of current health expenditure in the "Pragmatic Revenue Estimates" scenario is, on average, higher for lower-middle-income countries than low-income countries. Lao PDR is an outlier within the lower-middle-income country group and Haiti is an outlier within the low-income country group. The outlier status of these countries may be explained by the assumptions made for the product type "spirits." In both countries, additional excise tax revenue from spirits account for over 40% of total additional excise tax revenue. Data on a price per liter of spirits was not available for these countries, so the values were imputed from available data based on their income group and geographic region. The imputed values are near the top of the range for all prices per liter for low-income and lower-middle-income countries. Because the constraint in our analysis is based on percent of initial price, a small percentage change in a high initial price will lead to a larger real amount of additional revenue relative to that same percentage change applied to a lower price. In Lao PDR, this effect is compounded by a prevalence of alcohol consumption that is nearly double the mean consumption of the 16 target countries.

Figure 4 and Figure 5 show a similar relationship between income group and outcome: the average additional excise tax revenue as a percentage of total tax revenue and of GDP is greater for lower-middle-income target countries than for low-income target countries. With respect to additional excise tax revenue as a percentage of GDP, Haiti remains an outlier, while the estimate for Lao PDR is similar to other lower-middle-income countries such as Myanmar and Côte d'Ivoire.

Results from this modeling exercise are broadly aligned with the 2019 simulations by Summan and Laxminarayan.[6] Our results in Table 6 attribute 12%, 68% and 20% of additional revenues to tobacco, alcohol, and SSB, respectively, while their simulation attributes 14%, 79%, and 7% to tobacco, alcohol, and SSB, respectively. Our 16 target countries are expected to include 21%-25% of the world population over age 15 between 2016 and 2065[b]. The sum of 2016 median additional revenue across all 16 countries from Table 6 is US$68.8 billion. When this total is scaled up to reflect the world population over age 15 in each year, and a discount rate of 3% is applied, the result is US$8 trillion of additional revenue from excise taxation of "bads" over the 50 year period from 2016 to 2065. In the simulation of Summan and Laxminarayan, the scenario in which prices are raised 50 percent (similar to the scenario presented in our Table 6) results in US$20 trillion of additional revenue over 50 years. Several factors could explain the difference between our estimates and those of Summan and Laxminarayan, including alternative assumptions about the consumption of "bads", different levels of consumption between our target countries all other countries, and our inclusion of a top down estimation method.

Over the past 25 years, tax revenue as a percentage of GDP has increased an average of 2.8 percentage points in low-income countries and 1.2 percentage points in lower-middle-income countries.[c] "Pragmatic Revenue Estimates" from our modeling exercise range from 0.3% to 7.7% of GDP for low-income countries and 1.2% to 3.8% of GDP for lower-middle-income countries. Although the "Pragmatic Revenue Estimates" scenario is meant to account for the real-world challenges of tax administration, historical data indicate that all outputs are likely overestimates of the additional revenue that could be collected in the first year following a tax rate increase, and some estimates are unlikely to be achieved even over a period of 25 years (e.g. those for Haiti).

[b] Authors' calculations using data from the World Population Prospects 2019[13]

[c] Authors' calculations using the indicator "Tax Revenue (% of GDP)" from the World Bank Databank

Still, excise taxes "can be among the simplest taxes to implement".[14] Aggregate tax revenue statistics may not be the appropriate benchmark when considering changes to excise tax rates in the context of no, or minimal, changes to other tax types.

Limitations

There are several limitations to our modelling approach.

- The model does not account for substitution between tobacco, alcohol, and SSB or substitution between these products and other products. Cross-price elasticity is not incorporated.
- Price elasticity of demand for a given product category is a single number for all countries. Moreover, using a point estimate for price elasticity of demand may not be valid in the case of large price changes.
- In countries where consumption of tobacco, alcohol, and/or SSBs represents a substantial portion of household expenditure among the poor, large excise tax increases could generate a significant income effect. Under such circumstances, our model would overestimate additional revenue in all three scenarios.
- Values of Q_0 based on surveys may underestimate actual consumption due to underreporting or recall bias.
- The model does not allow for "mixed" taxation through a combination of ad valorem and specific taxes.
- If there is no current ad valorem tax in a target country, the model cannot provide an estimate for additional revenue from ad valorem tax.
- The model does not account for the ability of a target country government to collect additional excise taxes or the cost of collecting these taxes. We provide estimates in Table 8 and Table 9 for a scenario in which each target country is limited in its ability to collect excise taxes at the increased rates. However, these estimates may still be optimistic.
- The model does not take into account excise tax rates in neighboring countries and their impact on excise tax rates and illegal sales in a target country.

Conclusion

In this paper, we provide estimates for additional government revenue that could have been generated in 2016 if higher excise tax rates had been imposed on tobacco, alcohol, and SSBs. We developed a novel method for "triangulating" outputs and applied this method to 16 LMICs that span world regions and levels of "bads" consumption. Our country-level results indicate that increased taxation of "bads" could generate revenue that is important relative to select economic indicators. These results broadly align with the most recent excise tax modeling efforts by Summan and Laxminarayan. However, our "Pragmatic Revenue Estimates" scenario may still represent an upper bound, given historical experience with raising tax revenues and the possibility of significant income or cross-substitution effects in certain contexts. Future studies should seek to address the limitations of our modeling approach and to combine estimates of additional revenue from increased excise taxes on "bads" with expected health benefits.

References

1. Chaloupka FJ, Straif K, Leon ME. Effectiveness of tax and price policies in tobacco control. *Tob Control*. 2011;20(3):235-238. doi:10.1136/tc.2010.039982

2. Wagenaar AC, Salois MJ, Komro KA. Effects of beverage alcohol price and tax levels on drinking: a meta-analysis of 1003 estimates from 112 studies. *Addiction*. 2009;104(2):179-190. doi:10.1111/j.1360-0443.2008.02438.x

3. *The Economics of Tobacco and Tobacco Control. National Cancer Institute Tobacco Control Monograph 21*. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva, CH: World Health Organization: U.S. National Cancer Institute and World Health Organization; 2016:688.

4. Goodchild M, Perucic A-M, Nargis N. Modelling the impact of raising tobacco taxes on public health and finance. *Bull World Health Organ*. 2016;94(4):250-257. doi:10.2471/BLT.15.164707

5. Stacey N, Summan A, Tugendhaft A, Laxminarayan R, Hofman K. Simulating the impact of excise taxation for disease prevention in low-income and middle-income countries: an application to South Africa. *BMJ Glob Health*. 2018;3(1). doi:10.1136/bmjgh-2017-000568

6. *Health Taxes to Save Lives: Employing Effective Excise Taxes on Tobacco, Alcohol, and Sugary Beverages*. The Task Force on Fiscal Policy for Health; 2019. https://www.bbhub.io/dotorg/sites/2/2019/04/Health-Taxes-to-Save-Lives.pdf. Accessed July 25, 2019.

7. DataBank | The World Bank. https://databank.worldbank.org/home.aspx. Accessed July 25, 2019.

8. Global Revenue Statistics Database. https://stats.oecd.org/Index.aspx?DataSetCode=RS_GBL. Accessed July 25, 2019.

9. Blecher E, Liber AC, Drope JM, Nguyen B, Stoklosa M. Global Trends in the Affordability of Sugar-Sweetened Beverages, 1990–2016. *Prev Chronic Dis*. 2017;14:160406. doi:10.5888/pcd14.160406

10. Stacey N, Tugendhaft A, Hofman K. Sugary beverage taxation in South Africa: Household expenditure, demand system elasticities, and policy implications. *Prev Med*. 2017;105(Suppl):S26-S31. doi:10.1016/j.ypmed.2017.05.026

11. *Code Général Des Impôts*. Direction Générale des Impôts et des Domaines, Sénégal; 2013. http://www.impotsetdomaines.gouv.sn/sites/default/files/documentations/cgi2013.pdf.

12. Singh GM, Micha R, Khatibzadeh S, et al. Global, Regional, and National Consumption of Sugar-Sweetened Beverages, Fruit Juices, and Milk: A Systematic Assessment of Beverage Intake in 187 Countries. Müller M, ed. *PLOS ONE*. 2015;10(8):e0124845. doi:10.1371/journal.pone.0124845

13. *World Population Prospects 2019: Total Population (Both Sexes Combined) by Five-Year Age Group, Region, Subregion and Country, 1950-2100, Medium Fertility Variant, 2020 - 2100*. United Nations Population Division; 2019.

14. *Revenue Mobilization in Developing Countries*. International Monetary Fund; 2011.

15. The World Health Organization. WHO Report on the Global Tobacco Epidemic - Dataset. http://www.who.int/tobacco/global_report/access_form/en/. Published 2017. Accessed July 25, 2019.

16. STATcompiler. https://statcompiler.com/en/. Accessed July 24, 2019.

17. The World Health Organization. WHO | Global Health Observatory (GHO) data. http://www.who.int/gho/en/. Accessed July 25, 2019.

18. World Health Organization, World Health Organization, World Health Organization, Management of Substance Abuse Team. *Global Status Report on Alcohol and Health 2018.*; 2018.

Appendix 1: Data Sources, Method, and Assumptions/Conventions by Product Type, Estimation Method, and Tax Type

Tobacco – Top Down – Ad valorem

Data Source(s): OECD Global Revenue Statistics Database[8] and country-level documents and data sets (for current excise tax rates).

Method: Converted reported 2016 excise tax revenue for tobacco into USD, then divided by the excise tax rate to get V_0.

Assumptions/Conventions:

- Assumed that cigarette sales represent the bulk of tobacco sales. Thus, it is valid to use the excise tax rate for cigarettes and apply it the excise tax revenue for all tobacco.
- Assumed that excise tax rates from the indicated sources are applicable for the 2016 tax year. For example, if the only publicly available tax code document available is from 2018, it is assumed that the 2018 excise tax rates were applicable in 2016.

Tobacco – Top Down – Specific

Data Source(s): WHO Global Tobacco Epidemic 2017 Data Set.[15]

Method: Converted reported excise tax revenue from tobacco into USD. Estimated the USD specific tax per 20-cigarette pack using the WHO data set. Divided the tobacco excise tax revenue by the specific tax to obtain Q_0.

Assumptions/Conventions:

- Excise tax revenue for the year provided in the WHO Tobacco Epidemic data set is used for 2016. The median excise tax revenue year for countries in the data set is 2015.
- For the retail price of a 20-cigarette pack of the most sold brand:
    - If country-specific data were available, used these data.
    - For countries for which data were not available, a pivot table was created to calculate the average prices of a 20-cigarette pack of the most sold brand by World Bank region and income group.
        - If an average value was available for a country and income group pair, that value was used
        - If a value was not available, the following conventions were used:
            - Within the same World Bank region, used the value of the next highest income group (e.g. value in pivot table missing for South Asia | Lower Middle income; used value from South Asia | Upper Middle Income)
            - If a value for the next highest income group was not available, used next lowest income group within the same region
            - If no data were available for an entire region, used values for the same income groups from a "nearby" region (e.g. use value of East Asia & Pacific | Lower Middle Income for South Asia | Lower Middle Income)
- For Q_0: estimates provided only for countries that have a specific excise tax. Estimates are not provided for countries with a mixed excise tax, since the calculation method would lead to an over-estimation of the number of 20-cigarette packs sold.

Tobacco – Bottom Up – Specific

Data Source(s): Demographic and Health Surveys.[16]

Method: Converted data on the number of cigarettes smoked per day to the number of 20-cigarette packs consumed in 2016 (Q_0).

Assumptions/Conventions:

- Assumed that cigarettes consumed equals cigarettes sold.
- For a given country, used the most recent DHS report that includes cigarette consumption.
- Excluded countries with data on only male or only female cigarette consumption, since the objective was to estimate total cigarette consumption.
- Excluded surveys for which less than 80% of interviewees who smoke answered the question about number of cigarettes smoked in the last 24 hours.
- Assumed that cigarette consumption for the reported DHS year reflects cigarette consumption in 2016 (e.g. 2012 DHS figures used for 2016 in Gabon).
- The percentage of interviewees that regularly smoke cigarettes, based on a sample of individuals ages 15-55, was applied to adults greater than 55 years of age.
- In the DHS reports or STATcompiler tables, for the number of cigarettes smoked in the last 24 hours:
    - If the table heading was "<A", A was used as the number of cigarettes smoked per day.
    - If the table heading was "B-C", the midpoint between B and C was used as the number of cigarettes smoked per day.
    - If the table heading was ">=D", D was used as the number of cigarettes smoked per day.

Alcohol (All, Beer, Spirits) – Top Down – Ad Valorem

Data Source(s): OECD Global Revenue Statistics Database[8] and country-level documents and data sets (for current excise tax rates).

Method: Converted reported 2016 excise tax revenue for alcohol into USD, then divided by the excise tax rate to get V_0.

Assumptions/Conventions:

- Assumed that excise tax rates from the indicated source are applicable for the 2016 tax year.

Alcohol (Beer, Wine, Spirits) – Top Down – Specific

Data Source(s): WHO Global Health Observatory[17], WHO Global Status Report on Alcohol and Health 2018[18], country-level documents and data sets (for current excise tax rates).

Method: Converted reported revenues from alcohol excise tax into USD and separated into revenue from beer, revenue from wine, and revenue from spirits. Calculated Q_0 by dividing excise tax revenue from beer/wine/spirits by the specific excise tax for beer/wine/spirits. For use later in the analysis, converted beer/wine/spirit prices into per-liter prices.

Assumptions/Conventions:

- Assumed that reported annual revenues from alcohol excise tax are applicable to 2016, even if the data point provided is for 2015 or 2014.
- Assumed that 50% of alcohol excise tax revenue comes from beer, 30% from wine, and 20% from spirits.
- For the retail price of 1 liter of beer/wine/spirits:
    - If country-specific data were available, used these data.
    - If country-specific data were not available, used the same approach described for the price of a 20-cigarette pack.

- The average price of one liter of alcohol (beer, wine, and spirits combined) is based on the average prices of beer, wine, and spirits weighted by the expected number of liters of each sold. The number of expected liters of beer, wine, and spirits sold is based on the WHO Global Status Report on Alcohol and Health 2018.

Alcohol (Beer, Wine, Spirits) – Bottom Up – Specific

Data Source(s): WHO Global Status Report on Alcohol and Health 2018[18], World Bank Databank[7].

Method: Converted the liters of pure alcohol consumed from beer/wine/spirits into liters of beer/wine/spirits consumed (Q_0).

Assumptions/Conventions:

- Assumed that liters of alcoholic beverages consumed equals liters of alcoholic beverages sold.
- Assumed alcohol consumption in 2016 the same as 2018.
- Assumed average alcohol by volume to be 5% for beer, 12% for wine, and 40% for spirits.
- Ignored the "other" category in the WHO Global Status Report. This category includes various types of locally produced alcohol that is unlikely to be sold through official channels and thus difficult to tax.

SSB – Top Down – Ad Valorem

Data Source(s): OECD Global Revenue Statistics Database[8] and country-level documents and data sets (for current excise tax rates).

Method: Converted reported 2016 excise tax revenue for SSB into USD, then divided by the excise tax rate to get V_0.

Assumptions/Conventions:

- Assumed that excise tax rates from the indicated source are applicable for the 2016 tax year.

SSB – Top Down – Specific

Data Source(s): OECD Global Revenue Statistics Database[8] and country-level documents and data sets (for current excise tax rates).

Method: Converted reported 2016 excise tax revenue for SSB into USD, then divided by the specific excise tax to get Q_0.

Assumptions/Conventions:

- Assumed that excise tax rates from the indicated source are applicable for the 2016 tax year.

SSB – Bottom Up – Specific

Data Source(s): Singh *et al.* 2015[12]; Blecher, Liber, Drope, Nguyen, and Stoklosa 2017[9]; World Bank Databank[7].

Method: Converted mean SSB intake (servings per day per person) into total 300ml units of SSB consumed by population in each country (Q_0). Adjusted 1L 2010 prices to 1L 2016 prices using the consumer price index. Multiplied by 0.3 to get the price of a 300ml sales unit.

Assumptions/Conventions:

- Assumed that SSB consumption per person per day in 2016 equal to 2010.
- SSB prices are based on Coca-Cola.
- Assumed that 300ml of Coca-Cola = 0.3*[price of 1L of Coca-Cola].
- For the retail price of a 300ml bottle of SSB:
    - If country-specific data were available, used these data.
    - If country-specific data were not available, used the same approach described for the price of a 20-cigarette pack to fill data gaps.

Appendix 2: Sources and Definitions of Economic Indicators Used as Denominators

Except for GDP, all economic indicators used as denominators in the results tables were calculated by multiplying two to three other indicators. The source of the GDP indicator and all indicators used for calculations is the World Bank Databank.[7]

Economic Indicator Reported in Results Tables	**Calculation Method**	**Indicator Definitions**
Tax Revenue	[GDP (current US$)] * [Tax revenue (% of GDP)]	GDP (current US$): "GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used." Tax revenue (% of GDP): "Tax revenue refers to compulsory transfers to the central government for public purposes. Certain compulsory transfers such as fines, penalties, and most social security contributions are excluded. Refunds and corrections of erroneously collected tax revenue are treated as negative revenue."
Current Health Expenditure	[GDP (current US$)] * [Current health expenditure (% of GDP)]	GDP (current US$): See above Current health expenditure (% of GDP): "Level of current health expenditure expressed as a percentage of GDP. Estimates of current health expenditures include healthcare goods and services consumed during each year. This indicator does not include capital health expenditures such as buildings, machinery, IT and stocks of vaccines for emergency or outbreaks."
Out-of-Pocket Expenditure	[GDP (current US$)] * [Current health expenditure (% of GDP)] * [Out-of-pocket expenditure (% of current health expenditure)]	GDP (current US$): See above Current health expenditure (% of GDP): See above Out-of-pocket expenditure (% of current health expenditure): "Share of out-of-pocket payments of total current health expenditures. Out-of-pocket payments are spending on health directly out-of-pocket by households."
Domestic General Government Health Expenditure	[GDP (current US$)] * [Current health expenditure (% of GDP)] * [Domestic general government health expenditure (% of current health expenditure)]	GDP (current US$): See above Current health expenditure (% of GDP): See above Domestic general government health expenditure (% of current health expenditure): "Share of current health expenditures funded from domestic public sources for health. Domestic public sources include domestic revenue as internal transfers and grants, transfers, subsidies to voluntary health insurance beneficiaries, non-profit institutions serving households (NPISH) or enterprise financing schemes as well as compulsory prepayment and social health insurance contributions. They do not include external resources spent by governments on health."

Economic Indicator Reported in Results Tables	Calculation Method	Indicator Definitions
External Health Expenditure	[GDP (current US$)] * [Current health expenditure (% of GDP)] * [External health expenditure (% of current health expenditure)]	GDP (current US$): See above Current health expenditure (% of GDP): See above External health expenditure (% of current health expenditure): “Share of current health expenditures funded from external sources. External sources compose of direct foreign transfers and foreign transfers distributed by government encompassing all financial inflows into the national health system from outside the country. External sources either flow through the government scheme or are channeled through non-governmental organizations or other schemes.”
Taxes on Income, Profits, and Capital Gains	[GDP (current US$)] * [Tax revenue (% of GDP)] * [Taxes on income, profits and capital gains (% of revenue)]	GDP (current US$): See above Tax revenue (% of GDP): See above Taxes on income, profits and capital gains (% of revenue): “Taxes on income, profits, and capital gains are levied on the actual or presumptive net income of individuals, on the profits of corporations and enterprises, and on capital gains, whether realized or not, on land, securities, and other assets. Intragovernmental payments are eliminated in consolidation.”
GDP	N/A	GDP (current US$): See above

Appendix 3 Additional Assumptions/Conventions

- All zero values for V_0 and Q_0 were excluded from the calculations.
- We assumed that M must be at least 50%. Where standard values of Y_0 led to M less than 50%, the value of Y_0 was reduced until the value of M was greater than or equal to 50%. The minimum of 50% is a guess based only on the authors’ experience with pharmaceutical supply chains in low- and middle-income countries.
- The units for V_0, Q_0, and P_0 differ by product category. The units are:
  - V_0
    - Tobacco: total value of all cigarettes imported or locally manufactured in 2016 (value to which ad valorem excise tax rate was applied), in 2016 USD.
    - Alcohol: total value of alcoholic beverages imported or locally manufactured in 2016 (value to which ad valorem excise tax rate was applied), in 2016 USD.
    - SSB: total value of all SSB imported or locally manufactured in 2016 (value to which ad valorem excise tax rate was applied), in 2016 USD.
  - Q_0:
    - Tobacco: number of 20-cigarette packs imported or locally manufactured in 2016 (quantity to which specific excise tax applied).
    - Alcohol: number of liters of alcoholic beverage imported or locally manufactured in 2016 (quantity to which specific excise tax applied).
    - SSB: number of 300ml sales units (e.g. bottles, cans) of SSB imported or locally manufactured in 2016 (quantity to which specific excise tax applied).
  - P_0:
    - Tobacco: retail price (i.e. price paid by final customer) of a 20-cigarette pack in 2016, in 2016 USD.
    - Alcohol: retail price (i.e. price paid by final customer) of one liter of alcoholic beverage in 2016, in 2016 USD.
    - SSB: retail price (i.e. price paid by final customer) of one 300ml sales unit (e.g. bottle, can) of SSB in 2016, in 2016 USD.