APPENDIXES

Appendix A – Econometric procedures and price-elasticity estimates

Appendix B - Tax reform simulations

Appendix C – Price adjustment mechanism
Appendix A – Econometric procedures and price-elasticity estimates

A.1. Methodology and data

To implement the tax simulations, this research expands upon Divino et al. [1] to include a new set of estimations at national and subnational levels. The micro data are inputs in the simulation in order to determine the smoking behavior and consumer responses to price as accurately as possible across the different Brazilian States. The aggregate macro data is used to calibrate the model, such that it replicated the tobacco tax incidence and revenue collection in 2018. Then, different scenarios for the federal tobacco tax were developed and their effects on cigarette prices, smoking behavior, and tax revenue were simulated. Finally, the research demonstrates that the size of the illicit cigarette market also plays a key role in the tax revenue simulations. Appendix A reports details on the simulations of the scenarios.

Two nationwide representative and extensive surveys about individual smoking behavior have been conducted in Brazil: the National Household Sample Survey (PNAD) of 2008 and the National Health Survey (PNS) of 2013. Besides their completeness and detailed questionnaires, the main limitation of these surveys is their sporadic occurrence and temporal lag. Therefore, this micro data was complemented and updated with information from Vigitel, which uses a less detailed questionnaire, but is repeated annually.¹

PNAD and PNS data reported the number of cigarettes an individual smoked per day and also how much he/she paid for the cigarettes at the time of his/her last purchase. Individual socio-economic information, such as gender, income, years of smoking, was also used to refine the price-elasticity estimation, as will be explained in the next section. Further information about the data sets and descriptive statistics can be found in Divino et al. [1].

Based on the official minimum price, cigarettes purchased below this price were classified as illicit (or illegal), in line with Divino et al. (2019). This was considered as the Price Category 1 (PC1). To increase the precision of the simulations, the legal market was divided into low price and premium brands, according to the median in this market segment. These were represented by Price Category 2 (PC2) and Price Category 3 (PC3), respectively.

In order to obtain good estimates for cigarette consumption and tax revenue in each state and price category (PC), the daily cigarette consumption per price category and state from the PNAD and PNS is multiplied by the variation in daily cigarette consumption per Brazilian state between 2013 and 2018 according to the Vigitel data.

These updated consumption patterns and the current share of smokers is then multiplied by the exact number of inhabitants per state in 2018 according to the IBGE (Brazilian Institute of Geography and Statistics) to derive the aggregate cigarette consumption. Finally, average cigarette prices are updated by the aggregate wide consumer price index tobacco sub-category (IPCA-Tobacco) in the same period and for each Brazilian state. Because this information is not available for all states, regional averages are used as a substitute when needed.

¹ Vigitel is an annual national survey of the Ministry of Health conducted by phone call to individuals randomly chosen in the 26 state capitals and the Federal District. The purpose of Vigitel is surveillance of risk and protective factors for chronic diseases, see Vigitel Brasil (2019) for further details.
Further information on the current tax system, officially registered cigarette prices data, and cigarette tax revenue was obtained from Receita Federal. Unfortunately, Receita Federal only provides tax revenue aggregated at the federal level. Table A.1 reports a summary of the variables and respective sources.

Table A.1 – Variables and sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Cigarette Tax Rates</td>
<td>Federal and State Legislations</td>
</tr>
<tr>
<td>Proposed general tax rates for the new GST</td>
<td>Odair &amp; Gobetti [2]</td>
</tr>
<tr>
<td>New excise tax rate on cigarettes</td>
<td>Authors’ choice</td>
</tr>
<tr>
<td>Share of smokers per federal state</td>
<td>Vigil 2013, 2018</td>
</tr>
<tr>
<td>Cigarette consumption per smoker and state</td>
<td>Vigil 2013, 2018</td>
</tr>
<tr>
<td>Cigarette tax revenue at national level</td>
<td>Receita Federal</td>
</tr>
<tr>
<td>Population per state</td>
<td>IBGE</td>
</tr>
<tr>
<td>Share of smokers per federal state and price category</td>
<td>PNAD 2008 and PNS 2013</td>
</tr>
<tr>
<td>Cigarette consumption per smoker, state and price category</td>
<td>PNAD 2008 and PNS 2013</td>
</tr>
<tr>
<td>Mean price of cigarettes in price categories 1, 2 and 3</td>
<td>PNAD 2008 and PNS 2013 updated with tobacco-specific consumer price index from IBGE</td>
</tr>
</tbody>
</table>

A.2 Price-elasticity of cigarette consumption

We estimated the own-price elasticity of cigarette consumption by region and price category. A price elasticity of consumption is a measure that indicates how many percentage points cigarette consumption would change if cigarette prices changed by one percent. Based on the procedure described in Divino et al.,[1] the price elasticity is obtained in two steps. First, we estimate how smokers adjust the intensity of their current consumption for those individuals who continue smoking after a price change. Second, we estimate how many individuals would quit or start smoking due to higher or lower cigarette prices. The combination of these conditional and unconditional elasticities yields to the aggregate price elasticity that is used in the simulation exercises. Table A.2 reports the conditional and unconditional price elasticities by region and price category. Note that the price elasticities are specific for each geographical region and price category and are obtained through a single estimation. In both estimations (aforementioned steps), the individually reported price is substituted by the state average price in order to avoid the endogeneity bias that occurs because consumers may adjust to price changes by switching to a cheaper brand.

Table A.2 – Price-elasticities by region and price category

<table>
<thead>
<tr>
<th>Region</th>
<th>Unconditional</th>
<th>Conditional</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC1</td>
<td>PC2</td>
<td>PC3</td>
</tr>
<tr>
<td>Northeast</td>
<td>-0.26</td>
<td>-0.42</td>
<td>-0.41</td>
</tr>
<tr>
<td>North</td>
<td>-0.24</td>
<td>-0.42</td>
<td>-0.41</td>
</tr>
<tr>
<td>Southeast</td>
<td>-0.24</td>
<td>-0.29</td>
<td>-0.29</td>
</tr>
<tr>
<td>South</td>
<td>-0.21</td>
<td>-0.42</td>
<td>-0.41</td>
</tr>
<tr>
<td>Midwest</td>
<td>-0.23</td>
<td>-0.20</td>
<td>-0.30</td>
</tr>
<tr>
<td>BRAZIL</td>
<td>-0.24</td>
<td>-0.26</td>
<td>-0.29</td>
</tr>
</tbody>
</table>

Notes: PC1 = price category 1 or illicit market, PC2 = low price brands, and PC3 = premium brands.
Appendix B - Tax reform simulations

B.1 Tax reform simulations

The simulation scenarios start from the current tax burden on cigarettes, which are then changed to a new tax scheme, after the implementation of the tax reform with only two taxes—the GST and the federal selective tax. Odair and Gobetti [2] estimated the general tax rates for the new GST and the federal excise tax, for both Constitutional Amendment proposals, under the assumption of keeping the same overall tax burden (before and after the tax reform). This research uses their results in the simulation exercises, but properly adapted to the case of tobacco tax reform. The details and corresponding assumptions behind these steps are explained below.

B.1.1 Baseline scenario

The starting point of the simulations is the number of smokers, average consumption of cigarettes and average prices of cigarettes across all Brazilian states, and within the three price categories defined previously. As explained in Appendix A, these numbers refer to the baseline year of 2018. Recall that the share of cigarette sales in the first price category is equivalent to the extension of the illicit market of cigarettes, given that it is forbidden by law to sell cigarettes below the minimum price in Brazil. Price categories 2 and 3 represent cheaper cigarettes and premium brands, respectively.

The calibration of the model first adjusts the size of the illicit market, that is, the share of smokers that consume cigarettes of price category 1, such that the calculated aggregate tax revenue matches the observed cigarette tax collection in 2018. Based on the average cigarette prices and the number of smokers, the current tax rules are used to calculate the monthly aggregate tobacco tax revenue per state for the IPI, PIS/CONFINS, and ICMS. Note that in absence of further information about the brand of cigarettes purchased, the Special Rule for IPI calculation is considered throughout the simulations, as explained in Divino et al.[1] The ICMS tax rates on tobacco products for each Brazilian State are obtained from Ribeiro and Pinto work.[3]

The rationale for choosing the size of the illegal market as the free parameter for the initial calibration is the following. Even with the most sophisticated techniques, a quantification of illegal cigarette consumption will always remain an imprecise estimate because the share of the illicit market is an unobserved variable in practice. In this study, the classification of cigarette sales as legal or illegal is derived from the official minimum price and smokers’ responses of cigarette expenditure from the individual surveys in 2008 and 2013.2 The size of the illegal market changed over time so that the shares from 2013 need to be adjusted. Moreover, the estimates from 2013 and 2008 are likely to be lower than the true extent of the illegal market. First, some (illegal) cigarettes are sold individually “out of the pack”. Because the unit price of those individually sold cigarettes is higher than its original price per pack, the imputed price for an entire pack may lie above the minimum price and thus the purchase would be erroneously classified as part of the legal market. Second, illegally sold premium brand cigarette prices are also likely to be above the minimum price. Consequently, the 2013 and 2008 microdata most likely lead to an underestimation of the size of the illegal market. The "misspecification" is considered equal for the two price categories and across Brazilian states. Therefore, the additional percentage points of the illegal market that are necessary to replicate the

2 Alternative measures of the cigarette illicit market are discussed in Szklo et al.[4]
observed tobacco tax revenue in 2018 are equally subtracted from the share of cigarette price categories 2 and 3.

An explicit assumption in the reform scenario simulations is that, once the size of the illegal market is adjusted in the baseline scenario, it remains constant. This assumption is plausible because the official minimum price is not under discussion in the Constitutional Amendment Bills, and, therefore, it is likely to remain at its current level (anyway, this is a legal issue, not a constitutional matter). Nevertheless, in order to show how this assumption affects tax revenue collection under the new after-reform tax scheme, we include an additional exercise where the size of the illicit market is allowed to change exogenously in a sensitivity analysis.

**B.1.2 Constitutional amendment 45/2019 – No-Tax-Revenue-Loss Scenario I**

This scenario simulates the impacts of changing the Brazilian tax scheme according to the Constitutional Amendment Bill 45/2019. The reform intends to simplify the tax scheme by unifying different tributes into a VAT-based tax scheme with two components: (i) general tax on operations with goods and services (GST); and (ii) a special tobacco excise tax (TET). In this simulation scenario, the value of the TET is chosen such that no state would experience a loss of tobacco tax revenue compared to the baseline tax scenario from the year of 2018. Note that both types of taxes would not vary between federal states. That is, the state with the most unfavorable change of tobacco tax revenue after introduction of the new GST is taken and the TET is adjusted such that overall cigarette tax revenue change is equal to zero. This *ad valorem* TET rate is then applied in all other federal states. Given the current public deficit at all levels and the upcoming debates in the political landscape, the possibility of avoiding revenue lost from the tax reform is an important scenario to consider.

To make the simulations as realistic as possible, consumers’ responses to the cigarette prices in the new after-reform scenario are taken into account. In states where tax revenue and thus cigarette prices would be higher, consumers tend to smoke less because most of them are price sensitive and respond to price variations according to the estimated state and price-category specific elasticities. Of course, the price adjustments depend on the market power of the tobacco companies. However, given that few companies dominate the market, it is very likely that cigarette producers would fully pass-through any tax increase to consumers.\[^5\] For the sake of simplicity, we assume full pass-through from the reform’s tax variation to the final consumer prices. The assumption of full pass-through of tax changes to cigarette prices also implies that the factory price of cigarettes does not change due to the tax reform.

Consumers adjust their consumption behavior according to the estimated price-elasticity of demand. It is important to notice that, by assumption, the distribution of consumers by price category does not change. Consumers do not switch price categories, but instead adjust the intensity of their cigarette consumption.

**B.1.3 Constitutional amendment 45/2019 – Maximum-Excise-Tax Scenario II**

In this scenario, the TET rate is set so that total nationwide tobacco tax revenue is maximized under the condition that no Brazilian state would experience any reduction in tax revenue. The limit to maximize tax revenue depends on the price-elasticity of cigarette consumption and is given by the highest TET rate under which no state starts losing tax revenue. This latter condition seems a necessary element in the political process because the Constitutional Amendment Bill requires approval by the state representatives in the Federal Senate. After the tax reform proposed by the
Amendment Bill 45/2019, the implementation of this excise tax would be straightforward with the new TET.

B.1.4 Specific Excise Tax on Cigarettes with No-Tax-Revenue-Loss – Scenario III

In this scenario, instead of having a federal excise tax as pure *ad valorem* tax charged on the retail price as in the previous sections, a specific tax per pack is considered. That is, the TET is a fixed absolute value (in BRL) charged per cigarette pack and the GST would be levied along the lines of the tax reform. In this case, there is a specific tax plus an *ad valorem* tax on cigarettes while the previous two scenarios consider only *ad valorem* taxes. Although this kind of tax scheme is currently not under consideration by the Brazilian Congress under the tax reform Constitutional Amendments, it is worthwhile to evaluate this hypothetical scenario as an alternative framework of comparison, because best practices on tobacco taxation worldwide rely on a mix structure of *ad valorem* and specific tax on cigarettes.

B.1.5 Reduction in the illicit cigarette market

For all previous scenarios, there is an additional simulation by relaxing the assumption that illicit trade remains constant. This simulation allows the size of the illicit market to change exogenously in a sensitivity analysis. Despite the fact that the size of the illegal market is hard to determine and its estimate obviously affects the outcome of the tax revenue simulations, it is informative to show how the illegal market might affect tax collection in the reform scenarios. Moreover, the extent of the illegal cigarette market is a choice parameter because through tighter controls, monitoring, and many other public policies, cigarette smuggling could effectively be reduced. Specifically, the simulation considers the effects of a 10 percent reduction in the illegal market. To perform this simulation, the size of the illicit cigarette market in the initial calibration that was used to replicate the observed cigarette tax collection in 2018 is reduced. The reduction in the illicit market is equally distributed across price categories as consumption increases of both cheaper cigarettes and premium brands.
Appendix C – Price adjustment mechanism

Let $P_f$ be the cigarette pack factory value, that is, the tax-free price which already includes all associated costs for production, distribution, and profit margins for the associated parties. Considering $B$ is the tobacco tax burden, the retail cigarette pack price in Brazil is given by:

$$P_r = \frac{P_f}{1-B}$$

Under the current and after-reform legislation, the tax basis is the retail price including taxes. Since the main objective of this research is to assess the Brazilian tax reform, changing the tax structure implies a change in the tax burden, $B$.

Considering $P_f$ fixed, that is, the firms’ production cost and profit per pack do not change with the tax reform, the retail price change due to a tax reform change can be expressed as follows:

$$\frac{\Delta P}{P} = \frac{P_f^i - P_f^0}{P_f} = \left( \frac{P_f}{1-B^i} - \frac{P_f}{1-B^0} \right) \times \frac{1-B^0}{P_f}$$

$$= \frac{1-B^0}{1-B^i} - 1$$

$$= \frac{B^i - B^0}{1-B^i}$$

where the superscript $0$ indicates baseline scenario values and $i$ any of the reform scenarios. Therefore, the only sort of price changing is the tax burden change.

Below, the Figure B.1 shows how the final consumer price would behave given that $B^0 = 0.7$ as in the baseline scenario. It can be seen that if the new tax burden $B^i$ is lower than the $B^0$, the price will decrease. Otherwise, the price will increase. It also noticeable that, because the tax basis is the retail price (the final pack price the consumer faces) the price adjustment mechanism is nonlinear. In this case, for $B^i > B^0$, the change in prices is proportionally higher than the tax burden change and grows asymptotically as $B^i \to 1$.

Observations:

i. for scenarios I and II, the tax burden, $B^i$, is just the sum of the ad valorem taxes;

ii. for scenario III, since it considers a specific excise tax per pack, $\ell$, and ad valorem taxes which add to $\tau$, the tax burden is obtained as follows:

Let $B = \frac{\ell + \tau \times P_r}{P_r}$ and $P_f = P_r^0 \times (1-B^0)$ be the tax burden and the cigarette pack factory value, respectively; the latter in terms of the baseline retail price. Thus, the retail price for this scenario is $P_r^i = \frac{P_r^0 \times (1-B^0) + \ell}{1-\tau}$, and the tax burden is given by
\[ B' = \tau + \frac{\ell}{P'} \]

\[ = \tau + (1 - \tau) \times \frac{\ell}{P^0 \times (1 - B^0) + \ell} \]

**Figure B1 – Cigarette price adjustment mechanism**

\[ \Delta P \]

\[ \frac{\Delta P}{P} = \frac{B_i - B_0}{1 - B_i} \]

Appendix references


