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BRAZIL

ACCELERATING EFFECTIVE TOBACCO TAXES IN BRAZIL: TRENDS AND PERSPECTIVES

Livio Ribeiro and Vilma Pinto
Fundação Centro de Estudos do Comércio Exterior (FUNCEX)

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Economic Research Informing Tobacco Control Policy

Red Sur Country Studies Series

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Within this global initiative, Red Sur led the regional research "Tobacco taxes in Latin America", which mobilized seven research centers to study the different options for tobacco tax policies in Argentina, Brazil, Ecuador, Mexico and Peru.

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1. Introduction

The literature on the economics of tobacco control contains substantial evidence on the importance of increasing the price of tobacco products as an effective tool for reducing tobacco consumption (U.S. National Cancer Institute and World Health Organization, 2016). Usually, these price increases have been accomplished through the implementation of excise taxes which lead to higher prices for final consumers – whenever tobacco products are less affordable (i.e., represent a bigger part of a consumer´s income), final consumption tends to be smaller. Typically, these tax increases are implemented in tandem with non-price measures (such as educational campaigns and legislation for smoke-free places) that enhance the impacts of price increases.

The negative correlation between prices and consumption is beyond dispute. Nevertheless, increasing taxes do have side effects that can lead to changes in the tobacco consumption basket, and therefore have completely different implications in terms of policy evaluation.

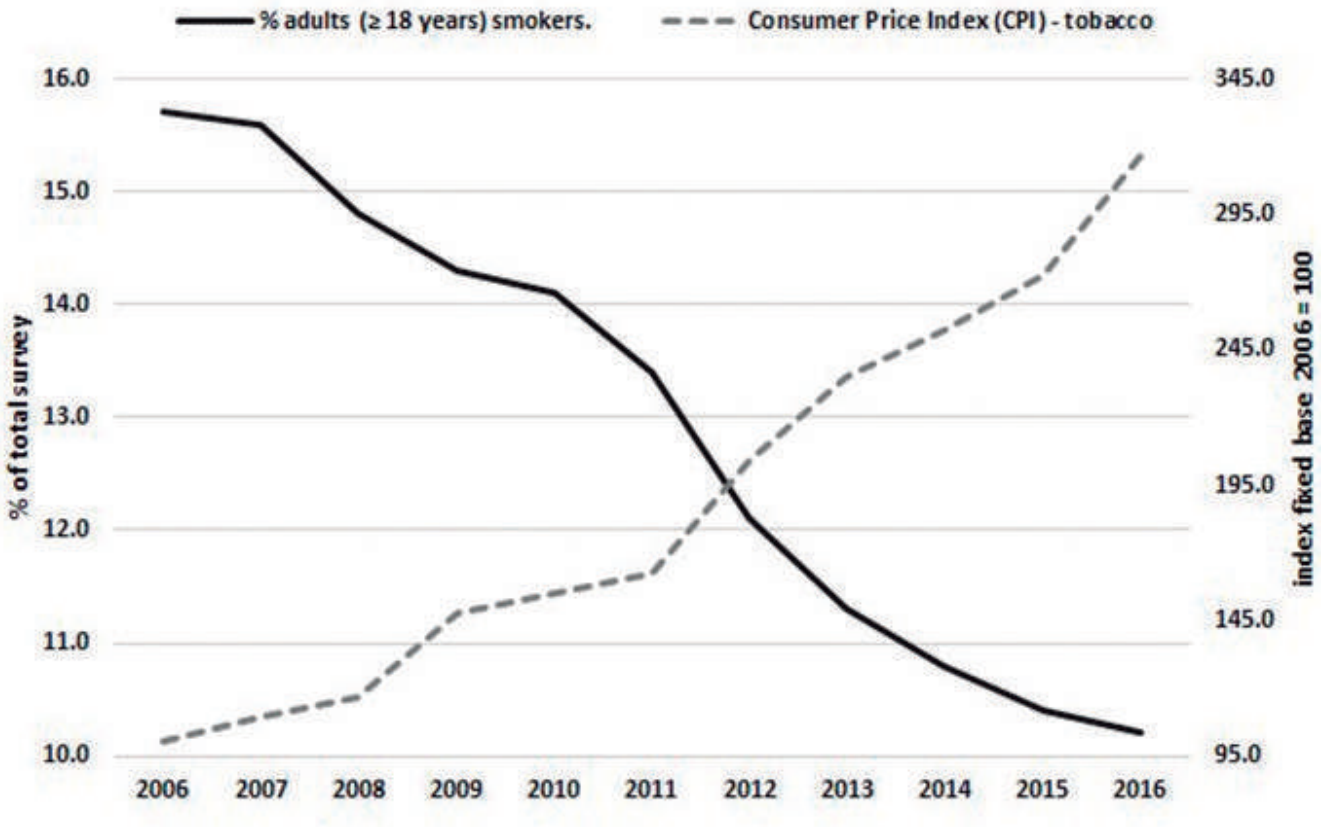
It is possible that higher prices on cigarettes result in demand substitution for other tobacco products (such as pipes or cigars). It is also possible that higher cigarettes prices could lead to consumption diversion for illegal products (both cigarettes and other tobacco products, produced locally or "imported").

Besides effects on prevalence (which are, at first, unclear), the above results could lead to completely different scenarios in terms of consumption patterns and implications on tax revenues and public health expenses – higher taxes could potentially lead to smaller revenues and diversion to other tobacco products, including illegal products.

Specifically in Brazil, several policies have been implemented over the last thirty years to reduce tobacco consumption, making us one of the world leaders in prevalence reduction: from around 35% in the end of the 1980s to a bit above 10% in 2016 according to Portes *et al*., (2018) and Brazil (2017).

Real price increases have acted alongside legislative, regulatory and educational efforts, including multiple rounds of excise tax increases (through several tax regimes) and the adoption of minimum cigarette prices. Among the plethora of tobacco control measures, price increases due to higher excise taxes were the spearhead of tobacco control policies. With price increases running above inflation, tobacco has become less affordable – and, as expected, prevalence has decreased.

Figure 1: **Prices vs. Tobacco prevalence in Brazil**



Source: Brazil (2017) and IBGE.

This reduction in tobacco consumption is considered a big success. Nevertheless, recent evidence suggests that consumption has spilled over to illicit products in a trend that has accelerated dramatically ever since the beginning of this decade to levels close to 45% of total consumption in 2016 (Szklo *et al.*, 2017).

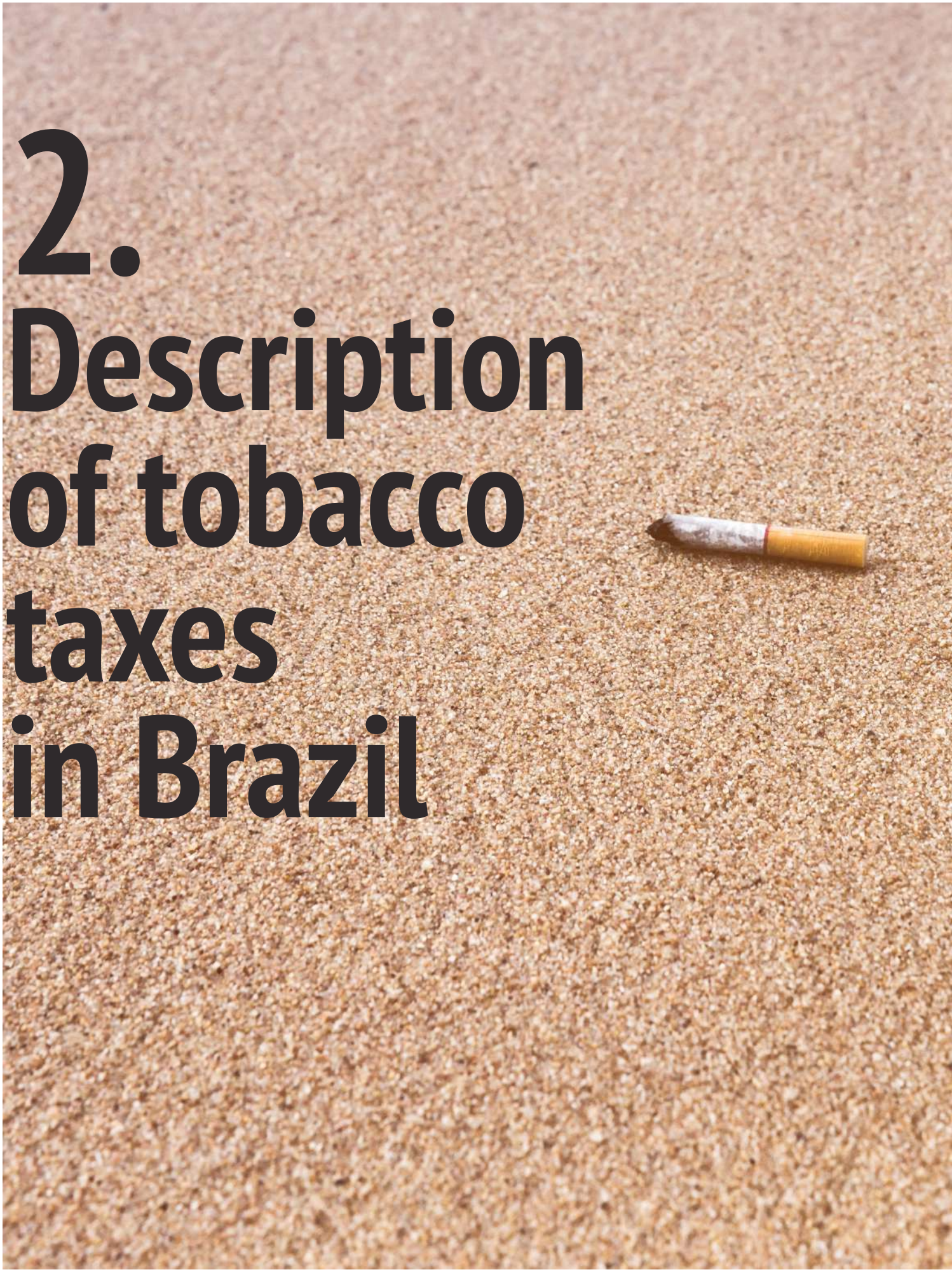
Tax increases and other tobacco control measures have been very effective in reducing prevalence, despite a significant illicit trade problem. However, tax revenues have been decreasing at a faster rate than the decline in prevalence. Thus, the decrease in revenue collection may be the result of the combination of rising illicit trade and declining smoking prevalence.

The question is where to go next, not only in terms of policy redesign to curb tobacco consumption even more but also in terms of tracking and forecasting Federal Revenue Office (SRFB) tax revenues in the presence of a growing number of illicit cigarettes. For that, updating the technology of tobacco control evaluation would be highly desirable, not only in terms of demand elasticities but also with efforts to understand illicit market dynamics.

Besides this brief introduction, this report is organized as follows. Chapter 2 discusses the tax structure applicable to the Brazilian tobacco market, highlighting taxation on cigarettes.

Chapter 3 provides some evidence on the linkages in the Brazilian and Paraguayan tobacco production chain using the technical transformation requirements approach. Chapter 4 updates price and income demand elasticities using new control variables and econometric techniques. Finally, Chapter 5 concludes by outlining our main policy recommendations.

2. Description of tobacco taxes in Brazil



The first part of a comprehensive analysis of tobacco control policies in Brazil is to fully understand the tax structure. Since the Law 12546/2011, tax increases also came with minimum prices for cigarettes[1]. Tobacco taxes in Brazil are charged both in Federal and State Levels, and tax burden is constituted by five different taxes.

On the federal level, there are four taxes: (i) Industrialized Products Tax (*Imposto sobre produtos industrializados*, IPI); (ii) Tax for Social Integration program financing (*Programa de Integração Social*, PIS); (iii) Tax for Social Security financing (*Contribuição para o Financiamento da Seguridade Social*, COFINS); and (iv) Import duty (*Imposto sobre Importações*, II). The only subnational tax is the Merchandise and Service Circulation Tax (*Imposto sobre comercialização de mercadoria e serviços*, ICMS), which has different burdens depending on the State. Therefore, the total tax burden on tobacco products varies across the country and, on the upper bound, represents up to 78% of the final sales price[2].

In addition, it should be noted that the taxation on tobacco products occurs through downstream tax substitution in the production chain ("*substituição tributária para frente*"), which reduces tax evasion and increases control of collected revenues. Downstream tax substitution is nothing more than the act of concentrating the responsibility of the tax collection in a single taxpayer. In the case of tobacco products, this concentration happens at the local producer (manufacturer) or at the importer (paid upon customs clearance), therefore clearing wholesalers and retailers from tax obligations.

In broad terms, the IPI is a federal tax paid upon two different tax events. The first one is on imports (the customs clearance of foreign products) and the second one is on domestic operations (the local output of a Brazilian industrial establishment). Thus, there are two possible IPI incidence bases: (i) the ex-factory value for domestic operations; and (ii) the customs value, considering all costs and in local currency, of imports.

However, special regimes apply when talking about tobacco products - understood as the majority of products classified under the Common Nomenclature of MERCOSUL (*Nomenclatura Comum do Mercosul*, NCM) code 24.02[3]. Furthermore, IPI tax incidence on tobacco products has changed significantly over time, both in terms of the tax rate and taxation method (*ad valorem* or *specific component*).

There were two noteworthy tax regimes before the current one. The first one lasted until May 1999, on which the IPI was charged on products classified under TIPI heading 24.02.20.00[4], with an effective *ad valorem* tax rate of 41.25% (on the retail selling price).

1. According to Secretariat of Federal Revenue of Brazil (*Secretaria da Receita Federal do Brasil,* SRFB) this price should be sufficiently elevated in order to accommodate all the cost (production and commercialization), taxes and a minimum profit margin of legal producers, therefore inhibiting tax evasion, predatory competition and warranting the minimum needed to finance public health expenses.
2. Considering that cigarettes are sold at the minimum price under the special rule in Brasilia.
3. Cigars, cheroots, cigarillos and cigarettes, of tobacco or of tobacco substitutes.
4. This is the NCM code for Cigarettes containing tobacco.

The second regime was in place between June 1999 and November 2011. The tax rate became dependent on the tax classification category of the product[5], and the taxation method changed to a specific rate with a clear upward bias (implemented in five tranches throughout the years). The table below consolidates those "historical" IPI tax and taxation schemes.

The general rule is *ad valorem* taxation with an effective tax rate higher than rates at the end of the 1990s. The tax rate is set at 300% with the calculation basis being 15% of the selling price – therefore, the effective tax rate is 45%. The special rule (which is optional) is composed by the sum of two installments, one *ad valorem* rate (with the same calculation basis observed in the general rule) and a specific tax charged differently on hard and soft packs. Both rates have been progressively increased since 2011 in order to reduce the affordability of cigarettes. The table above describes this evolution. Thus, IPI tax burden depends on several factors including the cigarette price and the tax rule chose by the manufacturer.

Table 1: **IPI taxes on cigarettes from December 2011**

Fiscal rule	General rule	Special rule		
	Ad valorem	Ad valorem	Specific	
			Soft pack	Hard pack
12/01/2011 to 04/30/2012	Tax rate: 300%. Calculation base: 15% of the selling price. Effective tax rate: 45%.	0%	R$ 0.80	R$ 1.15
05/01/2012 to 12/31/2012		40.0%	R$ 0.90	R$ 1.20
01/01/2013 to 12/31/2013		47.0%	R$ 1.05	R$ 1.25
01/01/2014 to 12/31/2014		54.0%	R$ 1.20	R$ 1.30
01/01/2015 to 04/30/2016		60.0%	R$ 1.30	R$ 1.30
05/01/2016 to 11/30/2016		63.3%	R$ 1.40	R$ 1.40
As of 12/01/2016		66.7%	R$ 1.50	R$ 1.50

Source: MF/SRFB.

5. As of June 1st, 1999, with the issuance of Decree No. 3070/99 the tax on cigarettes was based on specific rates according to the tax classification class of the product. Those classes were: I - Class IV: Brands in rigid packages (box) and versions in packages with length exceeding 87mm; II - Class III: Brands in rigid packages (box) and versions in packages with length up to 87mm; III - Class II: other brands in packages with length exceeding 87mm; and IV - Class I: other brands in packages with length up to 87mm.

Table 2: **Effective tax rate (IPI) calculations**

a) Sale price	R$ 5.00		
General Rule		**Special Rule**	
Basis of incidence		Basis ofincidence	
Criterion:15% of the sales pri		Criterion:15% of the sales price	
b) Value of the basis of incidence = (a) x criterion	R$ 0.75	b) Value of the basis of incidence = (a) x criterion	R$ 0.75
c) Ad valoremrate	300%	c) Ad valoremrate	66.7%
d) Ad valoremValue = (b) x (c):	R$ 2.25	d) Ad valoremValue = (b) x (c):	R$ 0.50
		e) Specific tax value	R$ 1.50
		f) Total tax value = (d) + (e)	R$ 2.00
Effective tax rate (e) = (d) / (a):	45%	Effective tax rate (g) = (f) / (a):	40%

Source: Authors calculations.

Suppose that cigarettes are sold by the minimum allowed price (R$ 5.00/pack). The general rule would charge an effective tax rate of 45%, implying in an IPI tax burden of R$ 2.25. On its turn, the special rule implies in an *ad valorem* tax burden of R$ 0.50 which sums up with a specific tax of R$ 1.50 (hard or soft packs). Therefore, the special rule would charge an effective rate of 40%, with a total IPI tax burden of R$ 2.00.

Of the 21 official cigarette suppliers in Brazil (both producers and importers), all of them have chosen the special rule - because it implies a smaller effective IPI tax rate.

2.1 PIS, COFINS and Import duties on tobacco products

PIS/COFINS.

PIS and COFINS are federal duties with very similar taxation schemes. According to art.10 of Normative Instruction SRFB No. 247/2002, the calculation basis of the PIS/COFINS is the gross company revenue and their rates were, respectively, 0.65% and 3.0%[6]. In the specific case of tobacco products, article No. 48 of the same Normative Instruction postulated that each incidence basis (retail selling price) would be multiplied respectively by 1.38 (PIS) and 1.18 (COFINS).

6. Those tax rates apply to the cumulative tax regime, on which the taxpayers are levied upon their presumed yearly profit - a simplified way to tax corporation´s income in Brazil. Basically all tobacco suppliers in Brazil use the cumulative tax regime.

Table 3: **PIS and COFINS duties on tobacco suppliers**

Validity	PIS (R$)	COFINS (R$)
Until 02/28/2006	0.65% x 1.38 x retail price sales (R$)	3% x 1.18 x retail price sales (R$)
03/01/2006 to 06/30/2009	0.65% x 1.98 x retail price sales (R$)	3% x 1.69 x retail price sales (R$)
As of 07/01/2009	0.65% x 3.42 x retail price sales (R$)	3% x 2.9169 x retail price sales (R$)

Source: MF/SRFB.

Both manufacturers and cigarette importers pay those taxes[7] and, as with the IPI, duties have been rising since 2006 within the framework of overcharging tobacco (in this case, tobacco producers as PIS/COFINS are charged upon companies and not over NCM codes). That wasn´t done by changing the tax rate, yet by increasing incidence basis multipliers. A historical evolution of PIS and COFINS assessed on cigarettes is summarized in Table 3.

2.2 Import Duty (II)

The last Federal tax applicable on tobacco products is the import duty, which is levied on customs clearance. The tax is charged not only when companies do imports, but also when imports are done by individuals (in their own personal luggage). The calculation basis for the import duty is the value of the imported good in local currency (CIF customs value[8]) and Mercosul´s Common External Tarif (Tarifa Externa Comum, TEC) indicates the applicable import tax rate.

As with the IPI, each Common Nomenclature Code of Mercosul (NCM) tobacco product has its own applicable tax rate, varying from 10% to 20%. A summary of all TEC rates by NCM can be found in the table below.

7. See art. 5 of Law n° 9715/1998, art. 3 of Supplementary Law n° 70/1991, art. 53 of Law n° 9532/1997, art. 29 of Law n° 10865/2004, art. 62 of Law n° 11196/2005 and art. 5 of Law n° 12024/2009
8. CIF: Cost, Insurance and Freight

Table 4: **Import duties on tobacco products**

NCM Code	Product Description	TEC (%)
24.01	**Not manufactured tobacco; waste of tobacco.**	
2401.10	Tobacco not stemmed	
2401.10.10	Sheets, without drying or fermenting	14
2401.10.20	In dry leaves or fermented type capeiro	14
2401.10.30	In leaves dried in a hot air dryer (flue-cured) of the virginia type	14
2401.10.40	In dry leaves with a content of volatile oils exceeding 0.2% by weight, type of turkish	10
2401.10.90	Others	14
2401.20	Tobacco whole or in part stemmed	
2401.20.10	Sheets, without drying or fermenting	14
2401.20.20	In dry leaves or fermented type capeiro	14
2401.20.30	In leaves dried in a hot air dryer (flue-cured) of the virginia type	14
2401.20.40	In dry leaves (light air cured), the type burley	14
2401.20.90	Others	14
2401.30.00	Tobacco refuse	14
24.02	**Cigars, cigarillos and cigarettes, tobacco or its substitutes.**	
2402.10.00	Cigars and cigarillos, containing tobacco	20
2402.20.00	Cigarettes containing tobacco	20
2402.90.00	Others	20
24.03	**Products of tobacco and its substitutes, manufactured; tobacco "homogenized" or "reconstituted"; extracts and tobacco sauces.**	
2403.1	Tobacco for smoking even containing substitutes of tobacco in any proportion:	
2403.11.00	Tobacco for hookah (water pipe) mentioned in subheading note 1 to this chapter	20
2403.19.00	Others	20
2403.9	Others:	
2403.91.00	Tobacco "homogenised" or "reconstituted"	14
2403.99	Others	
2403.99.10	Extracts and sauces	14
2403.99.90	Others	18

Source: Ministry of Industry, Foreign Trade and Services (MDIC)

IPI taxes on tobacco products

IPI taxes on other tobacco products are summarized on the table below, in which all tobacco products are classified by its NCM code and respective tax rates under TIPI (*Tabela do IPI*, IPI´s Table).

Non-manufactured tobacco (NCM 24.01), non-stemmed tobacco (NCM 24.01.10) and refuse tobacco (NCM 24.01.30) are not taxed (NT), whether at least partially stemmed tobacco (NCM 24.01.20) has an *ad valorem* tax rate of 30%, with calculation basis of 100% of the retail selling price. The same tax rate and calculation basis apply to NCM 24.03. Finally, within NCM 24.02 there are also products which comply with those rules, such as cigars and hand-made cigarettes. Nevertheless, this table highlights that the majority of 24.02 products comply with the special taxation regimes previously explained.

At the subnational level (States and the Federal District), the ICMS is levied on tobacco products. The general constitutional regulation of ICMS is provided by the Supplementary Law 87/1996 ("Lei Kandir") and is locally regulated by State decrees. As with the IPI, the ICMS is based upon the selling price and is charged with downstream tax substitution – tax collection is made on final good suppliers (producers or importers).

As a subnational tax, there are actually 27 ICMS legislations across the country. Talking specifically about tobacco products (NCM 24.01, 24.02 and 24.03), tax rates range from 25% to 37%. Furthermore, many States charge an additional earmarked 2% duty for their Poverty Alleviation Funds (*Fundo de Combate à Pobreza*) - what could be within the total tax burden.

Only the State of Pernambuco (PE) charges differently NCM 24.02 (*Cigars, Cigarrillos and cigarettes*) from other tobacco products. For them, NCM 24.02 is charged on 27% ICMS + 2% for the State Poverty Combat and Eradication Fund, whereas NCM 24.01 and 24.03 are charged with a 25% ICMS tax rate. Furthermore, only the States of Minas Gerais (MG) and Espírito Santo (ES) charge hard and soft packs differently – hard packs pay an additional 2% tax.

Table 6 below summarizes all final ICMS tax rates (tax + additional) which are assessed on cigarettes across the country.

Table 5: **IPI taxes on tobacco goods**

NCM Code	Product Description	TIPI (%)
24.01	**Not manufactured tobacco; waste of tobacco.**	
2401.10	Tobacco not stemmed	
2401.10.10	Sheets, without drying or fermenting	NT
2401.10.20	In dry leaves or fermented type capeiro	NT
2401.10.30	In leaves dried in a hot air dryer (flue-cured) of the virginia type	NT
2401.10.40	In dry leaves with a content of volatile oils exceeding 0.2% by weight, type of turkish	NT
2401.10.90	Others	NT
2401.20	Tobacco whole or in part stemmed	
2401.20.10	Sheets, without drying or fermenting	30
2401.20.20	In dry leaves or fermented type capeiro	30
2401.20.30	In leaves dried in a hot air dryer (flue-cured) of the virginia type	30
2401.20.40	In dry leaves (light air cured), the type burley	30
2401.20.90	Others	30
2401.30.00	Tobacco refuse	NT
24.02	**Cigars, cigarillos and cigarettes, tobacco or its substitutes.**	
2402.10.00	Cigars and cigarillos, containing tobacco	30
	Ex 01 – Cigarillos	300
2402.20.00	Cigarettes containing tobacco	300
	Ex 01 - Hand-made products	30
2402.90.00	Others	30
	Ex 01 - Cigarettes not containing tobacco, except hand-made products	300
24.03	**Products of tobacco and its substitutes, manufactured; tobacco "homogenized" or "reconstituted"; extracts and tobacco sauces.**	
2403.1	Tobacco for smoking even containing substitutes of tobacco in any proportion:	
2403.11.00	Tobacco for hookah (water pipe) mentioned in subheading note 1 to this chapter	30
2403.19.00	Others	30
2403.9	Others:	
2403.91.00	Tobacco "homogenised" or "reconstituted"	30
2403.99	Others	
2403.99.10	Extracts and sauces	30
2403.99.90	Others	30

Source: MF/SRFB

Table 6: **ICMS taxes on tobacco products**

Unit of the Federation	ICMS		Unit of the Federation	ICMS		Unit of the Federation	ICMS	
	Pack	Box		Pack	Box		Pack	Box
AC	30%	30%	**MG**	25%	27%	**RR**	25%	25%
AL	31%	31%	**MS**	30%	30%	**RS**	27%	27%
AM	30%	30%	**MT**	37%	37%	**RO**	34%	34%
AP	25%	25%	**PA**	30%	30%	**SC**	25%	25%
BA	30%	30%	**PB**	31%	31%	**SP**	32%	32%
CE	30%	30%	**PE**	29%	29%	**SE**	28%	28%
DF	37%	37%	**PI**	29%	29%	**TO**	29%	29%
ES	25%	27%	**PR**	29%	29%	**Average**	**29%**	**29%**
GO	27%	27%	**RJ**	29%	29%	**Median**	**29%**	**29%**
MA	29%	29%	**RN**	29%	29%	**Standard Deviation**	**3%**	**3%**

Source: Subnational legislation

2.3 Total Tax Burden on Cigarettes

Based on the details of the taxes currently levied on cigarettes and other tobacco products in Brazil, it is possible to calculate the total tax burden. It is important to realize that such burden varies according to: (i) the retail price; (ii) the subnational (State) ICMS tax rate; (iii) PIC/COFINS tax collection; and (iv) the chosen rule (the general one and the special one) applicable for IPI calculation and collection.

The table above shows the total fiscal burden on final retail prices of domestically produced cigarettes (Import Duty do not apply) given two alternative retail prices. At first, the fiscal burden is calculated on the minimum price (R$ 5.00/pack as of May 1st, 2016). Secondly, the calculation is based on the maximum current price of *Derby* (the most popular legal brand in 2017 according to Euromonitor) for each State of the country (ranging from R$ 6.50 to R$ 8.25, therefore above the minimum price).

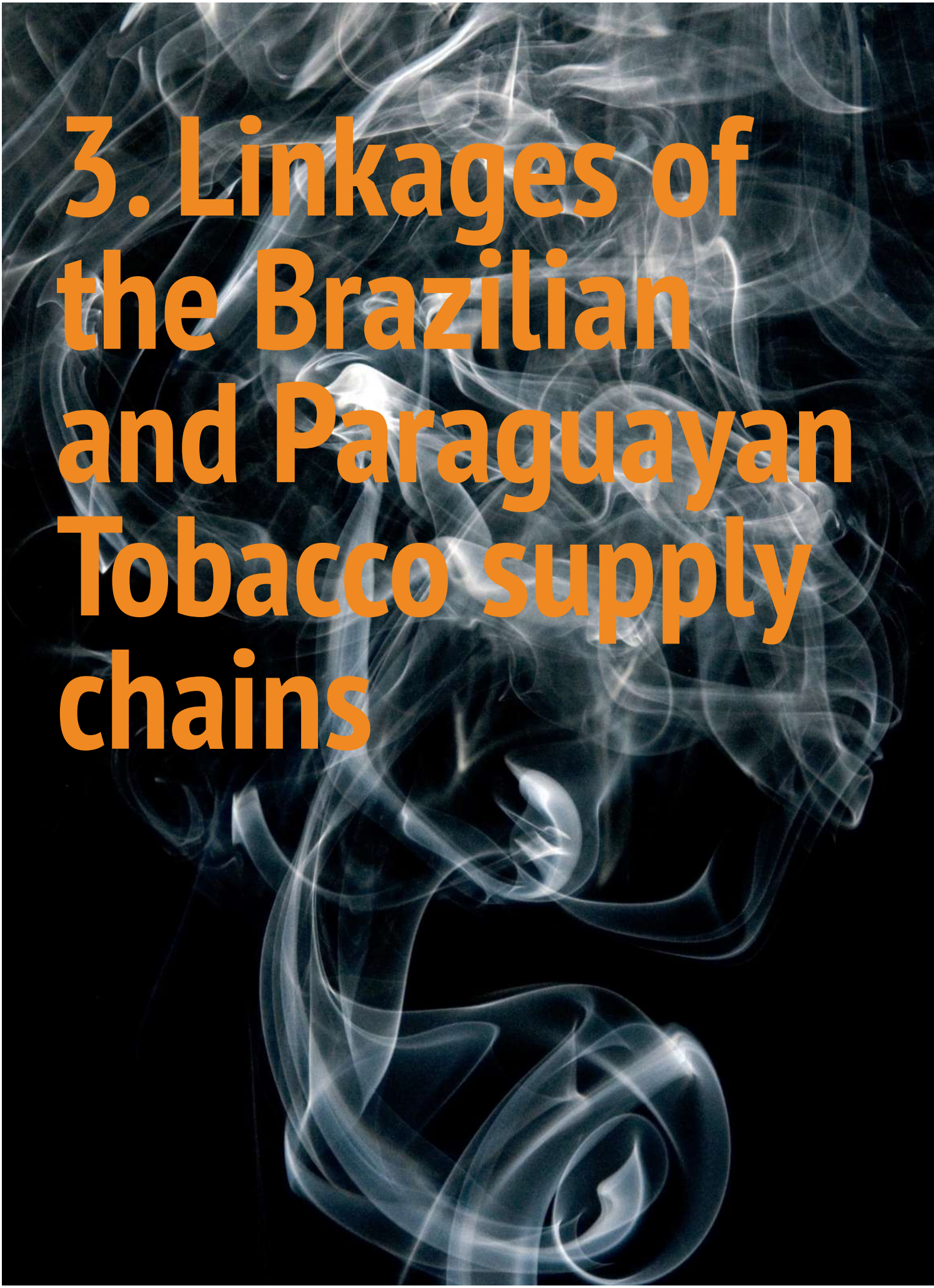
The total tax burden on cigarettes priced on the minimum allowed ranges from 81% to 93% on the general IPI rule and from 76% to 88% on the specific IPI rule, depending on the State. Results based upon *Derby* (priced above the minimum) show the same range for the general IPI rule yet smaller (from 66% to 78%) on the special IPI rule.

This difference occurs because the specific portion considered in the special IPI rule calculation (specific tax of R$ 1.50 ever since December 1st, 2016) implies that the higher the incidence basis (retail selling price), the lower the tax burden (in terms of the effective tax).

Table 7: **Total Tax Burden on National Cigarettes Across the Country (2018)**

State	Effective tax rate - Minimum Price		Effective tax rate - Derby*	
	General Rule	Special Rule	General Rule	Special Rule
DF	93%	88%	93%	78%
MT	93%	88%	93%	77%
RO	90%	85%	90%	76%
SP	88%	83%	88%	71%
AL	87%	82%	87%	73%
PB	87%	82%	87%	75%
AC	86%	81%	86%	72%
AM	86%	81%	86%	72%
BA	86%	81%	86%	72%
CE	86%	81%	86%	74%
MS	86%	81%	86%	73%
PA	86%	81%	86%	72%
MA	85%	80%	85%	73%
PE	85%	80%	85%	73%
PI	85%	80%	85%	70%
PR	85%	80%	85%	69%
RJ	85%	80%	85%	72%
RN	85%	80%	85%	71%
TO	85%	80%	85%	71%
SE	84%	79%	84%	70%
GO	83%	78%	83%	70%
RS	83%	78%	83%	68%
ES**	82%	77%	82%	69%
MG**	82%	77%	82%	69%
AP	81%	76%	81%	67%
RR	81%	76%	81%	69%
SC	81%	76%	81%	66%

*Based on maximum current Derby's retail selling price for each State.
** Average rate of ICMS.
Source: Authors calculations



3. Linkages of the Brazilian and Paraguayan Tobacco supply chains

3.1 Introduction

Illicit tobacco trade seems to be a worldwide phenomenon: according to Joossens and Raw (2012), one out of nine cigarettes smoked globally are illicit, representing a significant source of income for criminal activities and corruption. In that sense, it comes with no surprise that curbing the illicit tobacco trade has become an agenda on its own with the creation of the Protocol to Eliminate Illicit Trade in Tobacco Products (PEITT), the first protocol to the WHO Framework Convention on Tobacco Control (WHO FCTC).

Estimating the size and dynamics of the illicit market is obviously a difficult task. Nonetheless, it is a centerpiece of tobacco control policy design and evaluation as illicit trade undermines the impact of taxation and increases health-related costs of tobacco consumption and jeopardizes tax collection efforts.

3.2 Recent trends and characteristics of the illegal cigarette market in Brazil

Over the last 30 years, Brazil has taken successful steps in tobacco control, leading to progressively lower prevalence rates. More recently, the tobacco control strategy has included price increases as the leading policy instrument through higher taxes and the imposition of minimum prices, which have dramatically the affordability of cigarettes.

More recently, however, tax revenues have begun to decouple from decreasing prevalence (i.e., revenues are declining at a faster pace than smoking prevalence). Part of this decoupling could be attributable to recent jitters in the Brazilian economy (a recession from 2014 to 2016, with very mild recovery afterwards and especially negative impacts on employment, income and wealth), but the size of such decoupling indicates that something else is also at play.

Specifically, there is mounting evidence of consumption spill-over to illicit products and to a rising share of illegal cigarettes in Brazilian tobacco consumption basket. Not only is this result is relatively established in the Brazilian literature, but anecdotal evidence also supports it.

Despite that, the rising share of illicit cigarettes in Brazil lacks proper quantification and understanding. There are no official data on the size of the illegal market in the country, and estimates vary widely due to different methodologies or vested interests (for example, tobacco industry estimates apparently over-report the size of the illicit market).

Measuring illicit trade is paramount for the proper evaluation and design of tobacco control policies in Brazil. The objective of this chapter is to collect and critically analyze the most recent estimates for the illegal cigarette market in Brazil, pinpointing the numbers obtained by different researchers in the government, tobacco industry and

independent researchers, who apply different methodologies.

This chapter outlines six basic methods for measuring the illicit cigarette market, and provides a "Pros and Cons" analysis applied to the Brazilian case (i.e., considering Brazil´s data limitations and shortcomings); and presents the most recent estimates by the government, the tobacco industry and independent researchers in Brazil with special attention to methodological issues. Finally, the chapter concludes by setting the groundwork for a deeper analysis of the Paraguay/Brazil tobacco supply chain.

3.3 Illegal cigarette market analysis

Economics of tobacco literature has consistently pointed out that increasing the price of tobacco products is an effective tool for prevalence reduction (U.S. National Cancer Institute and World Health Organization, 2016).

There is a negative correlation between prices and tobacco consumption. As a side effect, price increases can result in changes in the tobacco consumption basket, with consumers prone to search for cheaper products – either to other less expensive tobacco products, or to illegal cigarettes.

The rise of the illicit cigarette market (as apparently has happened in Brazil) is a central variable when evaluating the effectiveness of tobacco control policies. Its illegal nature, however, implies that there are no observable statistics. Therefore, measuring its size, trends and general behavior is usually done by estimates and proxies, and not necessarily reliable or unbiased, nor made upon replicable methodologies. When dealing with such uncertainty, the best that analysts can do is to collect and compare several estimates based on different methodologies and datasets. Most likely none will be precise, though they should yield compatible results if appropriate data and techniques are employed.

At the outset, it is important to understand the different forms of illicit trade in tobacco. As defined in Merriman (2002), ***smuggling*** *is the evasion of excise taxes on goods by circumvention of border controls* - a definition that encompasses both legal and illegal tax circumvention. According to Joosens *et al*., (2000), on the legal side there is (legal) ***cross-border shopping*** (in which cigarettes are purchased in a neighboring lower price jurisdiction and purchasers pay all the applicable taxes in that location), (legal) ***tourist shopping*** (basically the same in non-neighboring jurisdictions and up to the customs maximum allowed amount) and (legal) ***duty free shopping*** (either in the country of destination or in the country of origin).

In this report, we use the term 'illicit trade' to refer to smuggling. Merriman (2002) splits smuggling in two different categories: ***Bootlegging*** is the legal purchase of tobacco in one country but consumption or resale in another country without paying the applicable duties – usually small amounts, though bigger than the ones on legal tax circumvention, transported through small distances. ***Wholesale Smuggling***, however, occurs when tobacco products are sold

without the payment of any taxes or duties, including those applicable in the country of origin. Given the scale necessary to circumvent all taxes, wholesale smuggling involves large amounts of goods and a comprehensive and sophisticated "shadow network" of production, transportation, storage and distribution – usually with global reach.

Merriman (2002) has outlined five different methodologies that are valid approaches to understanding the dynamics and level of illicit trade, given the uncertainty inherent to illicit trade (bootlegging + wholesale smuggling) estimates. Each one has its pros and cons, including feasibility, cost of implementation, data requirements, and specific technical knowledge.

Therefore, they should not be seen as competing analytical tools, but rather complementary ones. With minor differences from Merriman (2002) and Ross (2015), this sections outlines six approaches to illicit market estimates and then analyzes their advantages and disadvantages in the Brazilian context.

3.3.1 Ask the experts:

Obviously, the biggest experts on cigarette smuggling will not likely be willing to provide information about their business – illicit trade is an activity subject to legal punishment. Nevertheless, there is indirect information that could be used to gauge the size of the illicit market, such as cigarette seizures by law enforcement and broad information present in comprehensive publications such as the Global Tobacco Surveillance System Data (GTSSD) by the U.S. Centers for Disease Control and Prevention (CDC)[9].

To use cigarette seizures as a proxy of illicit trade we should assume for instance, cigarette seizures are a stable share of illicit trade and, at the same time there are no efficiency gains on law enforcement from time to time. Bearing in mind their limitations (especially the subjectivity of the estimates, the lack of experts and bias from the tobacco industry[10]), though not able to provide precise estimates, these sources should be able to set loose boundaries for the size of the illicit market.

3.3.2 Ask the buyers:

Sellers of illicit cigarettes are probably quite reluctant to talk, but the same is not necessarily applicable to buyers. In legal terms, buyers have no incentive to hide their consumption patterns, and therefore could be, in theory, directly approached to provide an accurate estimate of the illicit market share. Polling is a well-known data collection method applied in a wide variety of situations, such as elections and confidence surveys. There are several disadvantages of this approach. "Social embarrassment", even in anonymous surveys, could result in unwillingness of respondents to admit they have engaged in behaviors such as buying

9. The Global Tobacco Surveillance System Data (GTSSData) is a Web-based application that houses and displays data from four tobacco-related surveys conducted around the world: (i) Global Youth Tobacco Survey (GYTS); (ii) Global School Personnel Survey (GSPS); (iii) Global Health Professions Student Survey (GHPSS); and (iv) Global Adult Tobacco Survey (GATS).
10. Van Walbeek (2014).

illicit goods or smoking[11]. As a result, illegal purchases of cigarettes will be most likely under-reported.

Second, consumers could be genuinely unaware that they bought illicit goods, especially if the cigarettes are fakes of legal brands and sold at the regular price (or at least close to them). At last, biases could emerge from the survey itself: Iglesias *et al*., (2017) describe several limitations of their estimate of the illicit market in Brazil, including excluding responses from self-described smokers who stated that they had never bought cigarettes for themselves.

3.4 Trade Approach

International trade statistics contain a substantial amount of information on global legal flows of tobacco products. In theory, exports from the country A to B should match imports of the country B from A. In practice, it is well-known that those numbers do not always match for reasons that have nothing to do with illicit trade: different accounting methods within the country[12], mishaps when reporting (for instance, exports actually went from A to C) and fiscal benefits[13].

Nevertheless, one possible explanation for such discrepancy is the purposeful misreporting in order to avoid duties and taxes. As in most countries, there are no export duties on tobacco products in Brazil, so exporters do not have an incentive to misreport. On the other hand, most countries do charge import duties on tobacco, and therefore, importers are prone to "adjust" their numbers in order to evade taxes.

As such, a simple way to gauge the illicit trade between two countries is to compare reported exports from A to B with reported imports of B from A. The benefits of this method are that it relies on well-documented information, uses already available global databases (such as COMTRADE, WITS and DOTS) and has a straightforward application.

In principle, the crude use of trade statistics has several strong assumptions and limitations. At first, it works for wholesale smuggling but is not applicable for bootlegging estimation – trade statistics are "large", and therefore, are not able to account for small-scale smuggling.

Also, it implicitly requires that all goods "lost" between two countries are smuggled between them and not diverted (either to a third country or even coming back to the original country). This hypothesis has decreasing adherence with current patterns of global trade, which show an increasing use of trade hubs (in a simple way, smaller countries that act as a warehouse between

11. Gallus (2011).
12. In Brazil, Central Bank´s and MDIC´s (Ministry of Development, Industry and Commerce) numbers for the trade balance differ every month. That happens because Central Bank´s methodology accounts for electricity imports from Paraguay (Itaipu), something that has no FX coverage and therefore is not accounted by MDIC. Yearly, the difference amounts to US$ 2,5bi, around 4% of total trade balance.
13. In Brazil, an example of fiscal benefit occurs with REPETRO, a special tax regime that allows imports on goods and services related to oil exploration without the incidence of certain federal duties and taxes. As such, oil platforms are "accounting exported" and come back as "rented platforms", leading to higher trade balances in the short run and higher services balances (rent of equipment) in the longer run. Such platforms never actually leave the country.

two bigger countries[14]). Therefore, this methodology, used as a way to evaluate illicit trade between two certain countries is flawed, in spite of being still valid to scope global or regional flows of illicit merchandise.

3.5 Expanded Trade Approach

A modified version of the Global Trade Approach is recurrently used in the literature, especially in the case of Southeast Asian countries such as in Pavananunt (2011) and Ahsan *et al*., (2014). In general terms, the Expanded Trade Approach uses foreign trade data as part of the construction of total legal supply (domestic production + legal imports) and total demand (local consumption + legal exports) series. If total demand is consistently bigger than total supply, then there is an illegal market, irrespective of where the illicit goods were produced (locally or abroad).

This approach is also quite simple to implement and highly intuitive. Nevertheless, besides shortcomings also present in the Trade Approach, it relies on data for calibration, which is not always available, especially on domestic consumption. Therefore, it should be combined with estimates, either from surveys or from econometric modelling, which are described below.

3.6 Sales vs. Consumption (using surveys)

Cigarette tax revenues are usually readily available. Therefore, one can reconstruct (legal) sales series using the applicable tax rate. Such information is usually kept by Tax Administration or Customs Offices worldwide. On the other hand, consumption series accounting for both legal and illicit goods are usually not available and must be estimated.

One way to estimate total sales is to use surveys, such as household surveys like the *Global Adult Tobacco Survey* (GATS) and *Pesquisa Especial do Tabagismo* (PetAb)[15] (a nationwide tobacco consumption survey) or telephone surveys like VIGITEL[16] - to directly ask respondents about their consumption habits with certain products (specifically cigarettes). If reported consumption is higher than legal sales, there is likely an illegal market supplying this gap.

Despite being similar to the "Ask the buyers" approach, this method does not (necessarily) ask consumers if they are buying illicit goods. Therefore, it could bypass (at least part of) the "social embarrassment" issue and not be affected by consumer´s ignorance (not knowing if the goods are illicit).

14. For instance, iron ore exports from Brazil to Asia (in particular China) usually "stop" at Singapore, where iron is warehoused and eventually transshipped to smaller vessels that bypass ship´s draft restrictions in Asian ports
15. PeTab is a Brazilian nationwide survey conducted within the National Household Survey (*Pesquisa Nacional de Amostra de Domicílios*, PNAD), first implemented in 2008 and being the Brazilian version of GATS.
16. VIGITEL is a yearly telephone survey conducted by the Ministry of Health, which evaluates several diseases and health habits, among which tobacco consumption

Nonetheless, there are still important limitations and necessary assumptions involved. Going beyond the budgetary issue (surveys are costly), respondents consistently understate the amount of tobacco or cigarettes consumed in such surveys – either because they genuinely "forget" or because there is a social stigma related to tobacco consumption as pointed both by Merriman (2002) and Ross (2015). Therefore, surveyed amounts have to be adjusted as done in Iglesias *et al*., (2017).

Moreover, this method is especially useful to detect trends in the illicit market by the comparison of legal sales and consumption patterns throughout the years (whenever surveys are available), as done by Szklo *et al*., (2018). In order to provide reliable illicit marker numbers in a given year, this method requires close estimates of the size of the illicit market in the base year.

If not, it is still useful to measure changes in the illicit market from time to time, even if it does not precisely measure its size. Also important to bear in mind: consumer underreporting should be stable throughout the sample, or estimates will be biased.

Lastly, this method does not allow a distinction between legal and illegal tax circumvention schemes. According to the definition of Merriman (2002), it accounts for *smuggling* and not for *illicit trade*[17], and therefore also leads to biased estimates in countries in which legal tax circumvention schemes are relevant. However, that does not seem to be the case in Brazil.

3.7 Sales vs. Consumption (using econometric modelling)

An alternative way to measure tobacco consumption is to use econometric modelling. Total consumption is related to prices and household income, plus other factors, such as the economic cycle or the implementation of "non-financial" tobacco control policies. In addition, illicit trade should be positively correlated to price differentials between the origin and the destination (illicit consumption tends to happen where legal cigarettes are more expensive though not always the case), to the ease of cross-border shopping and other factors that foster smuggling (for example, a high level of corruption).

Despite having several advantages, this methodology has important caveats to bear in mind. On the positive side, the approach is relatively less expensive to apply and robustness checks are readily available through different econometric techniques, different regression specifications and comparison of such estimates as done by Van Walbeek (2014). Moreover, if legal consumption data is available, results for total consumption and illicit consumption could be cross-checked and confirmed.

On the negative side, this method does not separate legal and illegal tax circumvention schemes, what could eventually bias

17. Following Hana Ross (2015), smuggling is defined as importing or exporting secretly, contrary to the law, and especially without paying duties imposed by law. The term Illicit tobacco trade is defined as a practice or a conduct prohibited by law which relates to production, shipment, receipt, possession, distribution, sale or purchase of tobacco products, including any practice or conduct intended to facilitate such activity. Therefore, the term "illicit tobacco trade" covers all illegal activities related to the tobacco trade, not just the circumvention of tobacco taxes.

estimates of the illegal market size (i.e., if "legal circumvention cigarettes" are relevant for the consumption basket). Much more important, this method requires proper data (in terms of availability, quality and timespan) and specific technical knowledge, not only in terms of which econometric technique to use, but also in terms of the compromise between degrees of freedom and necessary controls. Econometric models are subject to errors, and understanding how to balance them is sometimes tricky.

3.8 "Pros and Cons" applied to the Brazilian case

The six methodologies described above have been already applied to estimate illicit trade in Brazil, either separately, combined, or adapted. The goal of this subsection is to overview their application in Brazil, and associated disadvantages and advantages. In that sense, more general analyses, such as the ones implemented in Merriman (2002) and Ross (2015) are useful guides, though they have to be customized in terms of actors involved, surveys implemented, budgetary constraints, and data quality/ availability.

For instance, it is well-known that Paraguay plays a decisive role in Brazil's illicit cigarette market. Even more, Brazil is a paramount input supplier for Paraguayan cigarette production (tobacco leaves, paper for hard/soft packs, and raw materials for filters), meaning that the supply chain (from raw materials to retail sold cigarettes) is highly interconnected between the two countries.

Therefore, Paraguayan data is central not only to methodologies based upon trade data but also to econometric methodologies that require such variable as controls. Unfortunately, Paraguayan data is hard to obtain and its quality is questionable. This type of weakness is very specific to the Brazilian case and has be properly accounted for. An overview of Brazil´s "Pros and Cons" can be seen in the table below.

Table 8: **Pros and Cons applied to the Brazilian case**

	GENERAL PRINCIPLE	ADVANTAGES	DISADVANTAGES	ISSUES IN BRAZIL	EXAMPLES IN BRAZIL
ASK THE EXPERTS	Systematic data collection from law enforcement (cigarette seizures) and tobacco experts (tobacco industry or worldwide researchers)	Little technical skills required; low cost; provides agreeable "common sense" view; relatively quick way to scope the illicit market	Subjectivity of estimates; bias from the tobacco industry; sensitive to "technological change" (efficiency gains in law enforcement)	Opaque methodologies; strong assumptions required; limited pool of experts; lobby agenda from the tobacco industry; lack of replicability and robustness	Cigarette seizures by Brazil Federal Police; Tax revenues by Brazilian Customs; GTSSD Brazil chapter; Souza Cruz and tobacco associations (ABIFUMO, SINDIFUMO)
ASK THE BUYERS	Directly ask tobacco buyers about their consumption patterns to estimate the number of illicit cigarettes	Transparent; buyers have no legal incentive to lie; polling and sampling technologies are well-known, including their limitations	Incentives to lie (social embarrassment); consumer may not be aware they bought illicit cigarettes (consumer ignorance); high level of expertise to properly pool, sample and inquire; relatively high cost (field surveys) or smaller cost at the (likely) expense of quality (telephone survey); non-replicable; no distinction between illegal and legal tax circumvention	Under-reporting for several reasons; faulty sampling and pooling; incoherent answers; necessary to adjust pooling results; scarce surveys probably due to cost; lack of strong methodological discussion when interpreting results; lack of robustness checks	ETCO, FNCP and IDESF reports based upon surveys by third parties such as IBOPE and EGOPE; Iglesias *et al.*, (2017)
TRADE APPROACH	Track the difference between countries´ records of exports and imports	Very low cost; readily available international trade statistics (COMTRADE, WITS and DOTS); reasonable technical skills required	Only detects wholesale smuggling; inconsistency in the presence of trade hubs; works better to evaluate global or regional flows; strong assumptions needed when dealing with trade discrepancies	FUNCEX and AliceWeb/ MDIC data available; overrepresentation of Paraguay in illicit trade; lack of necessary Paraguayan trade data (specifically on cigarettes); likely use of trade diversion	

	GENERAL PRINCIPLE	ADVANTAGES	DISADVANTAGES	ISSUES IN BRAZIL	EXAMPLES IN BRAZIL
EXPANDED TRADE APPROACH	Use trade data to compare total supply (domestic production + legal imports) and total demand (domestic consumption + legal exports). If demand is bigger than supply, this is evidence of illegal operations	Relatively low cost; data availability; very intuitive approach	Same as the "TRADE APPROACH"; higher technical skills required; bigger data set, not always available; eventual hypothesis and calculations necessary	Lack of proper Paraguayan data (in both demand and supply sides); estimations and calculations required, based upon (usually) strong hypotheses	Ramos (2009); Biz (2010); Iglesias *et al.*, (2012); Paes (2017); Iglesias *et al.*, (2018, *forthcoming*);
SALES VS. CONSUMPTION USING SURVEYS	Comparison of estimated legal sales (using tax revenues) and estimated consumption by household surveys	Transparent, trackable and comparable throughout the years; bypasses (a part of) "social embarrassment" and "consumers ignorance"; appropriate data usually available; relatively quick to generate	Same as the "ASK THE BUYERS"; technical skills required; better to track changes in the illicit market; requires assumption of the illicit market size in the base year; requires assumption that under-reporting is stable throughout the sample	PeTab and VIGITEL surveys available; underreporting might be changing given social patterns; incoherent answers; necessity to adjust pooling results; scarce number of surveys; budgetary issues	Szklo *et al.*, (2018)
SALES VS. CONSUMPTION USING ECONOMETRIC MODELLING	Comparison of estimated legal sales (using tax revenues) and estimated consumption by econometric models (due to price and income elasticities)	Easy to implement (with proper technical knowledge); replicable and transparent; robustness checks are part of the methodology; intuitive	Requires high level of expertise; appropriate data not necessarily available; small samples and econometric issues; uncertainty regarding regression controls; multiple feasible regression methods difficult result comparisons	Data quality and availability for proper estimation; issues on degrees of freedom (lack of sample for a given number of controls); lack of illicit market data; economic downturn in recent years may bias results; elasticity calculations are usually not applied to measure illicit market	

Source: Authors based upon Merriman (2002), Ross (2015)

In conclusion, the table above highlights two points. Firstly, there is a clear sub-representation of the "Trade Approach" methodology. The rationale is quite simple: there are significant shortcomings in Paraguayan data, therefore jeopardizing its use in Brazil. However, as can be seen in the "Expanded Trade Approach" trade data has been used in the Brazilian literature to measure the illicit market either combined with numbers from other research as in Paes (2017) or with adaptations such as in Biz (2010) and Iglesias *et al*., (2012) where focus is placed on input (tobacco leaf) trade in order to estimate the illegal supply of cigarettes (either produced domestically or abroad).

Secondly, it is striking that "Sales vs. Consumption (using Econometric Modeling)" has basically not been used to estimate the illicit market in Brazil. However, there is a preference for consumer surveys such as PeTab and VIGITEL as the consumption proxy as in Iglesias *et al*., (2017) and Szklo *et al*., (2018), and understandable given that they are well-established, sufficiently comparable, have known limitations and allow timely analysis.

Nonetheless, econometric models have been used to estimate tobacco price and income elasticities in several papers such as Carvalho and Lobão (1998), Iglesias (2006), Iglesias *et al*., (2007), Barbosa (2007) and Lampreia *et al*., (2015), but none has taken "the next step", i.e. trying to use the available consumption estimates in order to estimate the illicit market.

Data shortcomings and lack of proper econometric controls are probably the reason (one foremost criticism is that those elasticities are usually estimated using the legal market for cigarettes, and therefore should not be applicable to the consumption decision of counterfeit products). Nonetheless, it seems clear that a natural research agenda in Brazil would be to enhance the use of econometric modeling, not only fostering elasticity regressions due to the use of better controls but also expanding application to the illicit market analysis. A persistent and positive difference between estimated consumption and legal sales (if obtained), which is robust to several controls, using econometric techniques and bearing in mind limitations, would be a valid approach to measuring the illegal cigarette market in the country.

3.9 Recent estimates for the illegal cigarette market in Brazil

The previous sections outlined six basic methodologies that are used worldwide to estimate the size of illegal cigarette market. Each of the methods has structural limitations and variable degrees of applicability to the Brazil.

Besides this "methodological approach", it is also important to understand the "actor's approach", i.e., the representativeness of each group when building the "common sense" estimation for the illegal market. That is especially sensitive in the Brazilian case, on which the tobacco industry is still the foremost source of information (Szklo *et al*., 2018), in spite of being relatively clear that

their numbers have several inconsistencies and tend to be overestimations (Iglesias *et al*., 2017).

This chapter presents the most recent estimates by several actors, divided into three big groups: (i) Tobacco industry and non-profit organizations (NPOs), either tobacco-related or not; (ii) Government; and (iii) Independent researchers. Each actor´s estimates will be critically assessed in terms of methodological robustness and validity of results in three dedicated sub-sections (one for each actor). Finally, the last sub-section provides a concise overview of all results.

3.10 Tobacco industry and NPOs

The first organized attempts to measure the illicit cigarette market in Brazil have been done by the consulting company AC Nielsen[18] on behalf of tobacco industry players, mostly Souza Cruz (the biggest Brazilian producer, currently a subsidiary of British American Tobacco) and ABIFUMO (tobacco producers association)[19]. Their results cover the illicit cigarette market from the 1990s onwards, showing a very clear upward trend of illicit cigarettes sales. According to Cabral (2001), a representative of ABIFUMO, illicit market share (of total sales) rose from 5% in 1991 to 32% in 2001.

It is important to bear in mind that the lack of data before the 1990s is not the same as saying that illicit market was irrelevant Iglesias (2006). Furthermore, it is beyond dispute that AC Nielsen is a well-established company with reports that are known for their good reputation. Nonetheless, the methodology used to estimate such numbers is completely unknown; it is somewhat understandable that the specifics are undisclosed (AC Nielsen profits on those reports), but at least a general methodological approach should be available either by the producing company or the final contractors.

Over the last decade, a landmark estimate by the tobacco industry of the illicit market was a 2011 report by the consulting branch of *Getulio Vargas Foundation* (FGV Projetos), on behalf of several tobacco associations (SINDITABACO and STIFA)[20], agriculture producers of Brazil´s South region (FETAGRS and FETAESC[21]) and nationwide retail/tourism associations (CNTUR and ABRASEL)[22].

FGV Projetos (2011) was a comprehensive study related to possible effects of new regulations by ANVISA in 2010, which would restrict tobacco advertisement, implement stricter rules for tobacco commercialization and ban flavored cigarettes. The results of this report have been used in several tobacco control discussions thereafter, not only by the tobacco industry itself, in spite of the clear conflicting interests involved.

The report stated that illicit cigarette sales amounted to 27% of total sales, and that the majority of illicit cigarettes came from

18. An international consulting company specialized in retail trends and surveys.
19. Tobacco industry is basically a duopoly in Brazil, with British American Tobacco (BAT) / Souza Cruz market share at around 80% of legal salesand Phillip Morris market share at around 15%.
20. Sindicate of Tobacco Producers and Sindicate of Tobaco Workers from Santa Cruz do Sul.
21. Federation of Agriculture Workers from Rio Grande do Sul (RS) and Santa Catarina (SC) states.
22. National Confederation of Tourism and Brazilian Association of Bars and Restaurants.

Paraguay. The methodology used or even data sources necessary to this calculation were completely undisclosed. FGV Projetos (2011) failed to disclose the methodology used, sampling, error margin. Furthermore, the report had severe internal inconsistencies, such as regional illicit market shares (for each region of Brazil and obtained by IBOPE) which, if added-up, derive into a much lower national illicit market share (21.6% vs. 27%). These points, and many others throughout the report, have been extensively discussed by PAHO (2012). The report also used illicit cigarette presence in legal retail spots as a metric for illicit market share. These numbers, once again by AC Nielsen, stated that illicit cigarettes were present at 45% of legal retail spots.

Ever since, industry estimates have been updated in a non-regular basis. Souza Cruz presented results of an IBOPE *Inteligência* Survey for illicit cigarette market evolution from 2010 to 2014 in 2015, stating that the illicit share grew from 19.6% in 2010 to 31.5% in 2014. In this report, the 2010 numbers were quite lower than the ones produced by FGV Projetos (2011), highlighting the uncertainty of such exercises and, therefore, the necessity of methodological explanations to understand and critique the results. As with AC Nielsen, IBOPE´s quality is beyond dispute. Nonetheless, the complete lack of explanations leaves the question of accuracy unresolved.

Moreover, the historical stability of estimates around the 30% level has been pointed by Iglesias (2016) as a proof of internal inconsistency of the industry estimations despite significant changes in taxes, regulations and policies. Even more, in the second half of the 2000s real pack prices increased and no specific anti-smuggling efforts were implemented, what some would say should have led to higher illicit numbers. Nonetheless, industry benchmark estimation actually fell from 32% at Cabral (2001) to 27% at FGV Projetos (2011). Such result is highly counter-intuitive and has "raised eyebrows" on tobacco industry numbers.

Going beyond the industry itself, several NPOs have estimated the size of the illicit cigarette market, again, with very opaque, if available, methodologies. Most of the recently published estimates come from NPOs dedicated to market competition or to anti-corruption and the avoidance of business misconduct such as smuggling - not necessarily of cigarettes, but with clear preeminence of them. [23]

Just to name a few, the *Instituto de Desenvolvimento Econômico e Social de Fronteiras* (IDESF) and *Empresa Gaúcha de Opinião Pública e Estatística* (EGOPE) have been published annually since 2015. IDESF (2017) states that the illicit cigarette market accounted for 40% of total sales in 2016, a number roughly aligned with tobacco industry estimates, but with no methodological explanation.

In conclusion, tobacco industry estimations tend to change over time with its lobbying agenda, sometimes even suggesting revisions of historical data such as pointed by Iglesias (2016).[24] Even so, there

23. IDESF (2015) statedthat 67% of all smuggled products through the Paraguay/Brazil border are cigarettes.
24. In a Valor Econômico newspaper interview, an industry representative stated that illicit trade averaged only 20% prior to 2012.

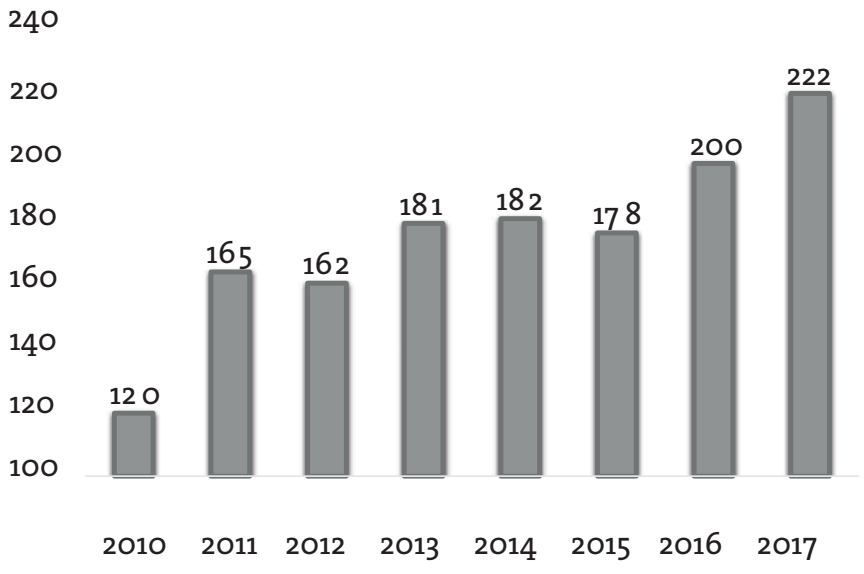
has been a clear upward trend on industry estimates in recent years. For instance, the Souza Cruz website[25] states (with no further explanation) that as of 2018, illicit cigarettes account for 48% of total sales in Brazil. The same pattern (and lack of methodological concerns) is found in the *Fórum Nacional contra a Pirataria e a Ilegalidade* in 2018, stating that illegal cigarette market has grown from 30% in 2015 to 45% in 2016 and then 48% in 2017.

3.11 Government

The Brazilian Government does not provide official illegal cigarette market estimates. This is at odds with the hugely successful efforts to reduce tobacco prevalence over the last decades. Spillovers to illicit market can decrease the impact of tobacco control policies and require careful design of futures policies. Accurate and publicly available information of the illicit market is central and should be as far-reaching as possible.[26]

Currently, the official set of information that is closest to estimating the illicit market is data of cigarette seizures and destruction by law enforcement, provided by Brazilian Secretariat of Federal Revenue (*Secretaria da Receita Federal do Brasil,* SRFB). Such data does not allow strong conclusions on illicit production or trade, mostly because the law enforcement efficiency ratio (seizures

Figure 2: **Cigarette seizures (millions of 20 cigarette packs)**



Source: Secretaria da Receita Federal (SRFB)

25. http://www.souzacruz.com.br/group/sites/SOU_AG6LVH.nsf/vwPagesWebLive/DO9YDBCE
26. Efforts o fInstituto Nacional do Câncer (INCA) researchers are treated as independent ventures, isspite of having clear connection with the government. Onthatsense, when ever talking about Government, what actually meant is "official numbers".

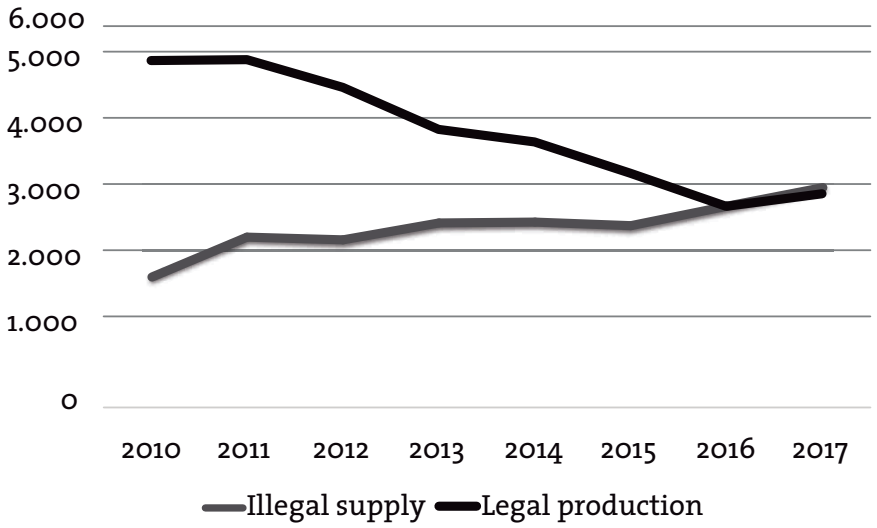
over illicit market) and the destruction ratio (destruction over seizures) are not constant over time and, most likely, unknown.

Despite these weaknesses, the numbers presented are shocking. The figure below depicts cigarette seizures since the beginning of the decade. In 2017, approximately 222 million packs were apprehended: an 85% increase over 2010 and an 11.2% increase over 2016. At first glance, it appears that this is rapid growth of the illicit cigarette market in Brazil, but this assumes that the law enforcement efficiency ratio is constant over time and known at least in one point of the sample.

For 2014, Federal Prosecution Office (*Ministério Público Federal,* MPF) stated that only about 5% to 10% of all smuggled merchandise in Brazil (among which are cigarettes) are actually apprehended. Specifics of these numbers (methodology and robustness) are unknown. Even so, assume they are correct, applicable to cigarettes and constant throughout the sample. Considering the median point (7.5% of efficiency ratio), the figure below compares the illicit market evolution (illegal supply) with the legal production registered by SRFB. The illicit market and the legal production would have comparable sizes ever since 2016, each accounting for nearly 3.0 billion packs in 2017.

In the Brazilian case, there has been an effort by independent researchers to scope the illicit market ever since mid-2000´s, recognizing not only that industry numbers were biased but also that they lacked

Figure 3: **Illicit market estimates vs. legal production (millions of 20 cigarette packs)**



Source: Secretaria da Receita Federal (SRFB)

scientific standards. Advances implemented within the National Tobacco Control Program (*Programa Nacional de Controle do Tabaco*, PNCT) were centerpieces, precisely the creation and maintenance of "surveillance surveys" PeTab and VIGITEL - both the basis for several studies recently implemented in the Brazilian literature. The most relevant studies produced over the last decade are further detailed below. In conclusion, it is noteworthy that this entire calculation, with very strong hypotheses within, is used to estimate the number of illicit cigarettes available in Brazil. If one wants to measure the illicit market share (illicit cigarettes over total consumption), then further unobserved data is still required, such as estimated total consumption either by surveys/econometrics or by tobacco experts.

3.11.1 Ramos (2009)

The first noteworthy effort to measure the illicit market came from Ramos (2009). Using a mix of qualitative data (interviews with law enforcement, customs tobacco experts and participants of illicit trade, journalistic, legal and institutional reports) and quantitative data (legal trade, production and consumption) for each of the MERCOSUR countries, boundaries were established boundaries for the potential cigarette production and trade in the region. As a by-product, this paper unveiled estimates for the Brazilian illegal cigarette market. The paper focuses mostly on potential cigarette production of Paraguay and the quantity of cigarettes that could have been available for illegal trade. For reference year 2007, the estimation was of around 65 billion cigarettes.

This number is the net result of total estimated supply (internal supply of raw inputs, including net exports and certain technical requirements which lack proper explanation[27] plus cigarette imports) minus domestic consumption (estimated of 3 billion sticks, from unknown sources) and was remarkably bigger than official exports (2.5 billion sticks).

Using experts to measure the illicit market in Argentina and Uruguay (obviously both subjective tasks) and assuming that all those illicit cigarettes came from Paraguay, the author stated that more than 90% of illicit Paraguayan supply was sent to Brazil.

Comparing this result with VIGITEL 2006, estimates for illegal internal Brazilian production and the size of the legal market (both obtained with Roberto Iglesias, a well-known Brazilian tobacco researcher, but without any proper references), Ramos (2009) concluded that the illicit market in Brazil was of 39.5 billion sticks in 2007 - 26% of total consumption, a striking resemblance to tobacco industry estimates at the time.

3.11.2 Iglesias *et al.*, (2012)

Iglesias *et al.*, (2012)[28] measure the illicit cigarette market in Brazil by evaluating the excess amount of tobacco available in the country. In that sense, it uses an updated version of Ramos (2009), focusing on technical requirements for cigarette production and the

27. Biz (2010) evaluates that those production numbers are feasible considering high efficiency levels on tobacco leaf processing (between 80% and 90%).
28. Iglesias *et al*. (2012) is heavily based upon Biz (2010), an undergraduate thesis supervised by Iglesias himself. Comments of this section basically apply for both papers.

estimated potential supply of cigarettes in the Brazilian market (either produced locally or abroad, legal or illegal).

Using data from 2000 to 2009, the authors used reliable official data (internal production of tobacco leaves by IBGE and foreign trade of tobacco leaves by MDIC) to measure the amount of available tobacco in the country. Thereafter, technical requirements for tobacco processing were applied following Corradini (2010) – i.e., the efficiency ratio of the transformation of raw tobacco into "industrial tobacco". The authors chose the levels of 81% (processing of leaves and stalks) and 89% (processing of leaves, stalks and reconstituted tobacco), dropping out the 61% level (processing of pure leaves). However, the methodologies applied to determine the levels are unknown and the decision to exclude the 61% lacks explanation.

Furthermore, the local available supply of industrial tobacco was obtained by adding up net exports of industrial tobacco. It was also acknowledged that processed tobacco could be inventoried for as much as three years. Thus, the effective amount of industrial tobacco for cigarettes in a given year is a combination of production, net exports, and inventory adjustments. The latter was supposed irrelevant (i.e., stable inventory), a strong but understandable hypothesis which had to be made given the inability to model producer inventory decisions.

After the estimation of available industrial tobacco supply, came its transformation into potential cigarettes. Different sizes, weights and diameters were analyzed in order to obtain physical measures of a "representative cigarette": 80mm length and regular diameter (no number shown), with 0.83g of tobacco per unit. This number, a centerpiece of the methodology, lacks proper explanation in the paper, yet was subject to a sensitive analysis with alternative levels of tobacco per unit (0.75g and 1.0g).

Lastly, the potential illicit supply of cigarettes in the country was calculated as the difference between estimated potential supply, legal cigarette production in the country, and net legal exports of cigarettes.

The authors estimated that the potential supply of illicit cigarettes amounted to somewhere between 54bi (*ttr* = 81%) and 86bi (*ttr* = 89%) units per year throughout the sample, numbers somewhat bigger than the 39.5bi sticks estimated by Ramos (2009) – yet not directly comparable given different samples. Also remarkable is that they do not account for illicit cigarette market imports, though it is feasible that when dealing with input trade they actually control for them – Brazilian tobacco leaves most likely return to the country as illicit cigarettes, mainly from Paraguay; thus, net trade of cigarettes[29] is historically irrelevant in Brazil.

At last, it is important to realize that the authors failed to deliver an explicit estimate for the illicit market share, as they did not properly cross their results with consumption estimates, either from the tobacco industry or from official surveys such as VIGITEL.[30]

29. Understood as products under Common Nomenclatureof MERCOSUL (Nomenclatura Comum do Mercosul, NCM) heading code 24.02.20.00..
30. None the less, they report VIGITEL numbers in their conclusion as obtained at Corradini (2010), with unknown baseyear – yet most likely 2006. Supposing that those numbers apply, on average, for the whole sample, Iglesias *et al.* (2012) results would suggest an illicit market share of something between 36% and 57%.

3.11.3 Iglesias *et al.*, (2017)

Departing from trade-related approaches, this paper used PeTab (2008) and (2013) surveys to measure illicit tobacco consumption in Brazil by the share of PeTab interviewees who stated they paid prices below the minimum price that legal producers would charge (hereafter, "threshold price"). This information applied to total consumption would be a valid measure for the illicit market share. It is important to realize, however, that the threshold price is not the minimum price allowed per (legal) pack – which was established between the 2008 and 2013 PeTab surveys. Minimum prices allow a producer profit and, thus, are above the threshold price.

The research methodology had three steps, focusing on the careful analysis of microdata and several working hypotheses. The first step was to establish the minimum price for each year. Threshold prices were defined as the minimum to cover: (i) production and distribution costs of a representative cheap brand; (ii) taxes; and (iii) retail margin per pack assuming no profit for the manufacturer. Given the tax structure applicable on cigarettes in Brazil, threshold price (TP) would be derived as:

$$TP = \frac{Production\ \ cost + distribution\ \ cost + ad\ rem\ taxes + fees}{1 - ad\ valorem\ \ tax - retail\ \ margin}$$

The tax structure was well-known from official data and standard retail margins were used (from an unknown source). Production and distribution costs were provided by SRFB, but with no methodological explanation for them. From this, authors derived threshold prices for 2008 (R$ 1.668/pack) and 2013 (R$ 3.236/pack).

The second step was extracting the purchase price per pack of the surveys. Illicit cigarette consumers were those who paid self-declared prices below the threshold price.

Lastly, the third step was to estimate the size (in billions of sticks) of the illicit yearly consumption among daily smokers who bought illicit cigarettes at their last purchase.

Comparing all the information led to results for prevalence rates (irrespective of legal or illegal products), proportion of illicit consumption, and the yearly amount of illicit sticks bought for both 2008 and 2013, including confidence intervals obtained with clear methodological care. Furthermore, results were stratified by sociodemographic variables (gender, age and educational level), by smoking pattern (light, regular and heavy) and by location (rural or urban, and States with land borders to other countries or not), opening up new analytical paths.

Iglesias *et al.*, (2017) has three analytical breakthroughs. The first one is to use two consecutive PeTab surveys, allowing not only a detailed analysis of smoking patterns in the country, but also its evolution in a five-year window (both surveys are built-up on strict and comparable methodological standards). For instance, it shows that smoking prevalence fell from 13.3% in 2008 to 10.8% in 2013, strong evidence that the tobacco control agenda implemented throughout those years was successful in reducing the smoking epidemic in the country.

The second breakthrough is that it compares the evolution of prevalence

with the illicit cigarette market share. In that sense, a very important finding is that counterfeit products penetration rose from 16.6% in 2008 to 31.1% in 2013.

Last, but not least, the stratification analysis has shown that increasing illicit market shares between 2008 and 2013 were irrespective of sociodemographic, location and smoking pattern variables. Nonetheless, there was a clear bias for the consumption of illicit products by the less educated, heavy smokers and inhabitants of both rural areas and states with land borders with other countries. Such refinements do not only increase the power of the analysis but also could be used to fine-tune public policies.

3.11.4 Paes (2017)

According to the author, the strong correlation observed worldwide between tax rates and final prices of cigarettes is much weaker in Brazil, where the final retail prices is much lower than expected given the tax rate. One of the possible reasons for such phenomena would be the size of the illicit market in the country, not only due to price differentials between Brazil and bordering countries (especially Paraguay) but also due to the friendly environment for illicit activities in Brazil (institutional fragility, corruption, and lack of legal punishment and law enforcement).

Estimates of the illicit market are, therefore, a centerpiece of his thesis. The author provides yearly numbers from 2000 to 2012, placing the illicit market in the 26%-32% range for the whole sample. The author also found an increasing share of illicit cigarettes from 2006 (26%) to 2012 (31%), somehow mimicking results of the Brazilian literature.

Nevertheless, the methodology is flawed because it simply combines production data from SRFB, net exports from Development, Industry and Commerce Ministry (MDIC) and estimated consumption, either legal or total, by ACT (2012) and Souza Cruz (2013) to produce residual estimates for the illicit consumption. No critical analysis of any of these numbers is provided, and the illicit market share is the comparison of this residual with industry estimates of total consumption.

3.11.5 Szklo *et al.*, (2018)

Once again referring to surveys as a way to estimate total cigarette consumption, the authors used self-reported consumption data from an annually conducted telephone survey (VIGITEL) and legal sales provided by SRFB not only to measure the illicit cigarette market but also, with certain hypothesis, to evaluate its yearly evolution from 2012 to 2016.

The general idea of the paper was quite simple: the yearly difference between self-reported consumption and legal sales would be a valid gauge for the illicit cigarette market in the country. Nonetheless, it is well-known that such consumer surveys tend to be biased due to under-reporting of tobacco consumption. To circumvent that bias, the authors implemented Merriman's (2002) methodology, on which self-reported consumption from a specific survey (and on a specific year) is used to calculate an under-reporting constant to be applied to the whole sample.

Their methodology had five steps, with several hypotheses within and strong support from previous research pieces. In the first step, the authors used PeTab (2013) to estimate the "under-reporting constant". That was done because they knew the illegal consumption figure for that year from Iglesias *et al*., (2017).

In the second step, this under-reporting constant from the PeTab survey was translated to VIGITEL survey. The authors multiplied VIGITEL 2013 consumption data[31] by the estimated proportion of legal consumption from PeTab (2013). Then, to calculate the under-reporting parameter at VIGITEL, they divided the "estimated legal consumption from VIGITEL" by official legal sales from SRFB.

In the third step, the authors also calculated the under-reporting parameter stratified by education level to take into account the likely bias related to conducting phone surveys across different socioeconomic groups – a significant innovation over Merriman (2002). The difference between legal sales and overall sales was the estimated illicit market (billions of sticks), by education level, for base-year 2013.[32]

The fourth step was to estimate illicit cigarette use for other years in which continuous VIGITEL surveys were available (from 2012 to 2016). For that, the authors used not only the yearly self-reported consumption data by education level but also the "under-reporting constant" applied to consumption and sales in order to calculate new yearly overall sales (either legal or illegal) by education level. The difference between legal and overall sales was the estimated illicit market (billions of sticks), by educational level, for every year other than 2013.

Finally, the fifth and final step was to obtain the illicit market share by dividing illicit market estimates by the overall sales for every year and on every education level. The authors then provide yearly illicit market share estimates from 2012 to 2016.

Sensitivity analysis was also provided by changing baseline proportions of illegal cigarette consumption, as VIGITEL and PeTab do not have fully comparable sampling procedures[33]. Moreover, the authors were very careful on data limitations, devoting a full section of their paper to several data hypotheses that had to be done and doubts on data quality (either official sales data or surveyed consumption data) which could bias their results.

Szklo *et al*., (2018) estimated that illegal cigarette market shares fluctuated throughout the sample[34], increasing from 2012 to 2013 (from 28.6% to 32.3%), decreasing in 2014 (to 28.8%) and then monotonically increasing

31. Information on yearly cigarette consumption from VIGITEL was based on two questions: (i) "Do you currently smoke?"; and (ii) (If Daily), "On average, how many cigarettes do you smoke per day (or per week)?"
32. Illegal cigarette consumption is remarkably bigger on the lower educational level, somehow mimic the results of Iglesias *et al.* (2017).
33. As the authors correctly point out, data on smokers living in urban areas (PeTab) may not be consistent with data on smokers in state capitals (VIGITEL), as the latter may have higher socioeconomic status. The proposed sensitive analysis was a way to tackle this potential bias, yet obviously to not accounting for the real sampling issue.
34. In the baseline scenario.

from 2015 onwards (36.5% in that year and 42.8% in 2016). The authors speculated that this upward trend after 2015 was due to Brazilian political and economic jitters – a very plausible explanation but lacking scientific validation.

In conclusion, the biggest breakthrough of this research was to create and provide a consistent methodology to measure the illicit market on a yearly basis. Furthermore, their methodology is replicable and updateable given proper data availability. Further publications of PeTab and VIGITEL will allow researchers to confirm or deny their findings. Last but not least, researchers were very careful to disclose the strengths and weaknesses of their approach, according to the scientific standard.

3.12 Establishing the boundaries of the illicit cigarette market in Brazil

All tobacco researchers face similar issues in Brazil: the lack of systematic ways to collect primary data, under-reporting of individual consumption levels, uncertainty of data quality (including official statistics), budgetary constraints, and lack of representative samples. Despite being a centerpiece of tobacco control policy analysis, measuring the illicit cigarette market in Brazil is a task that still has a long way to go.

As pointed by Szklo *et al*., (2018), the comparison of different methodological approaches is necessary in order to cross-validate estimates and minimize weaknesses and limitations of one single method.

3.13 Comparing illicit cigarette market estimations

The overview of the attempts to measure the illicit cigarette market in Brazil show different estimations. The table below organizes them according to the values obtained (either market share or volume), reference year, methodology, and our own judgment about their scientific standards.

Table 9: **Setting the boundaries for the illicit cigarette market in Brazil**

TOBACCO INDUSTRY AND NPO´S	ILLICIT MARKET	REFERENCE YEAR	METHODOLOGY	SCIENTIFIC STANDARDS	COMMENTS
CABRAL (2001)	**From 5% in 1991 to 32% in 2001**	1991-2001	Survey by AC Nielsen	**Low**	ABIFUMO representative; AC Nielsen survey specifics unknown
FGV PROJETOS (2011)	**27% market share 45% presence on retail spots**	2010	Unknown for the 27% number AC Nielsen survey for the retail spots	**Low**	Methodology and data sources completely absent; severe internal inconsistencies, AC Nielsen survey specifics unknown
SOUZA CRUZ (2015)	**From 19.6% in 2010 to 31.5% in 2014**	2010-2014	Survey by IBOPE Inteligência	**Unknown**	IBOPE survey specifics unknown
IDESF (2017)	**40%**	2016	Survey by EGOPE (Empresa Gaúcha de Opinião Pública e Estatística)	**Unknown**	EGOPE survey specifics unknown
SOUZA CRUZ (2018)	**48%**	Unknown	Unknown	**Unknown**	Complete lack of any information
FNCP (2018)	**2015: 30% 2016: 45% 2017: 48%**	2015-2017	Unknown	**Unknown**	Complete lack of any information
SRFB	**From 120mi packs in 2010 to 222mi packs in 2017 (cigarette seizures)**	2010-2017	Official cigarette seizure information by SRFB	**Non-applicable**	Data does not allow conclusions on illicit market because law enforcement efficiency ratio (seizures over illicit market) is not constant over time and, most likely, unknown
MPF	**3.0bi packs in 2017, supposing law enforcement efficiency ratio of 7.5%**	2014	Unknown	**Unknown**	Our own calculation, supposing 2014 median law enforcement efficiency ratio applied to SRFB cigarette seizure time series

GOVERN-MENT	VALUE	REFERENCE YEAR	METHODOLOGY	SCIENTIFIC STANDARDS	COMMENTS
RAMOS (2009)	**26% market share 39.5bi sticks**	2007	Estimation of potential Paraguayan illicit production using soft and hard data from MERCOSUR countries; Hypotheses to scope diverted illegal Paraguayan production to Brazil; Adjustments with Brazilian internal illegal production and legal cigarette market estimated elsewhere; Comparison with VIGITEL 2006 total consumption figures to gauge illicit market share	**Medium**	Organized use of several information (both soft and hard data) and surveys to estimate the illicit market share in Brazil; Lack of critical assessment of third party information, including data from MERCOSUR countries; Subjective hypotheses; Lack of proper third-party references; Lack of robustness checks
IGLESIAS *ET AL.*, (2012)	**Between 54bi sticks (*ttr* of 81%) and 86bi sticks (*ttr* of 89%) per year**	2000-2009	Use of official data (internal production and foreign trade) to scope the amount of available raw tobacco in Brazil; Corradini (2010) technical requirements to transform raw tobacco into **industrial tobacco (*ttr*); Tobacco** content per stick (*tpu*) to transform industrial tobacco into potential supply of cigarettes; Comparison of this potential supply with legal cigarette production and net exports of legal cigarettes	**Medium**	Replicable methodology to account for potential cigarettes supply; Technical requirements from Corradini (2010) lack methodological explanation (*ttr*); Decision to drop the 61% *ttr* undisclosed reasons; Strong hypothesis of stable tobacco inventories; Strong hypothesis for tobacco content per stick (0.83g), yet robustness checks available (*tpu*)
IGLESIAS *ET AL.*, (2017)	**2008: 16.6% market share (vs. 13.3% prevalence rate) 2013: 31.1% market share (vs. 10.8% prevalence)**	2008 and 2013	Establishment of a minimum pack price per year using data official taxa data, production and distribution costs from SRFB and retail margins; Extraction of purchase prices from each year **survey, accounting for several adjustments; Extraction of prevalence rates** and illicit market shares for each year Stratification of results by sociodemographic variables, smoking pattern and location	**High**	Replicable and well-explained use of PeTab surveys (2008 and 2013); Retail margins lack references; SRFB cost numbers lack explanations; Comparison between prevalence rates and illicit market shares for each year; Evolution of both metrics between 2008 and 2013; Stratification imply stronger results

PAES (2017)	**26%-32% range Increasing market share between 2006 (26%) and 2012**	2000-2012	Combination of production data, net exports and estimated consumption (legal and total) to produce residual estimates for the illicit consumption	**Low**	Flawed methodology; No critical assessment of the data used; Lack of robustness checks
SZKLO *ET AL.*, (2018)	**2012: 28.6% 2013: 32.3% 2014: 28.8% 2015 36.5% 2016: 42.8%**	2012-2016	Use of PeTab 2013 to estimate the under-reporting constant as in Merriman (2002), based upon 2013 illicit figures of Iglesias *et al* (2013); Translation of PeTab 2013 under-reporting to VIGITEL 2013; Stratification of the under-reporting parameter by educational level; Estimation of illicit cigarette volumes for every year with continuous VIGITEL (from 2012 to 2016); Illicit market share estimation by the comparison of illicit volumes and total volumes	**High**	Replicable and wellexplained use of PeTab and VIGITEL surveys, allowing for yearly analysis; Strong hypothesis for under-reporting (not necessarily constant throughout the sample); Strong hypotheses for stratification (official legal sales are not stratified); PeTab and VIGITEL are not fully comparable: sensitive analysis by changing the yearly proportion of illegal cigarette consumption; Careful assessment of potential biases due to data limitations

Source: Authors

Table 9 showed that measuring the illicit market is a very difficult task in Brazil. Several methodologies and actors have attempted to do so in recent years, with significant shortcomings related to data issues and the Brazilian context. Results have varied widely, not only due to different methodologies and analytical preferences but also due to vested interests of the tobacco industry.

Several data innovations, such as PeTab and VIGITEL surveys have allowed independent researchers to open up new analytical paths over the last couple of years. Those estimates not only tend to be smaller than the ones championed by the tobacco industry but also are usually based on higher scientific standards. All estimates, however, confirm that illicit market shares have been rising despite falling smoking prevalence, something also suggested by the decoupling between prevalence and tobacco-related tax revenues.

Our understanding of tobacco illicit market in Brazil is evolving. However, some blanks are still missing. For instance, it is sufficiently established that Paraguay has a very important role in the Brazilian tobacco shadow market. *Tobacco industry media reports by Fórum Nacional contra a Pirataria e a Ilegalidade* (FNCP) recently stated that the top selling brand in Brazil is Eight, produced by Tabacalera del Este in Paraguay – and own by former Paraguayan President Horácio Cartes. In certain locations such as Rio de

Janeiro and São Paulo, another relevant brand is Gift – produced by the same company in Paraguay. Nevertheless, official data (both in Paraguay and Brazil) do not show any relevant trade of products classified under Common Nomenclature of MERCOSUL (*Nomenclatura Comum do Mercosul*, NCM) code 24.02.20.00 – Cigarettes containing tobacco – between those countries. Even more interesting, Brazil is a paramount supplier of inputs for Paraguayan production of cigarettes, such as raw tobacco (unmanufactured), specific types of paper and materials for filters. Above all, international trade data shows that Brazil has had a significant market share of Paraguayan imports of cigarette-related inputs, foremost unmanufactured tobacco and tobacco refuse – albeit decreasing more recently, yet above the 35% level in 2017.

Therefore, an analysis of the illicit cigarette market in Brazil necessarily involve a deeper discussion of the Paraguayan production chain and its interaction with the Brazilian market.

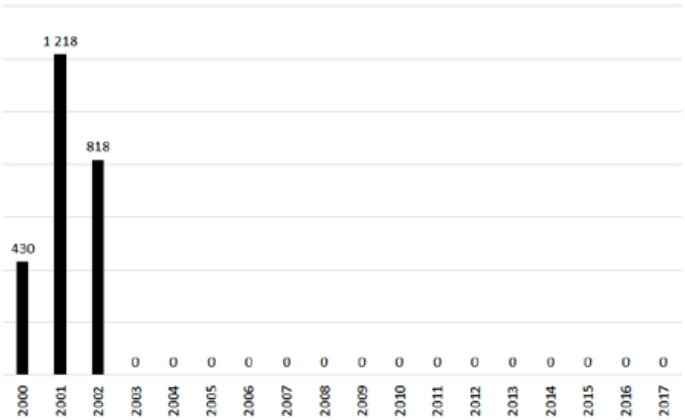
3.14 Analysis of the Paraguayan production chain and its linkages with Brazil

As noted by Merriman (2002), international trade statistics contain a substantial amount of information on global legal flows of tobacco-related products. As explained above, exports from the country A to B should match imports of the country B from A. In practice, those numbers do not precisely match given a broad range of reasons that go far beyond illicit trade: for example, different accounting methods between countries, mishaps when reporting, or fiscal benefits that could bias trade flows. These discrepancies in bilateral trade data appear in the Brazil-Paraguay tobacco flows in a rather remarkable way. Paraguayan brands seem to be easily found in Brazil (and apparently have a relevant market share), yet there have been no accounted cigarette imports from Paraguay since 2002 (figure X).

Despite clear limitations, trade statistics can still be used to analyze tobacco supply chain integration. In fact, a proper analysis should go much deeper than simply evaluating cigarette trade, which in the Brazil-Paraguay case is dubious. According to National Research Council and Institute of Medicine (2015), there are very specific raw materials required to produce cigarettes, whether they are legal or illegal. Key inputs go beyond tobacco and include certain types of paper and chemicals applied to filters, which are unique goods trackable through their international trade codes. In order to enhance replicability and comparability, trade flows were obtained from COMTRADE (a harmonized international database provided by the United Nations) instead from national sources[35]. Given the anecdotal roles of Paraguay as a supplier of final tobacco products and of Brazil as an input supplier for the Paraguayan production, datasets were constructed from the Paraguayan

35. Discrepancies between international and domestic datasets were minor over the last decade, yet grew for older data in certain specific goods. Even so, international databases are easier to manipulate and are readily available.

Figure 4. **Paraguayan legal exports of cigarettes to Brazil (2000-2017, ton)**



Source: UN COMTRADE

perspective, i.e., exports and imports from that country to/from partners, thus allowing to scope Brazilian position in the Paraguayan production chain. For this analysis, we considered annual data from 2000 to 2017.

3.15 Tobacco and tobacco products

This group of products is solely within HS/NCM heading 24 (*Tobacco and manufactured tobacco substitutes*), comprising both final products and industrial inputs. Paraguayan trade is tracked by four-digit codes 24.01 (*Tobacco, unmanufactured; tobacco refuse*), 24.02 (*Cigars, cheroots, cigarillos and cigarettes; of tobacco or of tobacco substitutes*) and 24.03 (*Manufactured tobacco and manufactured tobacco substitutes*). Given the importance of cigarettes, 24.02 is opened in two further categories, six-digit code 24.02.20 (*Cigarettes; containing tobacco*) and a residual that accounts for other final tobacco products within code 24.02 that are not cigarettes.

Table 10 summarizes Paraguayan trade of the aforementioned products. In terms of global flows (i.e., Paraguayan trade with the world), it is clear that the trade pattern is unbalanced, with imports consistently bigger than exports. That happens especially in the HS/NCM heading 24.01 that accounts for raw materials (unprocessed tobacco and tobacco

refuse). The same pattern is observable in the trade flows with Brazil, especially in raw materials.

There are no recorded exports of tobacco products under 24.02 (in spite of the presence of Paraguayan cigarettes in Brazil). More recently, exports of manufactured tobacco have been rising, yet still represent a small share of trade flows. In sum, Brazil is a relevant trade partner of Paraguay within this group of products, as much more of a supplier for the Paraguayan production chain than a consumer of Paraguayan production. One average, Brazil is the destination of 4.7% of Paraguayan exports (as a relevant consumer only of manufactured tobacco, albeit just recently) but is the origin of about 35% of Paraguayan imports (mostly raw tobacco).

3.16 Cigarette filters

The most usual type of cigarette filter is made of a pulp-based fibre (most commonly synthetic) called cellulose acetate. Despite being an input of several other products (such as highlighters, pens, markers oil filters and medical devices), its primary use is as an input of cigarette filters on its transformed form of acetate filament tow – obtained using a very sophisticated industrial process only mastered by a handful of global companies organized under GAMA (Global Acetate Manufacturers Association[36]).

According to National Research Council and Institute of Medicine (2015), more than 80% of global production of acetate tow is reportedly used in the manufacture of all cigarettes. Furthermore, several research reports as Neumann (2014) and Joossens *et al.*, (2014) find that acetate tow is largely oversupplied (given accounted legal demand), suggesting diversion to illicit (cigarette) manufacturers in huge amounts.

Within HS/NCM encoding, acetates have two possible matches. The first one is on six-digit codes 39.12.11 (*Cellulose acetates, non-plasticized in primary form*) and 39.12.12 (*Cellulose acetates, plasticized in primary form*), apparently related to more "raw" acetate products. The second match is within four-digit code 55.02 (*Artificial Filament tow*), split into six-digit codes 55.02.00 (*Fibres; artificial filament row*), 55.02.10 (*Fibres; artificial filament row of cellulose acetate*) and 55.02.90 (*Fibres; artificial filament row other than cellulose acetate*): precisely what is needed as input of cigarette filters.

Paraguayan external trade of 55.02 heading in presented in Table 11. As in the case of raw tobacco, global flows show an unbalanced trade pattern, with irrelevant exports and huge imports. The Brazilian role is once again significant, albeit not as much as with tobacco and tobacco products. Nonetheless, Brazil has been a significant supplier to Paraguay as the origin of 26.5% (average) imports of filament tow ever since 2005.

36. Celanese Corporation (USA), Eastman Chemical Company (USA), RhodiaAcetow (Germany), Daicel Corporation (Japan), Mitsubishi Chemical Corporation (Japan) and Sichuan Push Acetati Co., Ltd. (China).

Table 10: **Paraguayan trade balance – Tobacco and tobacco products (kilograms)**

	2000		2005		2010		2015		2016		2017	
	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)
Paraguay => World												
Tobacco and manufactured tobacco substitutes	**6 114 076**	**31 939 151**	**4 621 502**	**37 730 276**	**9 875 706**	**51 871 581**	**9 064 631**	**41 013 038**	**9 746 186**	**41 140 788**	**8 696 734**	**43 612 122**
Tobacco, unmanufactured tobacco refuse	2 352 063	15 007 455	3 212 786	32 746 597	4 831 698	45 956 263	6 658 700	34 966 247	7 044 215	35 339 371	5 680 970	38 478 837
Cigars, cheroots, cigarillos and cigarettes of tobacco or of tobacco substitutes	3 752 013	10 368 624	1 252 911	3 204 945	3 988 310	2 779 108	2 302 521	2 863 531	2 294 409	2 577 315	2 340 818	2 563 224
Cigarettes; containing tobacco	3 739 960	10 320 961	1 250 165	3 199 533	3 963 942	2 772 965	2 231 697	2 859 157	2 294 409	2 552 340	2 340 818	2 552 925
Others	12 053	47 663	2 746	5 412	24 368	6 143	70 824	4 374	0	24 975	0	10 299
Manufactured tobacco and manufactured tobacco substitutes n.e.c; homogenised or reconstituted tobacco; tobacco extracts and essences	**10 000**	**6 563 072**	**155 805**	**1 778 734**	**1 055 698**	**3 136 210**	**103 410**	**3 183 260**	**407 562**	**3 224 102**	**674 946**	**2 570 061**
Paraguay => Brazil												
Tobacco and manufactured tobacco substitutes	**471 963**	**11 731 312**	**228 944**	**1 077 519**	**672 066**	**15 922 021**	**22 825**	**16 081 140**	**293 496**	**16 039 730**	**450 068**	**14 183 251**
Tobacco, unmanufactured tobacco refuse	**41 410**	**6 727 911**	**228 944**	**862 345**	**672 066**	**15 489 520**	**9 600**	**15 984 210**	**56 485**	**15 510 730**	**17 800**	**14 177 000**
Cigars, cheroots, cigarillos and cigarettes of tobacco or of tobacco substitutes	**430 553**	**73 331**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5 051**
Cigarettes; containing tobacco	430 400	45 041	0	0	0	0	0	0	0	0	0	5 051
Others	153	28 290	0	0	0	0	0	0	0	0	0	0

	2000		2005		2010		2015		2016		2017	
	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)
Paraguay => Brazil												
Manufactured tobacco and manufactured tobacco substitutes n.e.c; homogenised or reconstituted tobacco; tobacco extracts and essences	**0**	**4 930 070**	**0**	**215 174**	**0**	**432 501**	**13 225**	**96 930**	**237 011**	**529 000**	**432 268**	**1 200**
Brazilian share on Paraguayan trade(%)												
Tobacco and manufactured tobacco substitutes	**7.7%**	**36.7%**	**5.0%**	**2.9%**	**6.8%**	**30.7%**	**0.3%**	**39.2%**	**3.0%**	**39.0%**	**5.2%**	**32.5%**
Tobacco, unmanufactured tobacco refuse	**1.8%**	**44.8%**	**7.1%**	**2.6%**	**13.9%**	**33.7%**	**0.1%**	**45.7%**	**0.8%**	**43.9%**	**0.3%**	**36.8%**
Cigars, cheroots, cigarillos and cigarettes of tobacco or of tobacco substitutes	**11.5%**	**0.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.2%**
Cigarettes; containing tobacco	11.5%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Others	1.3%	59.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	0.0%	-	0.0%
Manufactured tobacco and manufactured tobacco substitutes n.e.c; homogenised or reconstituted tobacco; tobacco extracts and essences	**0.0%**	**75.1%**	**0.0%**	**12.1%**	**0.0%**	**13.8%**	**12.8%**	**3.0%**	**58.2%**	**16.4%**	**64.0%**	**0.0%**

Source: UN COMTRADE

3.17 Cigarette paper

According to National Research Council and Institute of Medicine (2015), papers used in the production of individual cigarettes are highly specialized goods, designed to control factors such as density, porosity and burn rate of cigarettes. As with cellulose tow, just a few global companies are able to produce and supply this input to cigarette manufacture, which apparently has no other relevant industrial usage given its high specificity. Unlike cellulose tow, however, cigarette-related papers are more easily replaceable in their absence, which tends to be the case with counterfeit products.

Under HS/NCM coding system, cigarette paper clusters in the four-digit heading 48.13 (*Cigarette paper*), further split in six-digit codes 48.13.10 (*Paper; cigarette; in the form of booklets or tubes*), 48.13.20 (*Paper; cigarette; in rolls of a width not exceeding 5cm*) and 48.13.90 (*Paper; cigarette; other than in rolls of a width not exceeding 5cm or in booklets or tubes*).

Paraguayan external trade of such goods in presented in table 13. As seen in the previous two sections, global flows show significant trade deficits throughout the years. Brazilian trade shares are once again significant, not only on the imports side (on average, Brazil was the origin of 27% of merchandises in the sample considered) but also on the export side (almost entirely destined to Brazil). Nonetheless, as the latter is almost irrelevant, cigarette paper flows are another piece of information that suggests Brazilian preeminence as supplier of the Paraguayan production complex.

3.18 Brazil and Paraguay tobacco supply chain linkage

According to international trade data, Brazil is a relevant supplier of intermediate products for the Paraguayan tobacco complex, but has an irrelevant position as demander of Paraguayan tobacco-related products (either inputs or final goods). Obviously, that accounts only for legal trade – the clearest absence is of cigarette exports to Brazil, but most likely other effective trade flows (in both exports and imports) are also missing.

Brazil´s importance goes beyond absolute numbers: the country is consistently ranked as one the biggest suppliers, throughout the sample. Table 13 summarizes Brazil´s rank as Paraguay supplier (i.e., ranking in Paraguayan imports) for each of the major cigarette components (tobacco, filter and paper).

Net imports of each one of the intermediate products seem to be abnormally high. Supposing (i) Paraguayan production technology comparable to global standards; (ii) No excessive domestic consumption of cigarettes; (iii) No inventory build-up (on average); and (iv) using reported legal trade flows, Paraguayan input patterns strongly suggest a potential oversupply of cigarettes in the country, which is most likely diverted to illicit trade.

Table 11: **Paraguayan trade balance – Artificial filament tow (kilograms)**

	2000		2005		2010	2015		2016		2017	
	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)
Paraguay => World											
Artificial filament tow	0	1 133 163	0	5 298 114	9 958	17 465	6 319 557	1 798	6 723 923	2 517	7 192 075
Fibres; artificial filament tow	0	1 133 163	0	5 298 114	9 958	17 465	6 319 557	1 798	6 723 923	0	0
Fibres; artificial filament tow of cellulose acetate	0	0	0	0	0	0	0	0	0	2 517	7 191 979
Fibres; artificial filament tow other than cellulose acetate	0	0	0	0	0	0	0	0	0	0	96
Paraguay => Brazil											
Artificial filament tow	0	10 697	0	1 098 469	9 958	0	1 831 980	0	2 061 910	2 517	1 844 870
Fibres; artificial filament tow	0	10 697	0	1 098 469	9 958	0	1 831 980	0	2 061 910	0	0
Fibres; artificial filament tow of cellulose acetate	0	0	0	0	0	0	0	0	0	2 517	1 844 870
Fibres; artificial filament tow other than cellulose acetate	0	0	0	0	0	0	0	0	0	0	0
Brazilian share on Paraguayan trade (%)											
Artificial filament tow	-	0.9%	-	20.7%	100.0%	0.0%	29.0%	0.0%	30.7%	100.0%	25.7%
Fibres; artificial filament tow	-	0.9%	-	20.7%	100.0%	0.0%	29.0%	0.0%	30.7%	-	-
Fibres; artificial filament tow of cellulose acetate	-	-	-	-	-	-	-	-	-	100.0%	25.7%
Fibres; artificial filament tow other than cellulose acetate	-	-	-	-	-	-	-	-	-	-	0.0%

Source: UN COMTRADE

Table 12: **Paraguayan trade balance – Cigarette paper (kilograms)**

	2000		2005		2010		2015		2016		2017	
	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)	Exports (to)	Imports (from)
Paraguay => World												
Cigarette paper	5 327	1 966 410	297 463	3 880 975	14 709	5 391 487	13 048	5 388 922	9 881	4 789 747	15 855	6 095 391
Paper, cigarette in the form of booklets or tubes	0	0	0	0	0	1 173	0	2 271	0	2 221	0	5 706
Paper, cigarette in rolls of a width not exceeding 5cm	5 327	1 331 418	295 168	3 017 783	13 969	3 759 861	12 050	3 650 737	3 531	3 265 027	15 855	4 238 471
Paper, cigarette (other than in rolls of a width not exceeding 5cm or in booklets or tubes)	0	634 992	2 295	863 192	740	1 630 453	998	1 735 914	6 350	1 522 499	0	1 851 214
Paraguay => Brazil												
Cigarette paper	0	749 098	295 168	94 995	13 912	1 301 050	12 050	1 321 639	3 360	1 478 351	15 074	2 394 416
Paper, cigarette in the form of booklets or tubes	0	0	0	0	0	0	0	0	0	0	0	0
Paper, cigarette in rolls of a width not exceeding 5cm	0	511 113	295 168	94 995	13 912	910 319	12 050	962 468	3 360	1 127 330	15 074	1 807 630
Paper, cigarette (other than in rolls of a width not exceeding 5cm or in booklets or tubes)	0	237 985	0	0	0	390 731	0	359 171	0	351 021	0	586 786
Brazilian share on Paraguayan trade(%)												
Cigarette paper	0.0%	38.1%	99.2%	2.4%	94.6%	24.1%	92.4%	24.5%	34.0%	30.9%	95.1%	39.3%
Paper, cigarette in the form of booklets or tubes	-	-	-	-	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Paper, cigarette in rolls of a width not exceeding 5cm	0.0%	38.4%	100.0%	3.1%	99.6%	24.2%	100.0%	26.4%	95.2%	34.5%	95.1%	42.6%
Paper, cigarette (other than in rolls of a width not exceeding 5cm or in booklets or tubes)	-	37.5%	0.0%	0.0%	0.0%	24.0%	0.0%	20.7%	0.0%	23.1%	-	31.7%

Source: UN COMTRADE

Table 13: **Brazilian ranking within Paraguayan imports (2000-2017)**

	2000	2005	2010	2015	2016	2017
Tobacco and tobacco products (24.01, 24.02 and 24.03)	1st	7th	1st	1st	1st	2nd
Cigarette filter (48.13)	4th	2nd	2nd	2nd	2nd	2nd
Cigarette paper (55.02)	2nd	8th	2nd	2nd	2nd	1st

Source: UN COMTRADE

3.19 Establishing the boundaries for illicit cigarette supply

Estimating the illegal market size is a very difficult task, with multiple challenges in terms of data availability, compatibility and robustness of the requested exogenous calibration. Practical challenges abound, especially in the Paraguay-Brazil relationship.

Besides doubts on bilateral trade data, it is noteworthy that Paraguay generally lacks official information on tobacco-related themes: there are no data on cigarette production; revenue data cannot be used to calculate volumes due to methodological handicaps; and consumption figures are absent. In Brazil, legal market numbers are available, though illicit market estimates tend to be biased due to the preeminence of the tobacco industry figures as the primary source of information.

The literature has been dealing with these analytical loopholes for quite some time. In order to measure the illicit market, some researchers have quantified the potential supply of cigarettes, and the eventual excessive production in a given country (related to its cigarette demand, either legal or illegal).

For Paraguay, Ramos (2009) first estimated the potential production using technical requirements for the transformation of raw inputs (mostly tobacco leaves) into cigarettes. Combining it with available trade data and hypothesis for domestic consumption, the author estimated the amount of illegal cigarettes available for international trade on that country.

For Brazil, the same general principle was used by Biz (2010) and Iglesias *et al.*, (2012) - with minor adjustments. The authors estimated the potential supply of cigarettes based on the total legal supply of tobacco leaves in the country and obtained numbers by far in excess of legal demand needs (legal net exports + legal domestic production of cigarettes). Since there is no reason to believe in recurrent inventory

buildup, this was interpreted as an evidence of informal trade of tobacco, probably related to illegal cigarette production sold either in Brazil or abroad.

In spite of being intuitive and easy to implement, the use of the "technical requirement" approach as a way to gauge the potential supply of illicit cigarettes in a certain country has significant shortcomings. First and foremost, required data has to be available. For instance, the literature usually relies on raw tobacco as the primary input for supply estimates, failing to compare results with other inputs such as cellulose acetate tow or cigarette-related papers solely due to the difficulty of obtaining them.

Also noteworthy is that technical hypothesis for the transformation of inputs in the final output (i.e., cigarettes) have to be pacified as results vary widely depending of the "technology" used: the fewer inputs are needed per cigarette, and then more units would be produced with the same original volume of raw materials.

Specifically in the Brazilian case, additional issues emerge due to the close relationship between Paraguayan and Brazilian cigarette production chains, therefore requiring further information such as bilateral trade and hypothesis on non-available data (such as Paraguayan total consumption) in order to estimate the potential supply of illicit cigarettes in both countries.

Given the inability to cross-check results with inputs other than raw tobacco and recognizing that several required data and hypothesis are at least doubtful, this section falls short of using the "technical requirement approach" to estimate the potential supply of illicit cigarettes.[37]

Nonetheless, just outlining the methodology and the required data already provides some important insights on Brazil´s cigarette production chain – and, more important, supports the evidence of illicit trading observed at Biz (2010) and Iglesias *et al*., (2012). The following sections, review the technical requirement methodology.

3.19.1 The technical requirement methodology in five steps

The general purpose of the Technical requirement is to estimate the (potential) supply of cigarettes considering available inputs, more specifically tobacco, and every step of the industrial transformation from raw materials into final consumption goods (cigarettes). The procedure goes in five steps, as follows:

The first step is to consolidate the available volumes of unmanufactured tobacco eligible for processing as in equation (1), adding up local production of raw tobacco and net exports under HS/NCM codes 24.01.10 (*Tobacco; not stemmed or stripped*) and 24.01.20 (*Tobacco; partly or wholly stemmed or stripped*).

$$T_{raw} = QT_{raw} - XT_{raw} + MT_{raw} \quad (1)$$

Where:

T_{raw} is the raw tobacco available for processing (kg);

QT_{raw} is the domestic production of raw tobacco (kg);

37. Updates of previous literature estimates for both Brazil and Paraguay are available in the Annex, keeping in mind all the data shortcomings and weak reliability of results.

XT_{raw} are exports of raw tobacco (kg);

MT_{raw} are imports of raw tobacco (kg);

In the second step, unmanufactured tobacco is transformed into "industrial tobacco" (i.e., applicable for downstream industrial processes). For that, a technical transformation requirement (ttr) is requested as in equation (2).[38]

$$T_{industrial\ \ (DP)} = ttr * T_{raw} \quad (2)$$

Where:

$T_{industrial\ \ (DP)}$ is the industrial tobacco (raw tobacco after processing) domestically produced (kg);

ttr is technical transformation requirement of raw tobacco;

The third step is to consolidate total supply of industrial tobacco within a certain country. For that, domestically produced transformed tobacco adds up with net exports of industrial tobacco under HS/NCM codes 24.03 (*Manufactured tobacco and manufactured tobacco substitutes*) and 24.01.30 (*Tobacco refuse*) as in equation (3).

$$T_{industrial\ \ } = T_{industrial\ \ (DP)} - XT_{industrial\ \ } + MT_{industrial} \quad (3)$$

Where:

$T_{indus\ trial}$ is the industrial tobacco available in a certain country (kg);

$XT_{industrial}$ are exports of industrial tobacco (kg);

$MT_{industrial}$ are imports of industrial tobacco (kg);

The fourth step is the conversion of available industrial tobacco into potential cigarette production as in equation 4. For that, another technical constant is mandatory: tobacco per unit (*tpu*)[39] of cigarette. The smaller the *tpu*, the bigger the number of cigarettes produced for a given tonnage of industrial tobacco.

$$PCP = tpu^{-1} * T_{industrial} \quad (4)$$

Where:

PCP is the potential cigarette production in a certain country (sticks);

tpu is the amount of tobacco per cigarette unit;

The fifth step is to consolidate potential cigarette supply as in equation (5). For that, domestic potential cigarette production adds up with net exports of cigarettes under HS/NCM code 24.02.20 (*Cigarettes; containing tobacco*).

$$PCS = PCP - XC + MC \quad (5)$$

Where:

PCS is the potential cigarette supply in a certain country (sticks);

XC are (legal) cigarette exports (kg, converted to sticks);

MC are (legal) cigarette imports (kg, converted to sticks);

It should be noted that further assumptions are necessary to merge the number of sticks (millions) with international trade

38. Values of *ttr* vary at economics and industrial engineering literatures. Further details are available on the next section.
39. Once again, this technical requirement varies widely on the literature depending on cigarettes size, weight, and diameter. Further details are available in the next section.

information (in net weight, usually tons). Estimates for the net weight of a single cigarette vary depending of its physical characteristics (size, diameter, and tobacco content), but usually hover around 1g/stick[40]. Moreover, inventory adjustments are usually supposed irrelevant in order to facilitate data interpretation.[41]

Finally, if the goal is using the technical requirement approach to estimate the excessive cigarette supply, then a final methodological step in needed. In order to estimate it[42], we need to discount domestic legal consumption from the potential cigarette supply as in equation (6).

$$ECS = PCS - DCC \qquad (6)$$

Where:

ECS is the excessive cigarette supply (sticks) in a certain country;

DCC is the domestic (legal) consumption of cigarettes (sticks) in a certain country.

3.20 Practical issues in the Brazilian and Paraguayan cases

Despite being theoretically intuitive, accountable, and replicable, the technical requirements methodology is handicapped by significant data issues on quality and/or availability. In that sense, it usually comes along with certain assumptions necessary for calibration (besides the abovementioned technical requirements) and to "close" data loopholes.

That is especially true in the Brazilian case, in which not only our sovereign data is needed but also Paraguayan data has to be accounted for. Given interlinks between the cigarette production complexes (from inputs to final outputs) of both countries, any technical requirement evaluation in Brazil has also to carefully consider the supply/demand tobacco balance with that trading partner.

In a broad sense, the data required to implement this methodology could be split into four basic groups: (i) inputs; (ii) international trade; (iii) consumption metrics[43]; and (iv) "technical constants". Each one of them is discussed below, highlighting issues on data availability and compatibility between different data sources.

3.20.1 Input data

The paramount choice in the literature is tobacco (usually unmanufactured), though other intermediate goods (such as cigarette paper or cigarette filters) would also be applicable. Difficulties when obtaining data on other intermediate goods threaten their practical utilization and reinforce the election of raw tobacco for the estimation.

40. Choosing this specific metric makes the conversion between numbers and weights straightforward as 10^6 sticks = 10^6 grams
41. In theory, processed tobacco could be inventoried for as much as three years and cigarettes for even longer periods with correct storage. In essence, the effective amount of cigarettes in a given year is a combination of production, net exports and inventory adjustments. The later was supposed irrelevant (i.e., stable inventory), a strong but understandable hypothesis which had to be made given the inability to gauge producers´ inventory decisions in the whole industrial chain.
42. A seminal gauge for the potential illicit supply.
43. Keeping consistency with the previous chapter, datasets will comprise the 2000-2017 period.

At first, international databases for tobacco leaf production, such as the one by Food and Agriculture Organization of The United Nations (FAO), would be preferable given their consistency and ease-of-use for end users. Nonetheless, significant differences between international and government data sources eventually appear.

For Brazil, FAO numbers would be readily applicable as they closely match official data obtained from *Instituto Brasileiro de Geografia e Estatística* (IBGE). When looking at Brazilian production and its destination pattern, however, one discovers that tobacco leaf produced in certain parts of the country (Northeast) is usually used for other types of tobacco products, such as cigars. As this research piece is basically focused on cigarettes, it follows Biz (2010) by choosing unmanufactured tobacco production of the South Region of Brazil (Paraná, Santa Catarina e Rio Grande do Sul states) as the input metric.

Regional production data, obtained from IBGE at a specific agriculture survey called *Levantamento Sistemático da Produção Agrícola* (LSPA), shows that this region accounts for about 95% of tobacco leaf production in the country, being therefore a representative choice.

One could argue that production from the South could be readily obtained from *Associação dos Fulmicultores do Brasil* (AFUBRA), the national association of raw tobacco producers that is heavily concentrated on southern farmers. Nonetheless, AFUBRA consistently underreports production when compared to LSPA/IBGE (figure 5), reinforcing discrepancies according to the data source.

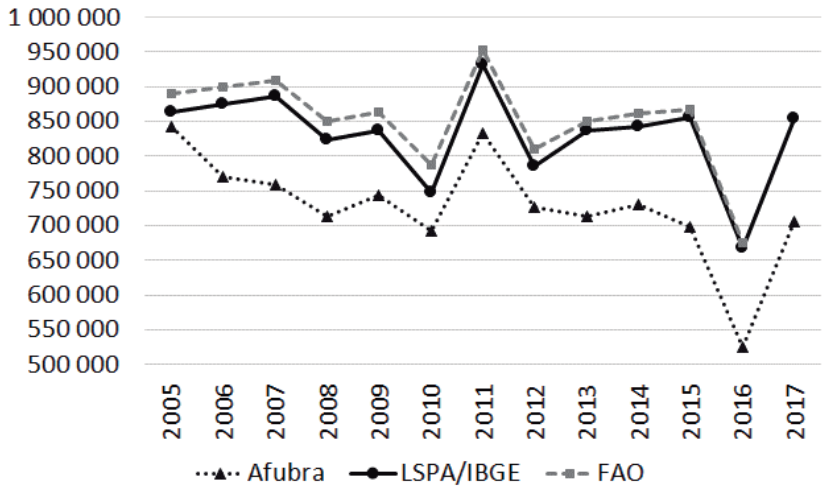
The same issues occur in Paraguay, even more strikingly. Raw tobacco production obtained from FAO and official data from the *Ministerio de Agricultura Y Ganadería del Paraguay* (MAG) basically match between 1991-2000 and from 2008 onwards. Nonetheless, there is a bizarre difference between these two data sources in the period 2000-2007. Not only government data seems much less volatile but also the behavior of FAO numbers in that precise window lacks reasonable explanation (figure 6) – once again, government numbers seem to be more reliable than international ones.

3.20.2 Trade-related data

The consolidation of potential cigarette supply in a given country requires net exports of basic goods (unmanufactured tobacco), intermediate goods (manufactured tobacco and tobacco refuse), and final consumption goods (cigarettes) to be included throughout the cigarette chain (from the tobacco farm to the cigarette retailer).

Keeping consistency with previous sections and highlighting its ease-of-use to end users, COMTRADE would be the primary data source chosen for both countries. Differences between COMTRADE and Brazilian external trade data sources (such as SISCOMEX from *Ministério do Desenvolvimento, Indústria e Comércio – MDIC*) are negligible, the same applying in the Paraguayan case.

Figure 5: **Brazilian tobacco production, unmanufactured (2005-2017, tons)***



Source: AFUBRA, IBGE and FAO.
*AFUBRA and IBGE account only for South Region production. FAO for the whole country as of 2016

Figure 6: **Paraguayan tobacco production, unmanufactured (1991-2017, tons)**

Source: FAO and MAG

3.20.3 Consumption data

The biggest data shortcomings are in consumption metrics, which demands a more careful debate. Most usually, consumption data is not a readily available. With the applicable tax rate, information commonly kept by Tax Administration or Customs Offices worldwide, cigarette tax revenues could be used to reconstruct (legal) sales series.

Unfortunately, total consumption series (both legal and illegal) have to be estimated, usually by: (i) asking the experts (tobacco industry or officials); (ii) using consumption surveys such as *Global Adult Tobacco Survey* (GATS) and *Pesquisa Especial do Tabagismo* (PetAb)[44] or telephone surveys like VIGITEL[45]; and (iii) econometric modelling. As a rule of thumb, certain assumptions are needed when interpreting these proxies.[46]

In Brazil, SRFB provides yearly numbers for legal cigarette production in the country. These are not exactly legal consumption figures, but are close enough given that net legal imports are just a tiny fraction of production, and, therefore, potentially of legal consumption.[47]

Issues are much more relevant for Paraguay, where there is a complete absence of official data related to production and/or consumption. Moreover, revenue data cannot be used to calculate production/consumption volumes because sales are officially reported as values to wholesalers, not quantities produced or sold to retailers. In addition, is well-known that the under-reporting of sales by Paraguayan manufacturers is very high.

Therefore, if one wants to implement the technical requirements approach for both Brazil and Paraguay, then several (strong) assumptions have to be made. For example, reliance on third-party numbers for domestic consumption in Paraguay is necessary.

Most usually, these figures come out with no methodological explanation, such as the 3 billion sticks/year from Ramos (2009). More recently, Ng *et al*., (2014) estimated cigarette consumption figures between 1980 and 2012 for a set of 187 countries using a careful (and documented) methodological procedure to estimate total domestic consumption (i.e., legal + illegal).

However, datasets are not available from 2012 onwards. Therefore, in order to "create" data up until 2017, additional *ad hoc* procedures (such as linearly extrapolating the series using a 5 year-rolling trend up from 2012) have to be implemented.

Based on that, Paraguayan total consumption could be estimated, on average, at 4 billion sticks/year, rising at the end of the sample to around 5 billion sticks/year (figure 7). Given recent economic performance (GDP annual growth rate averaged 3.5% from 1995 to 2017) and knowing that Paraguayan cigarettes are highly affordable (one of the cheapest in PPP terms), it seems to be a feasible estimation – yet with a methodology

44. PeTab is a Brazilian nationwide survey conducted within the National Household Survey (*Pesquisa Nacional de Amostra de Domicílios,* PNAD), first implemented in 2008 and is the Brazilian version of GATS.
45. VIGITEL is a yearly telephone survey conducted by the Ministry of Health in Brazil, which evaluates several diseases and health habits, among which tobacco consumption.
46. As discussed in the previous section.
47. During the period 2000-2017, legal net imports were of -1.4 billion sticks/year (i.e., legal net exports) while legal production was 93 billion sticks/year.

filled with strong assumptions and *ad hoc* hypotheses.

3.20.4 Technical constants

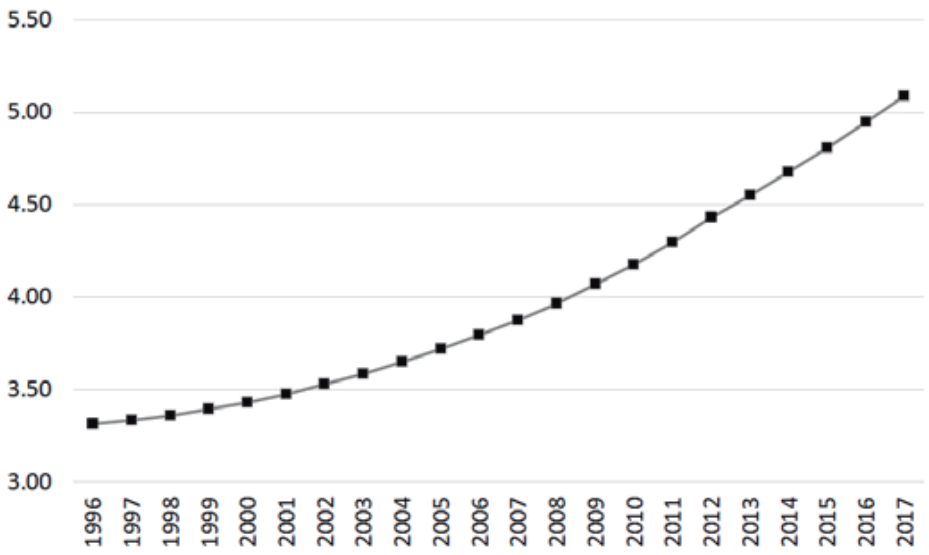
Finally, the last set of data and hypothesis needed are the technical requirements themselves. Properly calibrating them is essential for results as they provide the linkages between raw inputs and final cigarette production.

From the previous methodological discussion, two constants emerge. The first one is the technical transformation requirement from raw tobacco into industrial tobacco, dubbed in equation (2). The literature provides several estimates for it, yet not pinpointing a precise number.

For instance, at Iglesias *et al*., (2012) this variable was calibrated at alternative levels of 81% or 89%, following Corradini (2010). In the industrial engineering literature, Tuzzin (2015) stated that about 20% of tobacco leaf weight would be lost in its industrial transformation. Altogether, seems to cluster around 80%.

The second transformation constant was dubbed tobacco per unit () technical requirement in equation 4, linking available industrial tobacco to (potential) cigarette production. Calibration of this parameter is looser than for *ttr*. On the one hand, the chemistry literature estimated that each cigarette contained about 700mg of tobacco as by Trilha (2009). The same broad values were used in the economics literature, specifically by Corradini (2013) and Malson

Figure 7: **Paraguayan cigarette consumption (1996 – 2017, billions of sticks)**



Source: own estimations based on Ng *et al.* (2014)

et al., (2001) - the latter only for filtered cigarettes (738.6mg).

On the other hand, Iglesias *et al*., (2012) provided a relatively wide range for *tpu* – from 600mg to 900mg – depending on a cigarette´s physical characteristics (size, weight and diameter), choosing an average of 0.83 (equivalent to 830mg of tobacco per cigarette weighting 1000mg).

Such variability in *tpu* leads to very different results in terms of the potential production of cigarettes, and therefore jeopardizes conclusions based upon the technical requirements methodology. A simple example illustrates this point: for one gram of available industrial tobacco, changing *tpu* from 0.7 (the first cluster observed at the literature) to 0.83 (as done by Iglesias *et al*.) would lead to a 15% lower potential output[48], obviously with very different analytical implications.

3.21 Discrepancies in the Brazilian cigarette production chain

The previous section highlighted significant difficulties in applying the technical requirements approach to evaluate potential production of cigarettes and to estimate illicit market size. Specifically, for the Brazilian case, data shortcomings are widespread, covering lack of consistency from different data sources, inability to measure consumption, and uncertainty regarding the technical transformation constants. Obviously, the necessity to consider the interaction between Brazil and Paraguay is another issue that strongly jeopardizes the analysis.

Albeit being simple and replicable, the technical requirements approach lacks robustness as results are very sensitive to the chosen data and *ad hoc* hypothesis. Nonetheless, it provides a useful guide to approach the illicit market debate by analyzing the importance of each link of the tobacco industrial transformation chain, from raw materials to the final tobacco product (usually cigarettes).

Once again focusing on raw tobacco as the primary input, available unmanufactured tobacco within Brazil is obtained by adding up domestic production with net imports. Following discussions from the previous section, the external trade data source was COMTRADE and the domestic production data source was the regional (South Region) data from the *Levantamento Sistemático da Produção Agrícola* (LSPA) agricultural survey from IBGE. Both therefore account for legal supply of unmanufactured tobacco.

On final output, yearly cigarette production figures came from the SRFB database. Obviously, SRFB data relate to tax-based cigarette production – i.e., legal cigarette production.

It is well known that legal cigarette production has been trending downwards in Brazil, in line with falling survey-based prevalence and consumption figures.

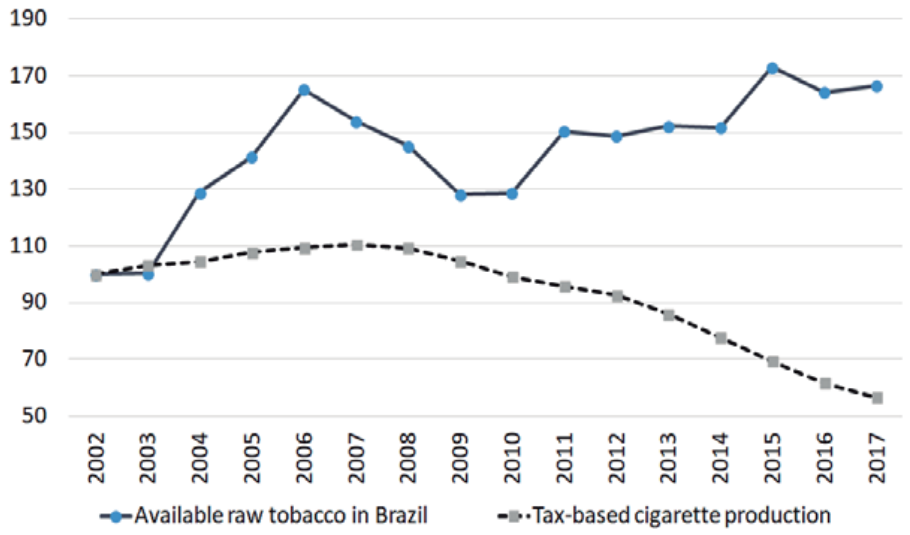
48. Using a *tpu* of 0.7, each industrial tobacco gram would suggest the production of 1,43 cigarettes; with a *tpu* of 0,83, the same amount of input would lead to just 1,20 cigarettes – i.e. a 15% lower potential output.

Available raw tobacco in the country should behave in a similar fashion supposing rational farmers/producers – for lower final usage, less domestically available supply. Nonetheless, figure 8 shows precisely the opposite: these two links of the Brazilian cigarette production chain are at odds.

There is a clear discrepancy between domestically available raw tobacco (input) and tax-based cigarette production (output) trends in Brazil. Even more, this difference has been growing over the last decade, with increasing available inputs and decreasing final output. Without running any technical requirement simulations, these numbers show an excessive amount of inputs given final legal needs.

In that sense, they support the illicit trade evidence presented by Biz (2010) and Iglesias *et al.*, (2012). Furthermore, the growing difference between these two series is also consistent with the increasing share of illicit cigarettes in Brazil, and in a very indirect way, confirming the broad trends shown by Iglesias *et al.*, (2017) and Szklo *et al.*, (2018).

Figure 8: **Input vs. output trends in Brazil (av. 3Y, 2012=100)**



Source: IBGE (LSPA), COMTRADE, SISCOMEX (MDIC) and SRFB

4. Updating price and income elasticities in Brazil

The estimation of price and income demand elasticities is an important exercise in tobacco taxation policy making and evaluation. Specifically in Brazil, not is only the evidence scarce but also, macroeconomic jitters ever since the mid-2010s have most likely affected historical estimates. Therefore, updating and enhancing elasticities using a new set of explanatory variables besides usual price and income data is needed. In addition, the macroeconomic environment and institutional efforts related to tobacco control should be accounted for.

The next section outlines our methodological approach, including data, estimation strategy and model specifications. Our basic results for price and income elasticities of legal cigarettes are presented afterwards. Lastly, the final section presents closing remarks.

4.1. Methodology and data

Several methodologies have been implemented in order to estimate cigarette demand elasticities worldwide. In common, all tried to establish relationships between cigarette consumption (most usually legal cigarettes), "macroeconomic determinants" (such as relative cigarette prices, income and employment) and "policy efforts" (such as tobacco control policies and higher excise taxes on cigarettes) – not only for the long run but also for the short-term dynamics.

4.2 Elasticity estimations literature review

4.2.1 International literature

The U.S. National Cancer Institute and World Health Organization (2016) provides an extensive summary of the international literature, with a variety of methodologies and data used for both high-income countries (HICs) and low-and middle-income countries (LMICs). The plethora of approaches and information has its origin in the lively debate on how to model consumption of an addictive product. In spite of its addictive nature, economic studies have found that cigarettes respond as in conventional models of rational choice: there is a clear inverse relation between prices and volumes.

The theoretical breakthrough stemmed from the adaptation of myopic behavior – when current consumption was mainly dependent on past consumption – into a rational addiction model as in Becker and Murphy (1988). Thus, consumers are inclined to be forward-looking as the current consumption depends on past and future consumption, and by implication, on past and future prices (understood not only as retail prices but also with other "costs" such as wealth expenses).[49]

Going beyond the theoretical framework, technical capacity on the tobacco consumption analysis has also had significant advances due to greater availability of data,

49. Despite that, models still included past consumption metrics in order to tackle present-biased preferences

econometric techniques, and computational capacity. In addition to time series data, researchers have begun to analyze pooled cross-sectional time series and a variety of individual and household surveys.

Controlling for other potential determinants of demand beyond prices and income, econometric methods improved and included variables such as tobacco company marketing expenditures and various population characteristics. Most of the empirical studies have found demand price elasticities clustering around -0.4 for HICs, while LMICs estimates spread on a wider range and cluster at -0.5.

Evidence for income elasticities is much less conclusive, with variability between social classes, countries and samples. In the U.S., for example, tobacco was generally a normal good (demand increasing with income) but has become a lower good (demand decreasing with income) for less wealthy social classes. In LMICs, cigarettes still behave as normal goods. Nonetheless, higher income elasticities among low-income classes in some LMICs suggest, for a certain homogeneous wealth effect, that poor smokers are affected disproportionately. Obviously, this type of "refinement" is central for policy discussion, especially in less wealthy and unequal countries.

Furthermore, several empirical studies have shown the presence of the illicit cigarette market worldwide. Wherever that happens (and Brazil is a case), legal consumption decouples from total consumption (by definition, the size of the illicit market is unknown) and the elasticity discussion is somewhat jeopardized as substitution from legal to illegal products tends to maximize estimated price and income coefficients.

Such caveats were explored in the international literature. Examining demand for cigarettes in Ireland, Chaloupka and Taurus (2011) arrived at price elasticities ranging from -1.0 to -2.3 and averaging -1.6 for the sample 2002-2010, therefore decoupling Irish price elasticities from HICs counterparts. The authors highlighted that increased tax avoidance and tax evasion in response to growing cigarette prices likely explained this result.[50]

Advancing over previous researches, Kennedy *et al*., (2015) highlighted the steady decline of Irish tax paid (legal) cigarettes while overall cigarette prices increased over the past decade. The study recognized the challenge of producing reliable estimates given the absence of illegal consumption data.[51] Using quarterly time series from 2002 to 2014, the study proxied cigarette consumption per capita by Revenue warehouse clearance data, therefore not reflecting actual cigarette consumption given that only Irish-taxed cigarettes were included.[52]

50. Euromonitor International (2011) estimated that consumption of untaxed cigarettes in Ireland rose roughly five-fold between 2002 and 2010, while the overall cigarette market, including both taxed and untaxed cigarettes, fell by nearly 14% overall and by over 31% on a per capita (15 and older) basis. Moreover, data on smoking prevalence showed a steady decline from 2002 through 2010, with an overall drop in prevalence of more than 20%.
51. Cigarette seizures and survey data were used to assess the scale of the illicit market, although they could not provide its trends and had several shortcomings.
52. In addition, clearances reflect withdrawals of cigarettes from warehouse by manufacturers, thereby affected by stockpiling in anticipation of tax increases. Finally, consumers could also personally stockpile.

With lags and leads of the consumption metric[53] and several controls (prices, relative prices, income, macroeconomic variables like the unemployment rate and institutional variables such as smoke-free laws[57]), the authors arrived at price elasticities of taxed (legal) cigarette demand ranging from -1.6 to -2.0, obtained in a variety of econometric specification and estimation techniques.[54] Income and macroeconomic controls were broadly found to be insignificant.

4.2.2 Brazilian literature

Price and income elasticity estimation is not a trendy topic in Brazilian tobacco economics, probably due to significant data difficulties both in terms of availability and quality. The first consistent estimates were made by Carvalho and Lobão (1998) using the proposition of stable preferences for consumer behavior formally outlined by Stigler and Becker (1977).

Using quarterly time series from 1983 to 1994, the authors estimated three types of behavior (adaptive, myopic, and rational) models both in the long run and in the short run. In general, results matched theoretical predictions: demand decreasing with higher prices and increasing with higher income.

By the adaptive model, the short-term price elasticity was -0.11 and the long-term price elasticity was -0.80. By the rational and myopic theoretical models, short-term price elasticities were, respectively, -0.14 and -0.20, while long-run price elasticities were about four times larger. Short-term income elasticity, calculated only from the rational and myopic theoretical models, were respectively of 0.23 and 0.31, while long-term income elasticities were 0.80 and 0.76.

Iglesias (2006) later refined the elasticity analysis by highlighting changes in cigarette consumption patterns or structural changes in the legal cigarette market. For the 1991-2003 sample, consumption decreased during a real price stability and income growth period and was stable during a period of real price decrease.

To estimate the elasticity of the legal demand for cigarettes, the author used aggregate quarterly data on cigarette consumption[55] per adult. Consumption was estimated as a function of a lagged consumption, cigarette real prices (based on a basket of five types of cigarettes), real per capita income, a time trend, an indicator of smoking restrictions (reflecting the tightness of legislation and the degree of its implementation) and seasonal dummies. [56],[57]

OLS estimates led to price elasticities of -0.25 for the short term and -0.42 for the long term[58], while none of the different income

53. Inspired by the myopic approach and the rational addiction theory. 57. Usually in first differences as data was generally trending and non-stationary.
54. OLS and instrumental variables, the latter to deal with potential endogeneity between consumed volumes and prices.
55. The variable consumption, not observed, was constructed based on the concept of apparent consumption: by the sum of the production with imports, deducting the exports. The unavailability of data for quarterly production of cigarettes was overturned by the construction of a data series from annual production, with monthly distribution given by rates obtained in the official survey of monthly production in the country.
56. Variables such as the real wage mass and a dummy representing the real stabilization plan, the real effective exchange rate and the bilateral real exchange rate Brazil-Paraguay were tested and discarded
57. All variables, expressed in logarithms, were stationary. The endogeneity of the cigarette real price variable was also tested and rejected.
58. More precisely, author´s estimates account for steady-state estimates instead of long-run estimates.

measures were significant. Iglesias *et al*., (2007) obtained similar results in a sample expansion to the 1991-2005 timeframe. Results were slightly different, with price elasticities of -0.27 for the short term and -0.48 for the long term, keeping income measures´ insignificance.

Lastly, Lampreia *et al*., (2015) also analyzed price and income elasticities[59] in the spirit of directing public tobacco control policies and providing a consumer profile. These authors used the database of *Pesquisa Especial do Tabagismo* (PetAb), the Brazilian version of GATS, and related tobacco consumption to socioeconomic and demographic factors such as education, age, gender, race and occupational status, all georeferenced (macro region and urban/rural).

Analyzing a random sample of 39,425 households and limiting discussion to manufactured cigarettes, the authors established price and income elasticities through Tobit models – therefore, measuring changes in the probability of cigarette consumption. Their estimates showed that a 10% price increase leads to a 0.5% decrease in the probability of consuming cigarettes, while a 10% income increase leads to a 0.36% decrease in the same probability.

This paper focused on searching for long run relationships between (legal) cigarette consumption and its determinants, foremost cigarette prices and per capita income, through cointegration techniques. This concept was first proposed by Engle and Granger (1987) and consists on finding a long run equilibrium between non-stationary variables as a linear combination of them.

This research used the legal per capita consumption of cigarettes in Brazil as a dependent variable, defined as the national production plus net imports. The Ministry of Industry, Foreign Trade and Services (MDIC) publishes data on external trade of cigarettes on a monthly basis, and production data are released by the Federal Revenue Office (SRFB) on an annual basis from 2000 to 2011 and on a monthly basis from December 2011 onwards. To generate per the capita series, legal consumption was divided by the working age population, which is defined as those aged between 15 and 64[60].

In order to construct a monthly series for the whole sample considered, it was necessary to devise a strategy to "standardize" the information for the "annual release" period. For this, we used the series of tax collection based on the "Tax on Industrialized Products - IPI" in order to construct a monthly series of implicit volumes of cigarettes, and then applied its monthly pattern into the official (annual) series by SRFB. [61]

59. In the study, we can also find the price and income elasticities of participation (the individual's decision to smoke or not), calculated with a non-linear probability model (probit). The authors also used linear regressions by least squares (OLS) to cross-check their results.

60. The data on working age population was extracted from the Continuous National Household Sample Survey (Continuous PNAD) for the period starting in 2012 onwards. For periods prior to 2012, we used the retropolated series constructed by the Brazilian Institute of Economics of the Getulio Vargas Foundation (IBRE/FGV), according to the methodology introduced by Ottoni and Barreira (2016).

61. Tax-implied series had several spikes related to legislation revamps (either taxes or minimum prices), representing reactions from both the industry and distributors – as dates were previously known, these agents had the incentive to stockpile at lower prices and then sell afterwards. As the main goal was to obtain cigarettes consumption series, these shocks were measured and distributed during the following months using these two different hypothesis.

Depending on hypothesis used, two alternative dependent variables were created: one distributing spikes on tax implied[28] series in exponential fashion up until the next shock (base dependent variable implicit per capita consumption of legal cigarettes) and the other one distributing spikes on the following four months to the shock (alternative dependent variable implicit per capita consumption of legal cigarettes[62]).

As explanatory variables, this study used the following information: (i) real overall earnings; (ii) real disposable overall earnings; (iii) real cigarette prices; and (iv) consumer confidence. Besides these, the other following variables were tested but did not arrive at satisfactory results: (v) Brazilian Economic Activity Index (IBC-Br);

(vi) monthly growth of FGV´s GDP Monitor; (vii) credit non-earmarked operations to households; and (viii) the unemployment rate.

On income, overall earnings (*massa salarial ampliada*) is defined by the Central Bank of Brazil as an aggregate that incorporates overall labor income, security benefits and receipts from welfare/social programs of the Government. The main difference of overall disposable earnings (*massa salarial ampliada disponível*) is that it excludes the burden of taxes and social security contributions from overall earnings. The latter relates more clearly to the actual income available for consumption and, therefore, represents the base variable. The former will be the alternative income variable.

On prices, real cigarette prices represent the relation between cigarette prices on the CPI and the whole CPI basket. Clearly, cigarette prices increased by far more than the consumption basket throughout the sample considered, therefore leading to real price increases. Further deterministic controls related to prices were minimum prices per pack and specific IPI values used in alternative model specifications.

The Brazilian Institute of Economics of the Getulio Vargas Foundation (IBRE/FGV) monthly Consumer Confidence Survey is designed to capture consumer sentiment about the general state of economy and their personal finances. Happy and optimistic consumers are likely to spend more, while unhappy and pessimistic consumers tend to spend less. Thus, it operates to induce or reduce economic growth and works properly as a cycle variable.

In order to enhance statistical power of cointegration tests and estimates, monthly data (from January 2000 to August 2018) has been used instead of quarterly data – the latter would imply in a very short analytical sample, lacking degrees of freedom and leading to potentially unstable results.

As previously said, monthly data was chosen due to samples constraints if using quarterly data. Nonetheless, even data on this frequency did not lead to particularly big sample, and therefore some "small sample" econometric challenges are still present and have to be tackled on a multistep econometric approach.

The table below outlines the full set of variables tested in the econometric models, highlighting their source and available sample.

62. For a discussion on implicit per capita consumption of legal cigarettes please check Appendix 2.

Table 14: **Variables tested (group, source and available sample)**

Variable	Group		Source		Available sample
Implicit per capita consumption	Consumption		SRFB and own calculations		jan00 - aug18
Implicit per capita consumption*	Consumption		SRFB and own calculations		jan00 - aug18
Real cigarette prices	Prices		IBGE and own calculations		jan00 - sep18
Real usual per capita income	Income		IBGE (2012 onwards) and FGV (2000-2012)		jan00 - jul18
Real effective per capita income	Income		IBGE (2012 onwards) and FGV (2000-2012)		jan00 - jul18
Real per capita disposable earnings	Income		Central Bank of Brazil and IBGE		mar04-jul18
Real per capita earnings	Income		Central Bank of Brazil and IBGE		mar04-jul18
Consumer confidence	Cycle		FGV		sep05-sep18
IBC-Br	Cycle		Central Bank of Brazil		jan03-aug18
GDP Monitor (YoY)	Cycle		FGV		dec01-jul18
Real consumer credit (flows)	Cycle		Central Bank of Brazil and IBGE		jun00-aug18
Unemployment rate	Cycle		IBGE (2012 onwards) and FGV (2000-2012)		jan00 - jul18
Minimum price per pack	Deterministic		SRFB		jan00 - sep18
IPI *specific component*	Deterministic		SRFB		jan00 - sep18
Effective average IPI tax	Deterministic		SRFB and own calculations		jan00 - sep18

Underlined variables are the ones that led to better econometric specifications, including the base model and its robustness checks. Models with cycle control had an adjusted monthly sample starting from the final quarter of 2005 (consumer confidence) or from the first quarter of 2004 (unemployment), the latter constrained by income variables. Obviously, models without cycle control had the same data span.

4.2.3 Estimation strategy

As a first step, all variables were tested for the presence of unit roots. It is known that, under small samples, unit root tests lack power and potentially lead to poor results. Because of that, three different types of unit root tests were used. First, "canonical" Phillips & Perron (PP, 1988) and Augmented Dickey & Fuller (ADF, 1979) tests were. Whenever these tests led to different conclusions, Kwiatkowski, Phillips, Schmidt & Shin (KPSS, 1992) unit root test was used and its results were taken as conclusive. To enhance statistical power, 5% confidence levels were the highest allowed. All variables were non-stationary of order 1 (i.e. their processes were I(1)).

Table 15: **Unit root tests (full sample)**

Variable	ADF		PP		KPSS	
Implicit per capita consumption	-2.832		-9.714	***	0.424	***
Δ (implicit per capita consumption)	-14.478	***			0.066	
Implicit per capita consumption*	0.063		-9.708	***	0.444	***
Δ (implicit per capita consumption*)	-10.941	***			0.070	
Cigarette real prices	-3.288		-2.964			
Δ (cigarette real prices)	-11.827	***	-11.508	***		
Real per capita disposable earnings	-1.599		-1.567			
Δ (real per capita disposable earnings)	-11.211	***	-12.915	***		
Real per capita earnings	-1.799		-1.650			
Δ (real per capita earnings)	-10.873	***	-11.829	***		
Consumer confidence	-1.093		-1.422			
Δ (consumer confidence)	-10.749	***	-10.852	***		
***** significant at 1%**						
**** significant at 5%**						
Sample (adjusted): 2000.M1 to 2018.M9						
ADF and PP: null hypothesis of unit root. KPSS: null hypothesis of stationarity						
ADF with MacKinnon one-sided p-values. PP and KPSS with Bartlett kernel and Newey-West automatic bandwidth selection criteria						

Table 16: **Number of cointegrating relations by Johansen procedure (full sample)**

	Variables		Intercept / no deterministic trend in data		Intercept / linear deterministic trend in data
Base models					
A	**Implicit per capita consumption + cigarette real prices + real per capita disposable earnings + consumer confidence**		2		1
B	**Implicit per capita consumption + cigarette real prices + real per capita disposable earnings**		1		0
Robustness checks					
C	**Implicit per capita consumption* + cigarette real prices + real per capita disposable earnings + consumer confidence**		1		1
D	**Implicit per capita consumption* + cigarette real prices + real per capita disposable earnings**		1		0
E	**Implicit per capita consumption + cigarette real prices + real per capita earnings + consumer confidence**		2		1
F	**Implicit per capita consumption + cigarette real prices + real per capita earnings**		1		0
G	**Implicit per capita consumption* + cigarette real prices + real per capita earnings + consumer confidence**		1		1
H	**Implicit per capita consumption* + cigarette real prices + real per capita earnings**		1		0

Selected 5% confidence number of cointegrating relations by model. 169 observations, with lag interval from 1 to 4. Critical values based on MacKinnon-Haug-Michelis (1999).

The second step was to discover the number of cointegrating relations.[63] This analysis used two different approaches. As a cursory look, Johansen test results were presented only for the max-eigenvalue statistic[64] and accounted for intercept in the cointegrating equation, but either no trend or linear deterministic trend in data.[65]

63. The literature provides several ways to estimate and identify them, generally testing restrictions over the cointegration space of vector error correction models as in the benchmark Johansen (1995) procedure. It is important to highlight that this procedure is highly unstable, demanding significant sample for multiple equations and with results that could change not only given different exogenous hypothesis (intercept, linear deterministic trend or quadratic deterministic trend in data) but also within the same exogenous hypothesis – trace and max-eigenvalues statistics could lead to different number of cointegrating relations.

64. Enders (1995).

65. Visual inspection of each variable and exogenous (intercept and trend) used on unit root tests suggest that all vectors should account for an intercept, but it is unclear if linear deterministic trend is present in the data. Therefore, the two specifications were tested.

Two types of X_t non-stationary vectors were tested, one with consumption/price/income/cycle variables (therefore allowing for, at most, 3 cointegrating relations) and other one dropping the cycle variable (therefore allowing for, at most, 2 cointegrating relations). Results at 5% confidence level were somewhat dubious, suggesting from two to no cointegrating relations depending on the vector of non-stationary variables and its test specifications.

Given such instability, we also implemented the simpler and more robust (especially in small samples) EngleGranger (1987) procedure, which gave one long run relationship (and related error correction term) for each model, accounting for all I(1) variables, as all residual terms were stationary.

The third step was to estimate the long run cointegrating relations. Following Stock and Watson (1993), this was done through *Dynamic Ordinary Least Squares* (DOLS) in order to induce well behaved residuals (for a discussion on DOLS estimation, please see Appendix 3). Following cointegration, the final step was to obtain short run relations by usual OLS estimation of a simple equation error correction model. Inference of estimated coefficients, both in long run DOLS and short run OLS error correction, was enhanced by using heteroskedasticity and autocorrelation (HAC) consistent covariances of Newey-West.

In this section, the goal is to estimate the demand curve for (legal) cigarette consumption in Brazil in the 2000-2018 period. It should also be noted that during this period several macroeconomic jitters (with the Global Financial Crisis in 2008/2009 and the Brazilian economic downturn beginning in 2012, leading to a recession from 2014 to 2016) that could have affected the consumption decision.

Furthermore, important tobacco control policies (such as advertisement restrictions) were implemented throughout the sample, which complemented tax increases (both specific and ad valorem) and minimum cigarette prices.

Therefore, this estimation of cigarette demand´s price and income elasticities controls for "cycle controls" (i.e., accounting for the macroeconomic effects affecting the consumption decision) and "policy controls" (i.e., accounting for the tobacco control policies implemented in the sample). Ideally, the illegal cigarette market should also be accounted for in order to control for the substitution effect, something especially true in tougher economic periods and with stricter tobacco control policies. However, there is no such metric available. As a result, price and income elasticities will be most likely magnified, showing bigger responses in the legal cigarette market.

Going beyond econometric steps, all the variables considered in the model were in logs and were rebased to the same point in time (2012=100). Furthermore, all variables were seasonally adjusted before being used in the model, allowing different seasonal patterns between the original variables and "saving" degrees of freedom on the DOLS estimation.

At last, this paper evaluated if the explanatory variables (income, price and

cycle controls) Granger caused legal cigarette consumption – i.e., if the contemporaneous and lagged values of explanatory variables were relevant for consumer´s decisions.[66]

We estimated every model using explanatory variables with lags from 0 to 3 (i.e., Granger causality would happen within the same quarter), choosing the best combination of lags due to informational statistics such as adjusted R^2, sum of squared residuals and evidence of well-behaved residuals by Durbin-Watson[67]. In conclusion, final model specifications for both the long run and the short run had the general forms as below.

$$Y = \beta_0 + \beta_1 \varphi + \beta_2 X_{-i}^{i=0\ to\ 3} + \alpha \Delta X_{-i}^{i=0\ to\ 3} + \sum_{j=1}^{n} \sigma_j \Delta X_{-i}^{i=0\ to\ 3}{}_{-j} + \sum_{j=1}^{n} \gamma_j \Delta X_{-i}^{i=0\ to\ 3}{}_{j} + \varepsilon \quad (11)$$

$$\Delta Y = \theta_0 + \theta_1 \omega + \theta_2 \Delta X_{-i}^{i=0\ to\ 3} + \tau EC_{-1} + \mu \quad (12)$$

Where

Y is a non-stationary I(1) variable

φ is a vector of long run deterministic regressors

X is a vector of non-stationary I(1) variables, including price, income and cycle metrics.

ε is the long run residual,

ω is a vector of short run deterministic regressors

EC is the error correction term derived from the long run relation

μ is the short run residual.

4.3 Results

This section summarizes the results for price and income elasticities of (legal) cigarette consumption in Brazil, explicitly accounting for innovations in terms of macroeconomic conditions and tobacco control policies. The results presented show the estimation for the full sample (2000-2018) considering **implicit per capita consumption** as a proxy of consumption and per capita disposable earnings as a proxy of income (for a full discussion of alternative variables for consumption and income, as well for different sample in order to account for the impact of the recession on the demand, check Appendix 2). Table 8 presents long run results of the six alternative models related to the dependent variable **implicit per capita consumption**. They differ basically on their explanatory variables, controlling for cycle (equations 1 to 3) or not (equations 4 to 6) and using different sets of deterministic variables and dummies. Accordingly, their best lag structure varies and is also presented below.

66. Using lagged consumption as an explanatory variable was not necessary in the models inspired by Granger causality of the explanatory variables.
67. If lagged explanatory variables are the sole survivors in model selection, then potential problems of endogeneity or simultaneity would be trivially solved – avoiding the use of instrumental techniques such as Two-Stage Least Squares (2SLS) or Instrumental Variables (IV).

Table 17: **Long run results (full sample, base models)**

Dependent variable: log

(implicit per capita consumption)

	(1)		(2)		(3)		(4)		(5)		(6)	
log (cigarette real prices)	-0.532	**	-0.515	**	-0.740	**	-0.558	*	-0.509	**	-0.706	**
log (per capita disposable earnings)	-0.660		-0.605		0.169		-0.358		-0.509		1.301	***
log (consumer confidence)	0.499	***	0.282	**	0.559	***						
Lag structure	(2,3,2)		(3,3,1)		(2,2,2)		(3,3)		(3,3)		(2,0)	
Deterministics												
C	7.809	***	8.464	***	4.622	***	8.833	***	9.293	***	1.783	
Minimum prices	-0.039	**	-0.043	***			-0.067	***	-0.055	***		
Dummy may/09	-0.643	***	-0.681	***			-0.738	***	-0.727	***		
log (IPI specific component)					-0.341	*					-0.801	***
Dummy jan16-feb/16	0.328	***					0.322	***				
Dummy 2016			-0.176	***					-0.239	***		
Adjusted R-Squared	0.902		0.904		0.869		0.893		0.910		0.862	
Sum squared residuals	1.461		1.451		1.942		1.928		1.627		2.511	
Durbin-Watson	1.507		1.790		1.667		1.173		1.664		1.381	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

All equations confirm that explanatory variables Granger-cause legal cigarette consumption, therefore tautologically solving issues on endogeneity and simultaneity. The price elasticity of taxed cigarette demand ranged from -0.5 from -0.75, always being statistically significant (usually at 5% confidence level).

All models were found to be inelastic in the long run, with the average price elasticity of -0.59 being higher than the usual estimate for LMICs[68] and the (scarce) previous results of the Brazilian literature. The illegal cigarette market most likely plays a role, as consumers tend to be more price sensitive in their (legal) consumption decisions.

Income elasticities were broadly found to be statistically insignificant and usually did not have the expected signal – it is important to realize that, throughout the sample, legal consumption has decreased while income has increased (despite the economic downturn).

68. As shown in US Nacional Cancer Institute and World Health Organization (2016) and Kennedy *et al*. (2015).

Table 18: **Short run results (full sample, base models)**

Dependent variable: dlog
(implicit per capita consumption)

	(1)		(2)		(3)		(4)		(5)		(6)	
dlog (cigarette real prices)	-0.050		-0.168		0.161		-0.159		-0.166		0.203	
dlog (per capita disposable earnings)	1.775	**	1.486	**	-1.037	*	1.795	**	1.260	*	-0.201	
dlog (consumer confidence)	-0.147		-0.533		0.287							
EC(-1)	-0.778	***	-0.911	***	-0.684	***	-0.609	***	-0.837	***	-0.542	***
Lag structure	(2,3,2)		(3,3,1)		(2,2,2)		(3,3)		(3,3)		(2,0)	
Deterministics												
C	-0.009		-0.008		-0.005		-0.008		-0.006		-0.006	
d(Minimum prices)	0.006		0.022				-0.003		0.016			
Dummy may09-jun09	0.749	***	0.750		0.628	***	0.772	***	0.775	***	0.682	***
dlog (IPI ad rem)					0.219						0.225	
Dummy jan16-feb16	0.507	***			0.373	***	0.494	***			0.388	***
Dummy 2016			-0.002						-0.022			
Adjusted R-Squared	0.623		0.602		0.622		0.577		0.573		0.571	
Sum squared residuals	1.397		1.477		1.402		1.613		1.629		1.645	
Durbin-Watson	2.308		2.138		2.340		2.343		2.196		2.374	

*** significant at 1%
** significant at 5%
* significant at 10%

Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, NeweyWest automatic bandwidth, NW automatic lag length)

Cycle controls were found to be statistically significant, with expected signal (improving economic conditions would lead to higher legal cigarette consumption) and, much more important, clearly improved the overall statistical estimation. Last, but not least, deterministic controls were found to be statistically significant and had the expected signals.

All residuals from models (1) to (6) were stationary, therefore confirming cointegration and allowing short-term dynamics discussions. Table 9 presents short run results for the same six specifications: the same structure observed in long run equations (in terms of explanatory variables, deterministic variables, dummies and best lag structure) applies. The variable is the

error correction term for each, measuring the speed of adjustment from short run to long run equilibrium.

Prices were statistically insignificant for short term legal consumption decisions, contrary to that observed in long run equations, irrespective of the way they were dealt (changes on cigarette real prices, on minimum prices or with specific taxes).[69] This is a sensible result – consumption of addictive products tends to be somewhat inertial, in a way that changing regular patterns takes time (e.g., substitution for cheaper legal brands, substitution for illicit brands, or smoke cessation).[70]

Furthermore, and once again against long run findings, income elasticities were found to be significant in four specifications ((1), (2), (4) and (5), generally at 5% confidence level) and, even more important, showing positive elasticities and elastic behavior - 1% increase in income led, on average of those four specifications, to a 1.58% increase in legal cigarette consumption. Cycle controls were also statistically insignificant. Last, but not least, error correction terms suggested a very strong convergence towards long run equilibrium: a bit more of 70% of the dynamics took place on just one time period.

Robustness checks were implemented both in terms of variables (changing the dependent variable and the explanatory income variable) and samples (cropping the sample to the 2000-2015 period).[71]

Long run results did hold: Average price elasticity ranged from -0.55 to -0.65 depending on model specification and sample considered, and price-related institutional efforts, such as excise taxes and minimum prices, were always significant. Income seemed to be mostly insignificant to long run (legal) tobacco consumption decisions, mimicking broad results of the literature.

Short run results lacked robustness, either on prices (in terms of alternative models and samples, also remembering that the procedure of inventory distribution could also play a role) or income. At last, the speed of adjustment towards the long run equilibrium did hold, being always very quick.

69. Coefficient signals also varied wildly
70. The procedure to dilute stockpiling in the industry could also play a role. Therefore, these conclusions have to carefully dealt with.
71. All results are available at the background paper "Activity 4: Updating price and income elasticities in Brazil

Table 19: **Summary of long run price elasticity results**

	1	2	3	4	5	6	Min	Average	Max
Long run results (full sample, base models)	-0.532	-0.515	-0.74	-0.558	-0.509	-0.706	-0.740	-0.593	-0.509
Long run results (full sample, alternative dependent variable)	-0.571	-0.529	-0.652	-0.461			-0.652	-0.553	-0.461
Long run results (full sample, alternative income explanatory variable)	-0.554	-0.535	-0.759	-0.601	-0.534	-0.691	-0.759	-0.612	-0.534
Long run results (full sample, alternative dependent and income explanatory variables)	-0.58	-0.556	-0.716	-0.445			-0.716	-0.574	-0.445
Long run results (small sample, base models)	-0.485	-0.865	-0.515	-0.741			-0.865	-0.652	-0.485
Long run results (small sample, alternative dependent variable)	-0.479	-0.892	-0.494	-0.725			-0.892	-0.648	-0.479
Long run results (small sample, alternative income explanatory variable)	-0.487	-0.871	-0.517	-0.725			-0.871	-0.650	-0.487
Long run results (small sample, alternative dependent and income explanatory variables)	-0.476	-0.784	-0.443	-0.706			-0.784	-0.602	-0.443

4.4 Closing remarks

The estimation of price and income elasticities is an essential element of tobacco control policy making and evaluation – not only for measuring previous and current results, but also for design to deliver the desirable outcomes of even lower tobacco consumption in the future and timely tracking (and forecasting) of tobacco related tax revenues by the government.

Our estimates show that prices negatively affect (legal) tobacco consumption in the long run. Price elasticity ranged from -0.55 to -0.65 depending on model specification and sample considered, being higher than the average estimate for LMICs and the (scarce) previous results of the Brazilian literature. The illegal cigarette market most likely plays a role, as consumers tend to be more price sensitive in their (legal) consumption decisions. Price-related institutional efforts, such as excise taxes and minimum prices, were also significant. On the other hand, income seemed to be mostly insignificant to long run (legal) tobacco consumption decision, mimicking broad results found in the literature.

Results were very different in the short run, showing that prices were irrelevant for (legal) consumption decisions. At first, this seems to be a sensible result (changing consumption patterns of addictive products

should take time), yet lacking robustness (in terms of alternative models and samples, also remembering that the procedure of inventory distribution could also play a role). Furthermore, higher income apparently had a very strong impact on legal consumption, but results also lacked robustness.

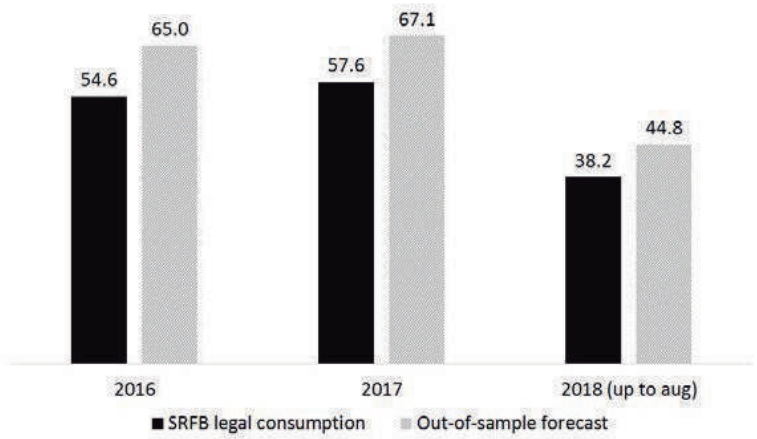
Overall, our estimates support tobacco control policies implemented in Brazil: increases in cigarette real prices and the strengthening of tobacco control policies has the desirable effect of curbing smoking prevalence and cigarette consumption.

The catch is that these results apply solely to legal cigarettes. The presence of illicit trade jeopardizes public health efforts, undermines the government´s ability to fight the tobacco epidemic in the country and handicaps policy evaluation as, by rule, the total consumption of cigarettes is unknown (only taxed cigarettes are accounted for).

The inelastic nature of price elasticities suggests that further price increases will have a less than proportional effect on volumes, therefore will increase the tobacco tax revenues. Nonetheless, simulations based on our (short sample) models suggest that taxed cigarette consumption should have been approximately 10bi stick/per year higher over the last three years (from 2016 to 2018, the latter annualized).

This gap potentially relates to tax evasion by domestic producers, further frustrating official efforts. Brazil is underachieving when it comes to tobacco tax revenues, which translates into less powerful public health initiatives (funded by tobacco taxes). Further steps are necessary in order to contain the consumption spillover to illicit cigarettes and to curb tax evasion.

Figure 9: **Official legal consumption vs. out-of sample model forecast (billions of sticks)**



Source: SRFB and own calculations.

5. Policy recommendations

Tobacco tax increases are the most effective and cost-effective tool to reduce tobacco consumption. A better control on illicit trade and evasion will enhance the effectiveness of tax increases in terms of health and revenue collection. Coordination between the government, independent researchers and civil society actors is key to enhance market knowledge, focus tobacco control policies and strengthen government interventions to curb the tobacco epidemic in Brazil. Our main policy recommendations are outlined below:

- **Improve potential cigarette production estimates in Brazil**: Cross check IBGE surveys in order to confirm raw tobacco production figures and create ways to evaluate potential production by other inputs than tobacco leaf.

- **Focus on the cellulose acetate tow and raw tobacco supply in Brazil:** Create track-and tracing mechanisms for cigarette inputs, including acetate tow and raw tobacco production, imports and sales, expanding SRFB SCORPIOS system. Acetate tow is particularly interesting because just a handful of companies dominate its global supply.

- **Impose a Tobin-tax on cigarette inputs:** A small tax rate levied in every step of the production chain would help tracing the tobacco flow from farmers to final products.

- **Increase surveillance on the Paraguayan border:** Besides focusing of illicit cigarette flows from Paraguay to Brazil, Federal Police operations should also focus on illicit raw inputs flows from Brazil to Paraguay.

- **Enhance the understanding of the Paraguay/Brazil cigarette production chain:** Trace the actors involved, scope bilateral flows of inputs and outputs and confirm potential changes on Brazilian illicit production structure with the emergence of actors specialized in "fakes" of best-selling brands that run their production-chains almost entirely "in the shadows".

- **Strengthen law enforcement on illicit activities:** Not only illicit trading but also illegal production and tax evasion.

- **Continue to increase real cigarette prices through increases in taxes and minimum prices.** The government should also consider strategies to reduce stockpiling and other tactics to anticipate tax increases anticipated by the actors involved in production-retail-consumption).

- **Create retail control mechanisms on top of enhancing production control mechanisms:** An example would be to demand personal identification when buying cigarettes, as done with restricted drugs such as antibiotics.

Brazil has been a successful case on tobacco control, adopting effective control policies and programs. Increases in cigarette taxes and prices have contributed to reductions in prevalence and tobacco-related deaths, diseases and economic costs. Strengthening cigarette tax administration will enhance the effectiveness of future price increases, both in terms of their effects in smoking reduction and in recouping revenues lost to tax evasion.

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Appendices

Appendix 1: Excessive supply estimates for Brazil and Paraguay

This Appendix will focus on the "technical requirement approach" to scope the potential excessive supply of cigarettes in both Brazil and Paraguay, updating previous estimates by incorporating new available data (such as the bilateral trade) and new hypotheses (for instance, Paraguayan total consumption) present in the literature.

In order to allow direct comparisons with the literature, tobacco will be used as the sole input for supply estimates (recognizing, however, that the trade pattern disclosed on this research report strongly suggests the use of other inputs to crosscheck results – an effort for future research).

For Brazil, using the (reasonable) assumption that legal consumption is made of legal cigarettes (either legally produced domestically or legally net imported), them the legal production variable could be used in order to scope the potential excessive supply as in:

$$DCC = LCP - XC + MC \qquad \text{(a.1)}$$

Applying (a.1) to (5) and (6);

$$ECS_{BR} = PCS_{BR} - (LCP_{BR} - XC_{BR} + MC_{BR})$$

$$ECS_{BR} = PCP_{BR} - XC_{BR} + MC_{BR} - LCP_{BR} + XC_{BR} - MC_{BR}$$

$$ECS_{BR} = PCP_{BR} - LCP_{BR} \qquad \text{(a.2)}$$

Where:

ECS_{br} is the potential excessive cigarette supply in Brazil (sticks);

PCS_{br} is the potential cigarette supply in Brazil (sticks);

XC_{br} are (legal) cigarette exports from Brazil (kg, converted to sticks);

MC_{br} are (legal) cigarette imports of Brazil (kg, converted to sticks);

PCP_{br} is the potential cigarette production in Brazil (sticks);

LCP_{br} is the domestic (legal) production of cigarettes (sticks) from SRFB;

Alternatively, and remembering that net imports are basically irrelevant when compared to legal production, SRFB production figures (LCP_{br}) could be directly interpreted as a sufficiently good proxy for the domestic legal consumption of cigarettes in Brazil (DCC_{br}) Therefore,

$$ECS^{*}_{BR} = PCS_{BR} - LCP_{BR} \qquad \text{(a.3)}$$

Where:

ECS^{*}_{br} is the alternative potential excessive cigarette supply in Brazil (sticks);

PCS_{br} is the potential cigarette supply in Brazil (sticks);

LCP_{br} is the domestic (legal) production of cigarettes (sticks) from SRFB, in this exercise matching the domestic legal consumption of cigarettes DCC_{br} in Brazil (sticks)

Table A.1 presents results for both excessive supply gauges, highlighting

intermediate estimates for the potential cigarette production (PCP_{br}) and potential cigarette supply (PCS_{br}), coupled with data for net imports ($^{XC}_{br}$ and $^{MC}_{br}$) and domestic legal production (LCP_{br}).[72]

Average potential excessive supply figures hovered around 150bi cigarettes/ year for the period 2000-2017, rising from an average between 85bi-90bi/year in the period 2000-2009 to around 225bi/year between 2010 and 2017.

On the positive side, these numbers correlate with the rising penetration of counterfeit products in Brazil, matching the trend observed by Iglesias *et al.* (2017), Paes (2017) and Szklo *et al.* (2018). On the negative side, they are very volatile - something also observable in the appendix of Biz (2010) - and, at first, are pretty higher than the ones from other researchers.

Table A.1: **Potential excessive cigarette supply in Brazil (2000-2017, millions of sticks)**

	Inputs			Intermediate steps		Excessive supply estimations	
	XC	MC	LCP	PCP	PCS	ECS	ECS*
2000	842	55	97 358	210 904	210 116	113 545	112 758
2001	521	41	106 924	94 328	93 849	-12 596	-13 076
2002	1 657	41	102 211	177 808	176 193	75 597	73 982
2003	2 614	42	107 061	158 203	155 631	51 142	48 570
2004	2 871	48	110 801	318 027	315 204	207 227	204 403
2005	2 808	65	112 289	235 320	232 577	123 031	120 288
2006	3 852	84	112 068	306 969	303 200	194 901	191 133
2007	5 197	115	114 032	173 170	168 088	59 138	54 056
2008	3 671	49	108 206	122 145	118 523	13 939	10 317
2009	1 931	23	98 513	164 889	162 981	66 376	64 468
2010	344	60	97 201	271 411	271 127	174 210	173 926
2011	247	10	97 576	424 805	424 567	327 229	326 991
2012	161	545	89 112	137 690	138 074	48 579	48 962
2013	772	321	76 545	206 554	206 103	130 010	129 558
2014	359	218	72 704	395 644	395 504	322 940	322 800
2015	263	581	63 206	358 070	358 388	294 864	295 182
2016	228	1 555	53 209	192 027	193 354	138 818	140 145
2017	1 662	0	57 107	431 015	429 353	373 908	372 246
Av. 2000-2009	2 596	56	106 946	196 176	193 636	89 230	86 690
Av. 2010-2017	505	411	75 833	302 152	302 059	226 320	226 226
Av. 2000-2017	1 667	214	93 118	243 277	241 824	150 159	148 706

Source: Author´s calculations

72. Table A.1 (Appendix 1) shows the entire structure of inputs and estimations.

A more detailed look, however, shows that different technical transformation requirements, data sources and samples explain a humongous part of the differences.

As shown in table A.2, potential excessive supply numbers almost match Iglesias *et al* (2012) when using their same tobacco per unit (*tpu*) and tobacco transformation (*ttr*) technical requirements: our numbers would decrease to around 60bi cigarettes/year in the period 2000-2009, broadly comparable with their estimate of 55bi cigarettes/year for the same period. As previously said, results are very sensitive to the chose hypothesis.

Table A.2: **Potential excessive cigarette supply in Brazil - comparison with Iglesias et al (2012)**

	Original estimation		Iglesias et al (2012) technicals	
	ttr = 80% / tpu = 0.7		ttr = 81% / tpu = 0.83	
	ECS	ECS*	ECS	ECS*
2000	113 545	112 758	83 856	83 069
2001	-12 596	-13 076	-24 659	-25 139
2002	75 597	73 982	51 343	49 728
2003	51 142	48 570	29 735	27 162
2004	207 227	204 403	162 875	160 051
2005	123 031	120 288	90 992	88 250
2006	194 901	191 133	152 477	148 708
2007	59 138	54 056	36 400	31 318
2008	13 939	10 317	-1 221	-4 843
2009	66 376	64 468	44 554	42 646
2010	174 210	173 926	136 146	135 862
2011	327 229	326 991	266 758	266 521
2012	48 579	48 962	30 863	31 246
2013	130 010	129 558	102 438	101 986
2014	322 940	322 800	266 991	266 850
2015	294 864	295 182	244 674	244 992
2016	138 818	140 145	112 672	114 000
2017	373 908	372 246	312 650	310 989
Av. 2000-2009	89 230	86 690	62 635	60 095
Av. 2010-2017	226 320	226 226	184 149	184 056
Av. 2000-2017	150 159	148 706	116 641	115 189

Source: Author´s calculations

For Paraguay, having Ng *et al* (2014) information about consumption (with proper data manipulation) would, at first, allow the direct use of equation (6) as the potential excessive supply gauge.

Nonetheless, there is a small twist first observed by Ramos (2009): if domestic consumption accounts for both legal and illegal goods, then the difference between potential cigarette supply and consumption would not be the excessive supply gauge – yet, the amount of cigarettes that would be available for excessive international sales.

Therefore, equation (6) should be interpreted and re-written in a slightly different manner:

$$ETC_{PY} = PCS_{PY} - DC_{PY} \qquad \text{(a.4)}$$

Where:

ETC_{py} is the potential amount of cigarettes available for excessive international trade in Paraguay (sticks);

PCS_{py} is the potential cigarette supply in Paraguay (sticks);

DC_{py} is the domestic consumption (legal + illegal) of cigarettes in Paraguay (sticks); Table 7 presents results for Paraguayan cigarettes from 2000 to 2017. Keeping consistency with the exercise for Brazil, intermediate estimates for the potential cigarette production (PCP_{py}) and potential cigarette supply (PCS_{py}) are provided, coupled with data for net imports (XC_{py} and MC_{py}) and domestic consumption (DC_{py}).[73]

Average available cigarettes amounted to 44 billion/year for the whole sample, rising from 40 billion/year in the period 20002009 to 48 billion/year between 2010 and 2017. Estimates were surprisingly much less volatile than in the Brazilian case, remembering that they do not measure the precise same thing, yet also showing an (gentle) upward trend across the sample.

As a final remark, once again estimates appear to be very different from the ones previously observed in the literature. Ramos (2009) estimated that the amount of cigarettes available was of about 65 billion cigarettes in 2007 – almost doubling our 38 billion estimate. As his technical requirements are unknown, it is impossible to "reverse engineer" Ramos´ numbers.

73. Table A.2 (Appendix 1) shows the entire structure of inputs and estimations.

Table A.3: **Potential excessive international trade of cigarettes from Paraguay (2000-2017, millions of sticks)**

	Inputs			Intermediate steps		Excessive trade estimation
	XC	MC	DC	PCP	PCS	ETC
2000	3 740	10 321	3 518	31 475	38 056	34 538
2001	3 841	6 132	3 567	40 543	42 834	39 267
2002	2 909	4 860	3 614	31 773	33 724	30 110
2003	3 222	3 882	3 662	39 980	40 640	36 978
2004	2 829	4 525	3 706	49 754	51 451	47 745
2005	1 250	3 200	3 751	45 903	47 852	44 102
2006	1 457	3 787	3 795	43 817	46 146	42 351
2007	2 740	3 943	3 885	40 975	42 178	38 292
2008	2 611	2 548	3 980	48 947	48 885	44 906
2009	2 758	2 842	4 086	51 158	51 242	47 155
2010	3 964	2 773	4 194	62 625	61 434	57 240
2011	4 877	3 068	4 308	56 411	54 603	50 295
2012	6 586	2 554	4 431	54 588	50 557	46 126
2013	4 346	2 769	4 554	55 940	54 364	49 810
2014	2 572	2 808	4 677	55 651	55 886	51 209
2015	2 232	2 859	4 800	46 742	47 370	42 570
2016	2 294	2 552	4 923	47 126	47 384	42 461
2017	2 341	2 553	5 046	50 965	51 177	46 131
Av. 2000-2009	2 736	4 604	3 756	42 432	44 301	40 544
Av. 2010-2017	3 651	2 742	4 617	53 756	52 847	48 230
Av. 2000-2017	3 143	3 777	4 139	47 465	48 099	43 960

Source: Author´s calculations

Appendix 2: Full technical requirements disclosure

Table A.4: Potential excessive cigarette supply in Brazil (2000-2017, millions of sticks)

								ttr 80% tpu 0.7					ECS = PCP - LCP ECS* = PCS - LCP		
	Inputs - in tonnes							Outputs - in tonnes			Outputs - in millions of cigarettes		in millions cigarettes		
Year	QTraw	XTraw	MTraw	XTindustrial	MTindustrial	XC	MC	Traw	Tindustrial (DP)	Tindustrial	PCP	PCS	LCP	ECS	ECS*
2000	547 754	276 313	6 096	75 856	1 458	842	55	277 537	222 030	147 632	210 904	210 116	97 358	113 545	112 758
2001	544 954	326 772	6 818	116 548	2 578	521	41	225 000	180 000	66 030	94 328	93 849	106 924	-12 596	-13 076
2002	645 673	355 683	8 433	117 130	2 857	1 657	41	298 423	238 738	124 466	177 808	176 193	102 211	75 597	73 982
2003	632 654	360 567	7 744	114 363	1 240	2 614	42	279 831	223 865	110 742	158 203	155 631	107 061	51 142	48 570
2004	895 122	447 661	5 681	142 279	2 385	2 871	48	453 142	362 514	222 619	318 027	315 204	110 801	207 227	204 403
2005	862 763	467 723	4 925	159 073	3 825	2 808	65	399 965	319 972	164 724	235 320	232 577	112 289	123 031	120 288
2006	875 064	414 006	8 312	163 480	2 862	3 852	84	469 370	375 496	214 878	306 969	303 200	112 068	194 901	191 133
2007	885 747	532 808	11 001	172 102	2 169	5 197	115	363 940	291 152	121 219	173 170	168 088	114 032	59 138	54 056
2008	823 910	506 181	11 943	181 715	3 480	3 671	49	329 671	263 737	85 501	122 145	118 523	108 206	13 939	10 317
2009	837 473	518 436	13 305	154 337	3 886	1 931	23	332 343	265 874	115 423	164 889	162 981	98 513	66 376	64 468
2010	746 933	394 426	16 562	110 779	5 512	344	60	369 069	295 255	189 988	271 411	271 127	97 201	174 210	173 926
2011	931 176	434 932	7 184	110 293	4 915	247	10	503 428	402 742	297 363	424 805	424 567	97 576	327 229	326 991
2012	785 440	472 734	6 843	164 700	5 443	161	545	319 549	255 640	96 383	137 690	138 074	89 112	48 579	48 962
2013	836 317	446 857	7 312	179 589	6 760	772	321	396 771	317 417	144 588	206 554	206 103	76 545	130 010	129 558
2014	842 540	348 022	5 039	127 829	5 135	359	218	499 557	399 645	276 951	395 644	395 504	72 704	322 940	322 800
2015	855 524	371 146	4 785	145 340	4 658	263	581	489 163	391 330	250 649	358 070	358 388	63 206	294 864	295 182
2016	668 292	351 164	9 175	131 659	5 035	228	1 555	326 303	261 042	134 419	192 027	193 354	53 209	138 818	140 145
2017	854 836	341 869	5 860	118 685	5 334	1 662	0	518 827	415 061	301 711	431 015	429 353	57 107	373 908	372 246

	Inputs - in tonnes							Outputs - in tonnes			Outputs - in millions of cigarettes		in millions cigarettes		
Average	QTraw	XTraw	MTraw	XTindustrial	MTindustrial	XC	MC	Traw	Tindustrial (DP)	Tindustrial	PCP	PCS	LCP	ECS	ECS*
2000-2009	755 111	420 615	8 426	139 688	2 674	2 596	56	342 922	274 338	137 323	196 176	193 636	106 946	89 230	86 690
2010-2017	815 132	395 144	7 845	136 109	5 349	505	411	427 833	342 267	211 506	302 152	302 059	75 833	226 320	226 226
2000-2017	781 787	409 294	8 168	138 098	3 863	1 667	214	380 660	304 528	170 294	243 277	241 824	93 118	150 159	148 706

Source: COMTRADE, LSPA/IBGE and author´s estimates

Table A.5: **Potential excessive international trade of cigarettes from Paraguay (2000-2017, millions of sticks)**

ttr	80%
tpu	0.7

Year	Inputs - in tonnes							Outputs - in tonnes			Outputs - in millions of cigarettes		in millions cigarettes	
	QTraw	XTraw	MTraw	XTindustrial	MTindustrial	XC	MC	Traw	Tindustrial (DP)	Tindustrial	PCP	PCS	DC	ETC
2000	5 861	2 152	11 475	210	10 095	3 740	10 321	15 184	12 147	22 033	31 475	38 056	3 518	34 538
2001	6 623	2 912	16 485	360	12 584	3 841	6 132	20 196	16 156	28 380	40 543	42 834	3 567	39 267
2002	6 610	4 937	12 105	560	11 778	2 909	4 860	13 778	11 022	22 241	31 773	33 724	3 614	30 110
2003	6 257	4 061	13 436	648	16 128	3 222	3 882	15 632	12 506	27 986	39 980	40 640	3 662	36 978
2004	6 378	5 414	21 566	287	17 091	2 829	4 525	22 530	18 024	34 828	49 754	51 451	3 706	47 745
2005	5 590	3 203	20 687	165	13 838	1 250	3 200	23 074	18 459	32 132	45 903	47 852	3 751	44 102
2006	4 988	3 832	18 849	396	15 064	1 457	3 787	20 004	16 004	30 672	43 817	46 146	3 795	42 351
2007	4 587	4 528	20 874	516	12 452	2 740	3 943	20 933	16 747	28 683	40 975	42 178	3 885	38 292
2008	3 761	2 762	25 037	649	14 084	2 611	2 548	26 036	20 829	34 263	48 947	48 885	3 980	44 906
2009	5 688	3 926	22 616	753	17 060	2 758	2 842	24 378	19 503	35 810	51 158	51 242	4 086	47 155
2010	6 340	4 795	26 992	1 093	22 101	3 964	2 773	28 537	22 830	43 838	62 625	61 434	4 194	57 240
2011	6 441	4 858	24 758	887	19 302	4 877	3 068	26 341	21 073	39 488	56 411	54 603	4 308	50 295
2012	4 830	7 312	27 251	1 388	19 785	6 586	2 554	24 769	19 815	38 212	54 588	50 557	4 431	46 126
2013	5 375	6 534	26 261	1 829	20 905	4 346	2 769	25 102	20 082	39 158	55 940	54 364	4 554	49 810
2014	5 616	6 505	26 378	1 512	20 076	2 572	2 808	25 489	20 391	38 956	55 651	55 886	4 677	51 209
2015	5 883	5 643	22 514	1 119	15 635	2 232	2 859	22 754	18 204	32 720	46 742	47 370	4 800	42 570
2016	5 971	6 221	20 720	1 231	17 843	2 294	2 552	20 471	16 377	32 989	47 126	47 384	4 923	42 461
2017	6 400	4 958	25 645	1 398	15 404	2 341	2 553	27 087	21 670	35 676	50 965	51 177	5 046	46 131

Average	Inputs - in tonnes							Outputs - in tonnes			Outputs - in millions of cigarettes		in millions cigarettes	
	QTraw	XTraw	MTraw	XTindustrial	MTindustrial	XC	MC	Traw	Tindustrial (DP)	Tindustrial	PCP	PCS	DC	ETC
2000-2009	5 634	3 773	18 313	454	14 018	2 736	4 604	20 175	16 140	29 703	42 432	44 301	3 756	40 544
2010-2017	5 857	5 853	25 065	1 307	18 881	3 651	2 742	25 069	20 055	37 629	53 756	52 847	4 617	48 230
2000-2017	5 733	4 697	21 314	833	16 179	3 143	3 777	22 350	17 880	33 226	47 465	48 099	4 139	43 960

Source: COMTRADE, MAG and author´s estimates

Appendix 3: Methodology for implicit cigarette volume calculation

In Brazil, the variable consumption refers to industry production. This production can be either sold for retailers or stored by the industry, but the IPI tax collection occurs only when sold for retailers. Therefore, if inventories exist, the industry production could be different than the implicit production by IPI.

We were able to calculate the amount of cigarettes available to retailers from the IPI, as follows:

The first step, estimating the average price[74] (in thesis, average prices of cigarettes are the best proxy of the variable P). According to equation (1).

$$P_t^{\mu} = P_{t-1}^{\mu} \times \pi \quad (1)$$

Where:

P_t^{μ} is the average prices in monthly t;

P_{t-1}^{μ} is the average prices in monthly t-1;

π_t and is the inflation measured by consumer price index (CPI) of cigarettes.

The second step, consists of estimating the effective tax rate of average prices, weighted by package type (hard or soft packs). According to equation (2).

$$Al_t = Al_t^{ad\ valorem} \times P_t^{\mu} + \sum_{i=1}^{N} Al_{i,t}^{ad\ rem} \times W_{i,t} \quad (2)$$

Where:

Al_t is the effective tax rate (based upon average prices) in monthly t;

$Al_t^{ad\ valorem}$ is the nominal specific tax rate in monthly t;

$Al_{i,t}^{ad\ rem}$ is the nominal specific tax rate in monthly t for each package type i;

and $W_{i,t}$ is the market share of package type i in monthly t.

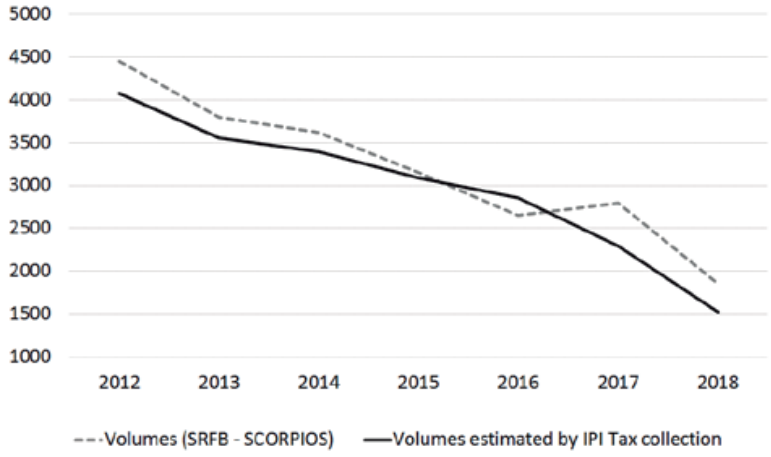
Now, we can estimate the quantity of the package type (packs or boxes) by IPI tax (Q_t^*). According to equation (3).

$$IPI_{t+1} = Q_t^* \times P_t^{\mu} \times Al_t \ \ \therefore \ Q_t^* = \frac{IPI_{t+1}}{P_t^{\mu} \times Al_t} \quad (3)$$

The graph below shows the results.

74. The average price series of cigarettes was estimated considering the starting point of the month of September 1999 (average of R$ 1.39 / pack) and adjusted according to the consumer price index for cigarettes (CPI Cigarettes). This average price information was taken from Iglesias et al. (2007). According to Iglesias *et al* (2007), "The average price of a basket of five cigarettes brands was used as nominal prices for the period. IBGE has published the average price for September 1999 and also monthly variations."

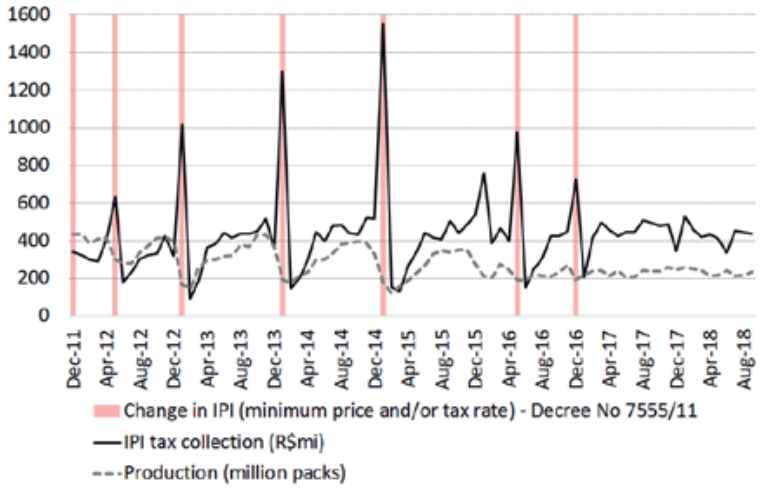
Figure A.1: **Quantity of cigarettes (millions of packs)**



Source: Authors, STN, Iglesias (2007), IBGE and SRFB. '2018 until August

When comparing the two series (IPI Tax implicit production and cigarette production by SRFB)[75] for the period in which both have official monthly data[76], the implicit series had marked shocks related to legislation changes (whether of a tax rate change or a minimum price change), while in the production series, these shocks were much smoother.

Figure A.2: **IPI tax collection (R$mi) and industry production (millions of packs)**

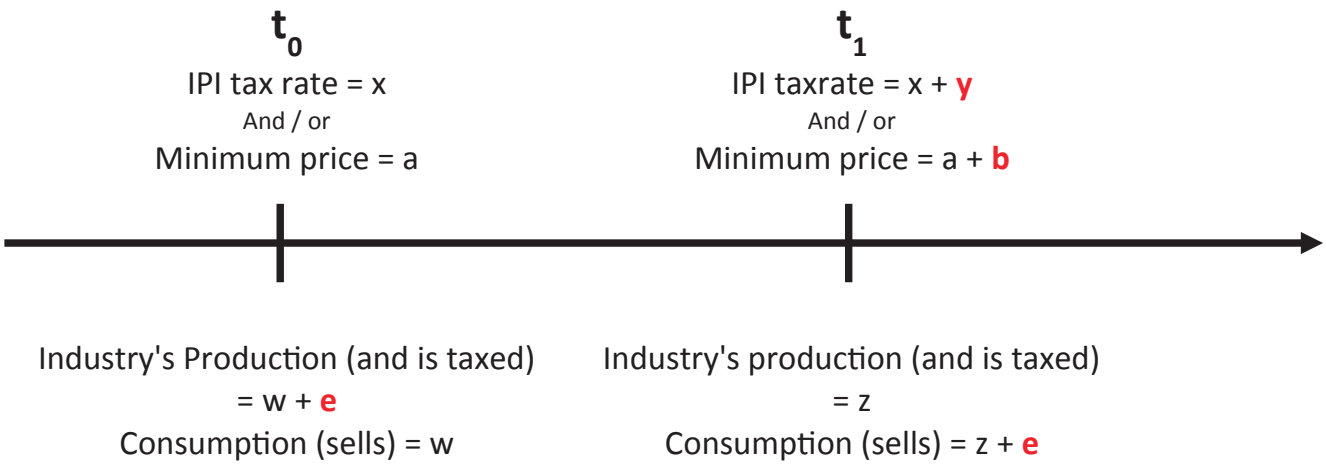


75. IPI revenues can be obtained both on the SRFB website and on the website of the National Treasury Secretariat (STN), with the difference that the SRFB series corresponds to gross collection, while the STN series corresponds to the series net of tax incentives. Although both are similar, in this study we chose to use net STN series.
76. From December 2011 to September 2018.

Source: SRFB and STN

These shocks represent reactions from both the industry and distributors (wholesalers and retailers) to price changes. As policies stating minimum price and IPI, tax rate changes were legally defined into the future (Decree No. 7.555/11, amended by Decree No. 8656/16), producers and distributors could anticipate production/ purchases when the price/tax was lower and then sell at higher prices. The figure below illustrates this decision making process.

Figure A.3: **Industry decision process on price/tax changes**



Note that the quantity produced in t_0 (e) was taxed at rate (x) and based on the minimum price (a), but the sale to the consumer occurred when the tax rate became (x + y) and the minimum price (a + b), this difference became an increase of profit for the industry.

Source: Authors

Another factor that is worth mentioning before connecting IPI's revenue series to cigarette production series relates to tax events, something that is also able to explain why revenue series have much wider shocks than production series prior to tax changes.

The cigarette production data released by SRFB corresponds to the information collected through the System to Control and Track Cigarette Production (SCORPIOS), so that the volume captured in the system refers to how much was produced, regardless of whether it was sold or inventoried. On the other hand, the tax revenue statistics of the IPI has as tax event the production of a certain good on an industrial establishment. Thus, by construction, if there is inventory formation in the industry, the series of implicit volumes obtained from IPI revenue would be different from that reported by the SCORPIOS system.

In addition to these methodological differences, we must also note that IPI tax of period ***t*** is only collected in ***t + 1***. However, there may be tax offsets to distort results. In this sense, it is necessary to analyze the weight of tax offsets in the total tax revenue of the tobacco sector, to know if these are significant to the point of jeopardizing our approach. The table below shows, for 2013 and 2014 (the only years with available information), how much tax was collected and how much of this was offset in the National Classification of Economic Activities (CNAE) number 12 (Manufacture of Tobacco Products). Companies mostly used other tax offsets (such as in PIS / COFINS and IR / CSLL) than in IPI.

Table A.6: **Tax Revenue and Tax Offsets - CNAE 12 (Manufacture of Tobacco Products), R$mi**

	Tax Revenue		**Tax Offset**		**Tax Offset / Tax Revenue**	
	2013	2014	2013	2014	2013	2014
Total	**6.896**	**7.392**	**166**	**189**	**2,4%**	**2,6%**
COFINS	1.190	1.230	16	85	1,4%	6,9%
IR - Total	722	748	95	51	13,2%	6,8%
CSLL	186	179	35	19	18,6%	10,6%
IPI	**4.275**	**4.677**	**15**	**15**	**0,3%**	**0,3%**
PIS/PASEP	365	382	3	0	0,7%	0,1%
Others	157	176	2	20	1,2%	11,3%

Source: LAI and SRFB

Having all these factors in mind, it was possible to obtain, using the IPI revenue series, a monthly series of cigarette volumes by applying the monthly pattern from this series to the official series of cigarette production published by SRFB (based on the SCORPIOS system).

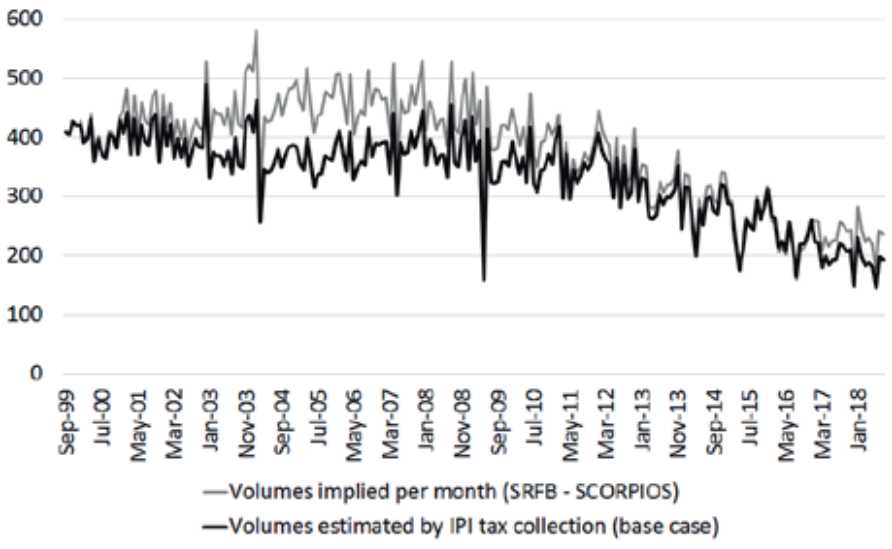
We must point out that since we are interested in obtaining a series of cigarettes consumption, we must treat the shocks (inventory formation) that are observed in the implicit volumes from the IPI and, consequently, in the official SRFB data. For that, the size of the shock must be defined and, thereafter, a procedure to dilute it over time has to be chosen.

In order to define the shock's size, we set the value without stock formation for period ***t***, as the average of the last 12 months. The difference between the observed value and the average value is the shock size (the inventory formation) in the period. This procedure was carried out for all months in which there were changes in the minimum price and/or tax rates.

Once the inventory formation is defined, it is necessary to distribute this value over the months subsequent to the shock. At first, we distribute the shock exponentially until the next month to be treated (the next shock itself), assigning a greater weight to the short term and decaying weights down the road.

After inventory treatment, finally the monthly series of implicit volumes of cigarettes was found by combining information from the IPI and by the SRFB. Results are below: when added to monthly net imports and divided by the working age population, this will be our base dependent variable (**implicit per capita consumption of legal cigarettes**).

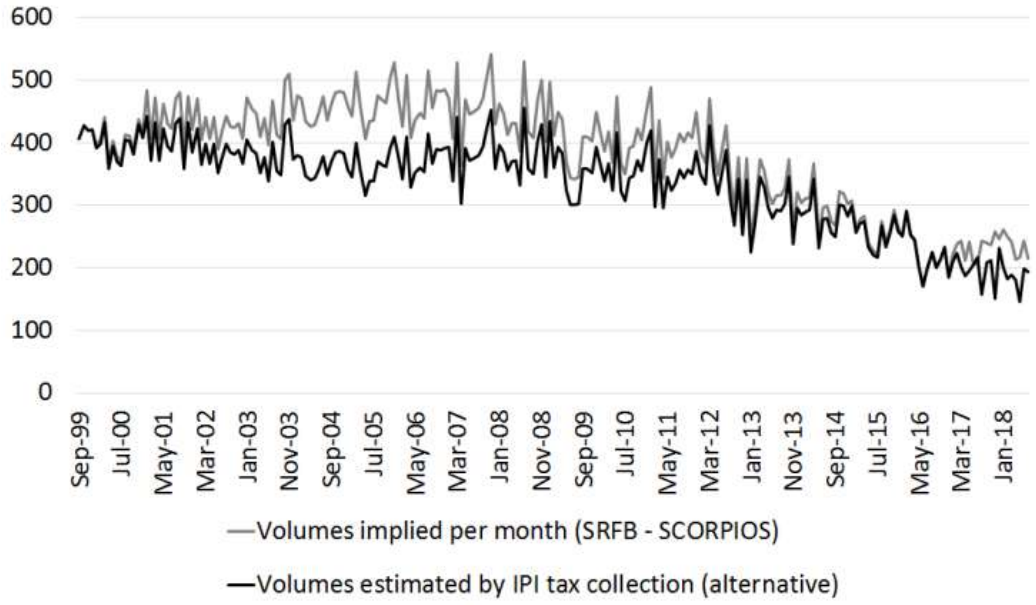
Figure A.4: **Volumes of cigarettes with inventory adjustment (base case)**



Source: Own calculations and SRFB.

It is also possible to assume that the inventories dilute only in the first months after the policy change and not throughout the whole period up until the next shock. For this reason, we proposed a second procedure of series adjustment, in which the inventories dilute over the 4 months following the price/tax shock. The series considering this shorter time span is below: when added to monthly net imports and divided by the working age population, this will be our alternative dependent variable (**implicit per capita consumption of legal cigarettes***).

Figure A.5: **Volumes of cigarettes with inventory adjustment (Alternative)**



Source: Authors and RFB.

Appendix 3: Dynamic Ordinary Least Squares (DOLS)

According to Banerjee *et al.*, (1993), simple (static) OLS regressions can lead to misbehaved long run residuals and imply spurious cointegrations[77] depending on the sample size. One way to bypass such difficulties is to estimate dynamic regressions. Following Stock and Watson (1993), this paper establishes long run relations through *Dynamic Ordinary Least Squares* (DOLS), which is a regular OLS augmented by the first difference of the non-stationary variables and by a given number of lags and leads of these differences[78] in order to induce well behaved residuals.

In its general form, DOLS goes as below; if the residual of such regression is stationary, then a cointegrating relation is determined between all I(1) variables.

$$Y = \beta_0 + \beta_1 \varphi + \beta_2 W + \beta_3 X + \alpha \Delta X + \sum_{j=1}^{n} \sigma_j \Delta X_{-j} + \sum_{j=1}^{n} \gamma_j \Delta X_j + \varepsilon$$

where

Y is a non-stationary I(1) variable

φ is a vector of deterministic regressors

W is a vector of stationary I(0) variables

X is a vector of non-stationary I(1) variables

ε is the residual

Following cointegration, short run relation was obtained by usual OLS estimation of a simple equation error correction model. Thus, the general form for the short run dynamics goes as below;

$$\Delta Y = \theta_0 + \theta_1 \omega + \theta_2 W + \theta_3 \Delta X + \tau EC_{-1} + \mu$$

where

ΔY is the first difference of a non-stationary I(1) variable (thus stationary)

ω is a vector of deterministic regressors

W is a vector of stationary I(0) variables

ΔX is a vector of first differences of non-stationary I(1) variables (thus stationary)

EC is the error correction term derived from the long run relation

μ is the residual

Lastly, inference of estimated coefficients, both in long run DOLS and short run OLS error correction, was enhanced by using heteroskedasticity and autocorrelation (HAC) consistent covariances of Newey-West, thus leading to robust standard errors.

77. Even with non-stationary variables, Stock (1987) proves that OLS estimations are super consistent. Under small samples, though, Saikonnen (1991) and Stock and Watson (1993) showed that those suffer of endogeneity, simultaneity and autocorrelation of the residuals.
78. Chosen by the minimization of Schwarz criteria.

Appendix 4: Robustness checks

Three types of robustness checks were implemented in the estimation of the demand curve for (legal) cigarette consumption in Brazil. First, the dependent variable was changed to another metric of implicit per capita consumption (**Implicit per capita consumption**, for **Implicit per capita consumption***) that is, changing the way that potential "in-company" inventories were distributed to consumers. Secondly, a new income variable was tested. Thirdly, the sample was cropped in order to evaluate the stability of econometric results.

Changing variables

Table A.7 presents long run results of the four alternative models related to the substitute dependent variable **Implicit per capita consumption***. 2016 related dummies were never statistically significant and, therefore, were dropped from final output. Once again, equations (1)* and (2)* control for cycle, opposed to (3)* and (4)*, with their best lag structure as below.

With the new dependent variable, most of "best equations" continued to confirm the Granger-cause hypothesis: lagged explanatory variables were most usually the ones relevant for legal cigarette consumption decisions in the long run. Equation (2)* shows that the real price of cigarettes relates to consumption contemporaneously, what may

Table A.7: Long run results (full sample, alternative dependent variable)

Dependent variable: log(implicit per capita consumption)*								
	(1)*		**(2)***		**(3)***		**(4)***	
log (cigarette real prices)	-0.571	***	-0.529	*	-0.652	***	-0.461	
log (per capita disposable earnings)	-0.622		0.043		-0.214		1.082	***
log (consumer confidence)	0.507	***	0.534	***				
Lag structure	(3,3,3)		(0,0,3)		(2,3)		(3,0)	
Deterministics								
C	7.774	***	4.345	**	8.614	***	1.655	
Minimum prices	-0.038	***			-0.067	***		
Dummy may/09	-0.621	***			-0.725	***		
log (IPI specific component)			-0.460	**			-0.895	***
Adjusted R-Squared	0.909		0.870		0.892		0.868	
Sum squared residuals	1.306		1.950		1.967		2.463	
Durbin-Watson	1.723		1.806		1.341		1.404	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

lead to endogeneity as prices and volumes could be jointly determined. Nonetheless, as equation (1)* - the other one that controls for cycle - clearly outperforms, equation (2)* will be sidelined.

The price elasticity of taxed cigarette demand ranged from -0.46 from -0.65, and was strongly statistically significant (at 1% confidence level) at (1)* and (3)*, and tended toward insignificancy at (2)* and (4)* which used specific IPI tax as a deterministic control. Despite these "statistical jitters", legal cigarette consumption was once again inelastic in the long run, with average price elasticity of -0.55 - almost matching previous estimate of -0.59.

In line with the original model, income elasticities were broadly statistically insignificant with swinging signals. Only equation (4)* had statistically significant and positive elasticity, but, as happened before, this equation had the poorest performance (smallest adjusted R^2, biggest sum of squared residuals and smaller Durbin-Watson) among the equations estimated.

Cycle controls were also found to be statistically significant, with elasticities matching the ones of the original model (in terms of size, signal, and significance) and improving general econometric performance. Deterministic controls also were very similar to the original model, confirming the impact of minimum prices and of specific taxes on legal cigarette consumption.

As previously shown, Johansen results related to the dependent variable **implicit per capita consumption*** were inconclusive, either showing cointegration or not between I(1) variables. In the spirit of Engle and Granger (1987) procedure, the next table shows ADF and PP unit root test results for the estimated residuals *EC(.)* of every long run equation from (1)* to (4)*: they were strongly stationary, confirming cointegration of the alternative dependent variable with I(1) independent ones.

Engle-Granger cointegration tests (full sample)

Table A.8: Unit root tests on the estimated residuals (full sample, implicit per capita consumption*)

Variable	ADF		PP	
EC*(1)	-10.615	***	-11.123	***
EC*(2)	-11.110	***	-11.534	***
EC*(3)	-3.783	***	-10.653	***
EC*(4)	-6.313	***	-10.699	***

*** significant at 1%
** significant at 5%
FULL Sample: 2000.M1 to 2018.M9
ADF and PP: null hypothesis of unit root.
ADF with MacKinnon one-sided p-values and PP with Bartlett kernel and Newey-West automatic bandwidth selection criteria

The table below presents short run results. In general, these estimates had poorer statistical performance, especially in terms of adjusted R^2 and sum of squared residuals. Prices were mostly (statistically) irrelevant for short term consumption, with exception of changes in minimum price at equation (1)* (at 5% confidence) and in cigarette real prices at equation (4)* - with elastic consumption reaction, albeit barely significant (at 10%) and in an equation that statistically underperformed.

Table A.9: **Short run results (full sample, alternative dependent variable)**

Dependent variable: dlog(implicit per capita consumption)*								
	(1)*		**(2)***		**(3)***		**(4)***	
dlog (cigarette real prices)	-0.895		0.019		-0.067		-1.013	*
dlog (per capita disposable earnings)	-0.211		1.531	**	0.225		1.894	**
dlog (consumer confidence)	-0.101		0.197					
EC*(-1)	-0.871	***	-0.770	***	-0.666	***	-0.574	***
Lag structure	(3,3,3)		(0,0,3)		(2,3)		(3,0)	
Deterministics								
C	0.000		-0.007		-0.005	*	-0.002	
d(Minimum prices)	-0.021	**			-0.020			
Dummy may09-jun09	0.724	***	0.501	***	0.747	***	0.564	***
dlog (IPI specific component)			-0.222				-0.320	
Adjusted R-Squared	0.569		0.569		0.499		0.507	
Sum squared residuals	1.528		1.529		1.833		1.815	
Durbin-Watson	2.265		2.213		2.288		2.306	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Meanwhile, income elasticities were found to be significant in two specifications ((2)* and (4)*) at 5% confidence, with positive elasticities and elastic behavior - 1% increase in income led, on average of these two specifications, to a 1.7% increase in legal cigarette consumption in the short run - therefore matching the base model pattern.

Similarities also occurred in cycle controls (statistically insignificant but helping to improve models) and with the 2009 "see-saw" monthly dummy. At last, the speed of convergence to long run equilibrium was consistently relevant: on average, a bit more of 70% of the dynamics happened in one period.

Perhaps more interesting than changing the dependent variable is to evaluate robustness with different explanatory variables. Getting back to the original dependent variable **Implicit per capita consumption**, the income variable was changed from per capita disposable earnings to per capita earnings. As always, all variables are seasonally adjusted and rebased to 2012=100[79].

The table below presents long run estimates for six alternative equations related to the new income variable. As in the base model, equations (1.1) to (3.1) control for cycle while equation (4.1) to (6.1) do not. The same set of deterministic variables and dummies applies and the best lag structure is presented as one of the outputs.

Similarities with base models were striking. First, the lag structure confirmed Granger-causality and was identical to that of the original model. The price elasticity of taxed cigarette demand ranged from -0.54 from -0.76, matching base model range, keeping statistical significance at 5% and the inelasticity of demand to prices in the long run.

Income elasticities were once again broadly statistically insignificant and with swinging signals[80]. Cycle variables were also significant and improved model performance when used. At last, this alternative explanatory specification confirmed the importance of the deterministic "institutional" controls: minimum prices and specific taxes negatively affected legal cigarette demand.

79. Specifications with other income variables and alternative cycle controls (for example, unemployment rate or IBC-Br growth) consistently led to poorer results, either in statistical terms or in economic terms (for example, decreasing significance of price/income variables or, in some cases, leading to significant "wrong signal" estimates). Those tests are not presented in this paper.

80. Only equation (6.1) had statistically significant income, showing the expected signal and elasticity (in the way of coefficient bigger than one). Nonetheless, and as happened in the base model, this specification clearly had the worst performance (smallest adjusted R^2, biggest sum of squared residuals and smaller Durbin-Watson) and, therefore, its results could be downplayed.

Table A.10: **Long run results (full sample, alternative income explanatory variable)**

	(1.1)		(2.1)		(3.1)		(4.1)		(5.1)		(6.1)	
log (cigarette real prices)	-0.554	**	-0.535	**	-0.759	**	-0.601	**	-0.534	**	-0.691	**
log (per capita earnings)	-0.602		-0.549		0.247		-0.272		-0.453		1.288	***
log (consumer confidence)	0.501	***	0.281	**	0.546	***						
Lag structure	(2,3,2)		(3,3,1)		(2,2,2)		(3,3)		(3,3)		(2,0)	
Deterministics												
C	7.631	***	8.309	***	4.417	***	8.644	***	9.148	***	1.779	
Minimum prices	-0.040	**	-0.044	***			-0.067	***	-0.055	***		
Dummy may/09	-0.637	***	-0.675	***			-0.736	***	-0.721	***		
log (IPI specific component)					-0.352	*					-0.805	***
Dummy jan16-feb/16	0.326	***					0.320	***				
Dummy 2016			-0.177	***					-0.240	***		
Adjusted R-Squared	0.902		0.904		0.870		0.893		0.910		0.864	
Sum squared residuals	1.465		1.448		1.926		1.930		1.624		2.466	
Durbin-Watson	1.494		1.772		1.637		1.163		1.647		1.396	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

On the one hand, Johansen tests related to the explanatory variable real per capita earnings were inconclusive, showing from two to no cointegrating relation depending on test hypothesis. On the other hand, Engle and Granger test (Table A.11) strongly suggested the presence of cointegration: estimated residuals from (1.1) to (6.1) were all stationary at 1% in both ADF and PP unit root tests.

Table A.12 presents short run results, with the variable *EC(..)* measuring the speed of adjustment from short run to long run equilibrium. Basically all the original results apply: prices kept being insignificant to short term consumption decisions, income elasticities were found to be elastic and significant in four specifications ((1.1), (2.1), (4.1) and (5.1)), cycle controls were in general insignificant (with exception of equation (2.1), with non-expected signal but barely significant), "see-saw" monthly dummies kept relevance and error correction terms suggested a rather strong speed of adjustment towards long run equilibrium.

Table A.11: **Unit root tests on the estimated residuals (full sample, implicit per capita consumption, real per capita earnings)**

Variable	ADF		PP	
EC(1.1)	-3.988	***	-10.136	***
EC(2.1)	-11.089	***	-11.545	***
EC(3.1)	-10.233	***	-10.788	***
EC(4.1)	-3.430	***	-9.393	***
EC(5.1)	-4.856	***	-11.659	***
EC(6.1)	-4.204	***	-10.672	***

*** significant at 1%
** significant at 5%
FULL Sample: 2000.M1 to 2018.M9
ADF and PP: null hypothesis of unit root.
ADF with MacKinnon one-sided p-values and PP with Bartlett kernel and Newey-West automatic bandwidth selection criteria

Table A.12: **Short run results (full sample, alternative income explanatory variable)**

	(1.1)		(2.1)		(3.1)		(4.1)		(5.1)		(6.1)	
dlog (cigarette real prices)	-0.028		-0.152		0.155		-0.158		-0.158		0.209	
dlog (per capita earnings)	2.134	**	1.774	**	-1.036		2.108	**	1.543	*	-0.232	
dlog (consumer confidence)	-0.162		-0.540	*	0.287							
EC.1(-1)	-0.776	***	-0.908	***	-0.683	***	-0.603	***	-0.828	***	-0.552	***
Lag structure	(2,3,2)		(3,3,1)		(2,2,2)		(3,3)		(3,3)		(2,0)	
Deterministics												
C	-0.010		-0.009		-0.005		-0.008		-0.006		-0.006	
d(Minimum prices)	0.005		0.020				-0.006		0.013			
Dummy may09-jun09	0.745	***	0.747	***	0.627	***	0.772	***	0.775	***	0.680	***
dlog (IPI specific component)					0.222						0.205	
Dummy jan16-feb16	0.504	***			0.372	***	0.491	***			0.391	***
Dummy 2016			-0.001						-0.021			
Adjusted R-Squared	0.625		0.603		0.639		0.576		0.570		0.574	
Sum squared residuals	1.393		1.474		1.405		1.618		1.643		1.635	
Durbin-Watson	2.301		2.135		2.347		2.347		2.205		2.370	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

As a final test, alternative dependent and income explanatory variables were combined. Table 13 presents the four alternative long run estimates with proper deterministic controls and respective lag structure. As with the other test using **implicit per capita consumption*** as the dependent variable, there is one specification that violates Granger-causality (equation (2.1)*), therefore eventually leading to endogeneity and simultaneity as prices and consumption may be jointly determined.

Apart from this caveat, price elasticities ranged from -0.45 to -0.72 with average of -0.58, and were insignificant in only one specification. Meanwhile, this same specification showed significant income elasticity - yet resulting in the worst statistical performance measured by informational criteria. Deterministic controls were also broadly significant and had the expected signals. Therefore, there were no remarkable differences from the original base models.

Every long run residual was tested for the presence of unit root in order to confirm cointegration. Results in the table A.11 confirmed stationarity at 1% confidence, therefore supporting short term dynamics disclosed in table A.14 below.

Table A.13: **Long run results (full sample, alternative dependent and income explanatory variables)**

	(1.1)*		(2.1)*		(3.1)*		(4.1)*	
log (cigarette real prices)	-0.580	***	-0.556	**	-0.716	***	-0.445	
log (per capita earnings)	-0.586		0.053		-0.094		1.095	***
log (consumer confidence)	0.509	***	0.539	***				
Lag structure	(3,3,3)		(0,1,2)		(3,3)		(3,0)	
Deterministics								
C	7.643	***	4.407	***	8.364	***	1.530	
Minimum prices	-0.039	***			-0.066	***		
Dummy may/09	-0.628	***			-0.734	***		
log (IPI specific component)			-0.448	*			-0.907	***
Adjusted R-Squared	0.909		0.870		0.892		0.870	
Sum squared residuals	1.302		1.973		1.961		2.418	
Durbin-Watson	1.710		1.809		1.295		1.429	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Table A.14: **Unit root tests on the estimated residuals (full sample, implicit per capita consumption*, real per capita earnings)**

Variable	ADF		PP	
EC(1.1)*	-10.545	***	-11.054	***
EC(2.1)*	-10.633	***	-11.159	***
EC(3.1)*	-3.646	***	-10.432	***
EC(4.1)*	-6.414	***	-10.780	***

*** significant at 1%
** significant at 5%
FULL Sample: 2000.M1 to 2018.M9
ADF and PP: null hypothesis of unit root.
ADF with MacKinnon one-sided p-values and PP with Bartlett kernel and Newey-West automatic bandwidth selection criteria

In opposition to long run estimates, short run results were different from previous models. Equations (3.1)* and (4.1)* showed elastic price coefficients at, respectively, 5% and 10%, while changes in the minimum price affected short run consumption decisions in equations (1.1)* and (3.1)*. Income elasticities were usually insignificant, with the exception of equation (4.1)*, which found a very elastic behavior - 1% increase in income led to 2% increase in short run legal cigarette consumption.

Lastly, other variables matched previous results: cycles variables kept their insignificance in the short run and the speed of adjustment towards long run equilibrium was still significant with an average coefficient of -0.62, yet with higher variability as it ranged from -0.37 to -0.87.

Table A.15: **Short run results (full sample, alternative dependent and income explanatory variables)**

	(1.1)*	(2.1)*	(3.1)*	(4.1)*
dlog (cigarette real prices)	-0.898	-0.424	-1.099 **	-1.008 *
dlog (per capita earnings)	-0.306	-1.619	0.113	2.037 **
dlog (consumer confidence)	-0.098	-0.011		
EC.1*(-1)	-0.871 ***	-0.365 ***	-0.647 ***	-0.584 ***
Lag structure	(3,3,3)	(0,1,2)	(3,3)	(3,0)
Deterministics				
C	0.000	-0.001	-0.001	-0.003
d(Minimum prices)	-0.021 ***		-0.026 **	
Dummy may09-jun09	0.724 ***	0.630 ***	0.758 ***	0.559 ***
dlog (IPI ad rem)		0.075		-0.333
Dummy jan16-feb16				
Dummy 2016				
Adjusted R-Squared	0.569	0.337	0.520	0.509
Sum squared residuals	1.528	2.353	1.755	1.807
Durbin-Watson	2.265	2.911	2.220	2.301

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2018M8. 153 to 172 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

In conclusion, long run estimates were broadly robust to different dependent and explanatory variables, recurrently confirming price inelasticity, limited income significance, and the importance of macroeconomic (cycle) and institutional (deterministic) controls.

Short run robustness was a tad below, with results for the specification that combines alternative dependent and explanatory variables being different from the other ones; in general, prices were insignificant, and income was highly important for the short-term legal cigarette consumption decision. Moreover, adjustment to long run equilibrium was very quick independent of the estimated equation.

Changing the sample

Anecdotal evidence supports that legal cigarette consumption has been falling in a faster pace over the last couple of years. The usual narrative relates that to the macroeconomic scenario: recession, progressively higher real cigarette prices, and a general lack of confidence took a toll on legal consumption and, most likely, pushed users away either to quit smoking or to illicit tobacco products.

In that sense, it is interesting to evaluate coefficient stability in the sample, precisely if there are observable changes before and after 2015 (the first year of our current economic downturn). Ideally, estimations would be done in two different samples, one before 2015 and another thereafter, and their results would be compared. Nonetheless, the second sample is too short, lacking robustness and stability for proper econometric analysis. As a second best, the full sample was cropped to the 2000-2015 period and estimates were compared to the original ones.

Ideally, original unit root and cointegration tests would apply. However, those tests are known to be very sensitive to the sample size, in a way that it is unclear if previous results would hold – all the procedure was to be done again. Keeping in mind their lack of power on even shorter samples and the strategy previously explained, PP, ADF and KPSS results are presented below – all variables were consistently non-stationary of first order (I(1)) in the sample 2000-2015.

Table A.16: **Unit root tests (small sample)**

Variable	ADF		PP		KPSS		
Implicit per capita consumption	-3.229		-9.925	***	0.421	***	
Δ (implicit per capita consumption)	-13.141	***			0.119		
Implicit per capita consumption*	-2.543		-10.223	***	0.422	***	
Δ (implicit per capita consumption*)	-13.813	***			0.059		
Cigarette real prices	-3.099		-2.788				
Δ (cigarette real prices)	-10.500	***	-10.120	***			
Real per capita disposable earnings	-1.280		-2.395				
Δ (real per capita disposable earnings)	-10.103	***	-11.430	***			
Real per capita earnings	-0.731		-1.851				
Δ (real per capita earnings)	-9.854	***	-10.032	***			
Consumer confidence	0.165		0.133				
Δ (consumer confidence)	-10.123	***	-10.097	***			

*** significant at 1%
** significant at 5%
Sample (adjusted): 2000.M1 to 2015.M12
ADF and PP: null hypothesis of unit root. KPSS: null hypothesis of stationarity
ADF with MacKinnon one-sided p-values. PP and KPSS with Bartlett kernel and Newey-West automatic bandwidth selection criteria

The number of cointegrating relations was established using the Johansen procedure, with results below. Opposed to what happened in the full sample, in general, test results led to just one cointegrating relation between all variables (both in base models and on its robustness checks). Therefore, a cross-check with Engle-Granger procedure was not mandatory, yet available below – and confirming cointegration.

Engle-Granger cointegration tests (short sample)

Table A.17: **Unit root tests on the estimated residuals (short sample, base models and robustness checks)**

Variable	ADF		PP	
EC_s(1)	-10.056	***	-10.163	***
EC_s(2)	-10.588	***	-10.626	***
EC_s(3)	-9.803	***	-10.133	***
EC_s(4)	-9.910	***	-10.244	***
EC*_s(1)	-9.869	***	-10.100	***
EC*_s(2)	-11.601	***	-11.588	***
EC*_s(3)	-4.039	***	-11.409	***
EC*_s(4)	-10.435	***	-11.069	***
EC_s(1.1)	-10.031	***	-10.136	***
EC_s(2.1)	-10.511	***	-10.531	***
EC_s(3.1)	-9.803	***	-10.133	***
EC_s(4.1)	-9.910	***	-10.244	***
EC*_s(1.1)	-9.869	***	-10.100	***
EC*_s(2.1)	-11.179	***	-11.166	***
EC*_s(3.1)	-4.334	***	-11.466	***
EC*_s(4.1)	-10.491	***	-11.094	***

*** significant at 1%
** significant at 5%
SMALL Sample: 2000.M1 to 2015.M12
ADF and PP: null hypothesis of unit root.
ADF with MacKinnon one-sided p-values and PP with Bartlett kernel and Newey-West automatic bandwidth selection criteria

Table A.18: **Number of cointegrating relations by Johansen procedure (small sample)**

	Variables	Intercept / no deterministic trend in data	Intercept / linear deterministic trend in data
Base models			
A	**Implicit per capita consumption + cigarette real prices + real per capita disposable earnings + consumer confidence**	2	1
B	**Implicit per capita consumption + cigarette real prices + real per capita disposable earnings**	1	1
Robustness checks			
C	**Implicit per capita consumption* + cigarette real prices + real per capita disposable earnings + consumer confidence**	1	1
D	**Implicit per capita consumption* + cigarette real prices + real per capita disposable earnings**	1	0
E	**Implicit per capita consumption + cigarette real prices + real per capita earnings + consumer confidence**	1	1
F	**Implicit per capita consumption + cigarette real prices + real per capita earnings**	1	1
G	**Implicit per capita consumption* + cigarette real prices + real per capita earnings + consumer confidence**	1	1
H	**Implicit per capita consumption* + cigarette real prices + real per capita earnings**	1	1

Selected 5% confidence number of cointegrating relations by model. 137 observations, with lag interval from 1 to 4. Critical values based on MacKinnon-Haug-Michelis (1999)

The next table presents long run estimates of the base model (i.e., using as dependent variable the implicit per capita consumption and as income model the real per capita disposable earnings) in the smaller sample (2000-2015). As always, equation (1) and (2) control for cycle, while equations (3) and (4) do not – there are fewer equations as 2016 deterministic controls are not necessary.

Table A.19: **Long run results (small sample, base models)**

Dependent variable: log(implicit per capita consumption)								
	(1)		(2)		(3)		(4)	
log (cigarette real prices)	-0.485	**	-0.865	***	-0.515	**	-0.741	***
log (per capita disposable earnings)	-0.696		-0.589		-0.528		-0.152	
log (consumer confidence)	0.287	***	0.439	***				
Lag structure	(3,2,1)		(2,1,2)		(3,1)		(3,2)	
Deterministics								
C	8.718	***	9.229	***	9.403	***	8.623	***
Minimum prices	-0.030	**			-0.042	***		
Dummy may/09	-0.696	***			-0.739	***		
log (IPI specific component)			0.110				-0.164	
Adjusted R-Squared	0.868		0.836		0.878		0.832	
Sum squared residuals	0.919		0.997		1.055		1.308	
Durbin-Watson	1.828		1.961		1.644		1.809	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

At first, the smaller sample does not change the Granger-causality result: legal cigarette consumption related to lagged explanatory variables, therefore solving potential issues on endogeneity and simultaneity.

Price elasticities hovered around full sample results, yet with a wider range of estimates from -0.49 to 0.87. On average, price elasticity was a bit higher at -0.65 (compared to -0.59 on the full sample), keeping price inelasticity on the long run. Also in line with full sample base models, income elasticities were found to be statistically insignificant in the long run.

Cycle controls (consumer confidence kept being the "best one") were also statistically significant and with expected signal as improving economic conditions (in the case, higher consumer confidence) pushed legal cigarette consumption. Equations using these controls also over-performed in the smaller sample, confirming our hypothesis that macroeconomic controls refine estimates in Brazil.

At last, the imposition of minimum prices were consistently significant to consumption decisions on the smaller. Nonetheless, IPI specific taxation was not significant to legal cigarette consumption in the 2000-2015 period.

Short run estimates based on the smaller sample are available below. Their results were remarkably different from those based on the full sample.

Table A.20: **Short run results (smaller sample, implicit per capita consumption)**

Dependent variable: dlog(implicit per capita consumption)								
	(1)		(2)		(3)		(4)	
dlog (cigarette real prices)	-0.147		0.122		-0.674	*	-1.042	**
dlog (per capita disposable earnings)	-0.263		0.762		0.637		0.918	
dlog (consumer confidence)	0.084		0.215					
EC(-1)	-0.930	***	-0.756	***	-0.917	***	-0.651	***
Lag structure	(3,2,1)		(2,1,2)		(3,3)		(3,2)	
Deterministics								
c	-0.005		-0.008		-0.003		-0.004	
d(Minimum prices)	0.015	*			-0.024	***		
Dummy may09-jun09	0.752	***	0.618	***	0.744	***	0.604	***
dlog (IPI specific component)			0.051				-0.033	
Adjusted R-Squared	0.675		0.587		0.663		0.563	
Sum squared residuals	0.867		1.097		0.929		1.196	
Durbin-Watson	2.021		2.598		2.057		2.665	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

In term of prices, two specifications (equations (3) and (4)) found statistically significant elasticities in the short run, suggesting that price increases would diminish legal cigarette consumption in the 2000-2015 period. The same pattern was observed in equations (1) and (3) due to the deterministic control "change in minimum prices".

Furthermore, income elasticities were insignificant to short run legal consumption decisions, matching long run results for the 2000-2015 and opposing full sample base model results of significance and elasticity (in the way that coefficients were bigger than unit).

Reconciling with full sample results, cycle controls were consistently statistically insignificant and the error correction terms were all statistically significant at 1%. Moreover, the speed of adjustment towards long run equilibrium was somewhat faster: on average of the four models, a bit more of 80% of the dynamics took place on just one time period.

In conclusion, long run estimates were robust to sample cropping, arriving at the same general results of the original sample:

price significance and inelasticity, income irrelevance, and importance of further controls, both in macroeconomic and institutional perspective. These comments are applicable not only to base model specification but also to all "variables related robustness checks".

Short run results, however, have been dramatically different with the smaller sample, suggesting price significance and income irrelevance in both base model and robustness check specifications– just the opposite of full sample results. Furthermore, the speed of adjustment in the 2000-2015 sample was even higher than in the full sample, suggesting that short term dynamics is very "short lived".

Robustness checks (short sample)

Table A.21: Long run results (short sample, implicit per capita consumption*, real per capita disposable earnings)

Dependent variable: log(implicit per capita consumption)*	(1)*	(2)*	(3)*	(4)*
log (cigarette real prices)	-0.479 ***	-0.892 ***	-0.494 ***	-0.725 ***
log (per capita disposable earnings)	-0.722	-0.164	-0.593	-0.097
log (consumer confidence)	0.272 ***	0.219 **		
Lag structure	(3,3,3)	(3,0,3)	(3,3)	(3,2)
Deterministics				
c	8.876 ***	8.395 ***	9.601 ***	8.298 ***
Minimum prices	-0.030 ***		-0.040 ***	
Dummy may/09	-0.604 ***		-0.688 ***	
log (IPI specific component)		0.013		-0.205
Adjusted R-Squared	0.897	0.868	0.889	0.840
Sum squared residuals	0.666	0.712	0.943	1.258
Durbin-Watson	1.822	2.131	1.825	1.795

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Table A.22: **Long run results (short sample, implicit per capita consumption, real per capita earnings)**

Dependent variable: log(implicit per capita consumption)								
	(1.1)		**(2.1)**		**(3.1)**		**(4.1)**	
log (cigarette real prices)	-0.487	**	-0.871	***	-0.517	**	-0.725	***
log (per capita earnings)	-0.675		-0.559		-0.516		-0.152	
log (consumer confidence)	0.271	***	0.430	***				
Lag structure	(3,2,2)		(2,1,2)		(3,2)		(3,2)	
Deterministics								
c	8.702	***	9.158	***	9.352	***	8.544	***
Minimum prices	-0.031	**			-0.042	***		
Dummy may/09	-0.702	***			-0.738	***		
log (IPI specific component)			0.110				-0.170	
Adjusted R-Squared	0.867		0.838		0.878		0.836	
Sum squared residuals	0.915		0.979		1.053		1.277	
Durbin-Watson	1.833		1.949		1.672		1.801	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Table A.23: **Long run results (short sample, implicit per capita consumption*, real per capita earnings)**

Dependent variable: log(implicit per capita consumption)*	(1.1)*		(2.1)*		(3.1)*		(4.1)*	
log (cigarette real prices)	-0.476	***	-0.784	***	-0.443	***	-0.706	***
log (per capita earnings)	-0.715		-0.511		-0.652		-0.085	
log (consumer confidence)	0.281	***	0.305	***				
Lag structure	(3,3,3)		(2,1,3)		(2,3)		(3,2)	
Deterministics								
c	8.788	***	9.104	***	9.638	***	8.153	***
Minimum prices	-0.030	***			-0.042	***		
Dummy may/09	-0.606	***			-0.678	***		
log (IPI specific component)			0.045				-0.218	
Adjusted R-Squared	0.897		0.868		0.890		0.842	
Sum squared residuals	0.668		0.758		0.935		1.238	
Durbin-Watson	1.828		2.041		1.868		1.805	

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Dynamic Least Squares (DOLS). Automatic leads and lags specification based on SIC criterion. HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Table A.24: **Short run results (short sample, implicit per capita consumption*, real per capita disposable earnings)**

	(1)*	(2)*	(3)*	(4)*
dlog (cigarette real prices)	-0.890 *	-1.156 **	-0.674 *	-1.042 **
dlog (per capita disposable earnings)	-0.444	0.378	0.637	0.918
dlog (consumer confidence)	0.695 *	0.711 **		
EC*(-1)	-0.945 ***	-0.686 ***	-0.917 ***	-0.651 ***
Lag structure	(3,3,3)	(3,0,3)	(3,3)	(3,2)
Deterministics				
c	0.001	-0.001	-0.003	-0.004
d(Minimum prices)	-0.014		-0.024 ***	
Dummy may09-jun09	0.722 ***	0.594 ***	0.744 ***	0.604 ***
dlog (IPI specific component)		0.105		-0.033
Adjusted R-Squared	0.604	0.508	0.663	0.563
Sum squared residuals	1.044	1.288	0.929	1.196
Durbin-Watson	2.387	2.902	2.057	2.665

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Table A.25: **Short run results (short sample, implicit per capita consumption, real per capita earnings)**

	(1.1)	(2.1)	(3.1)	(4.1)
dlog (cigarette real prices)	-0.160	0.077	-0.088	0.112
dlog (per capita earnings)	-0.148	0.958	-0.022	-0.549
dlog (consumer confidence)	0.376	0.213		
EC.1(-1)	-0.936 ***	-0.762 ***	-0.865 ***	-0.697 ***
Lag structure	(3,2,2)	(2,1,2)	(3,2)	(3,2)
Deterministics				
c	-0.004	-0.009	-0.005	-0.005
d(Minimum prices)	0.013		0.016	
Dummy may09-jun09	0.750 ***	0.638 ***	0.771 ***	0.616 ***
dlog (IPI specific component)		0.136		0.000
Adjusted R-Squared	0.681	0.592	0.659	0.599
Sum squared residuals	0.849	1.085	0.947	1.108
Durbin-Watson	1.996	2.612	2.078	2.456

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

Table A.26: **Short run results (short sample, implicit per capita consumption*, real per capita earnings)**

	(1.1)*	(2.1)*	(3.1)*	(4.1)*
dlog (cigarette real prices)	-0.896 *	0.143	0.101	-1.047 **
dlog (per capita earnings)	-0.529	-0.847	0.694	0.438
dlog (consumer confidence)	0.699 *	0.406	0.000	0.000
EC.1*(-1)	-0.944 ***	-0.713 ***	-0.933 ***	-0.658 ***
Lag structure	(3,3,3)	(2,1,3)	(2,3)	(3,2)
Deterministics				
c	0.002	-0.003	-0.006	-0.003
d(Minimum prices)	-0.013		-0.018 **	
Dummy may09-jun09	0.723 ***	0.571 ***	0.727 ***	0.610 ***
dlog (IPI specific component)		0.085		-0.010
Adjusted R-Squared	0.604	0.484	0.644	0.565
Sum squared residuals	1.043	1.358	0.981	1.191
Durbin-Watson	2.387	2.864	2.141	2.658

*** significant at 1%
** significant at 5%
* significant at 10%
Sample (adjusted): 2004M4 to 2015M12. 118 to 139 observations after adjustments
Estimation by Least Squares (OLS). HAC standard errors & covariance (Prewhitening with lags from SIC, Bartlett kernel, Newey-West automatic bandwidth, NW automatic lag length)

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