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CAMILA DE MOURA VOGT

THE FUTURE OF TOBACCO ECONOMY IN BRAZIL: PRODUCTION TRADE AND CONSUMPTION

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do Rio Grande do Sul

Camila de Moura Vogt

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This Thesis has been submitted in partial fulfillment of the requirements for the degree of Doctor of Economics, through the Graduate Program in Economics of the Business School of the Pontifícia Universidade Católica do Rio Grande do Sul.

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RESUMO

O Brasil é um dos maiores produtores de tabaco e o mais importante exportador de tabaco do mundo. Evidências sobre os efeitos negativos do tabagismo na saúde humana levaram a um intenso debate sobre políticas de controle. Este estudo possui três ensaios que objetivam analisar os efeitos de medidas restritivas na produção regional, bem como contribuir com políticas de saúde relacionadas ao consumo de cigarros. O primeiro ensaio analisou a restrição aos empréstimos agrícolas brasileiros, o Programa Nacional de Fortalecimento da Agricultura Familiar (PRONAF). Ele conclui que a redução da produção nacional de tabaco não está associada às políticas restritivas a que foi submetida. No entanto, as restrições do PRONAF ao tabaco mudaram o financiamento da produção e reduziram os subsídios do governo. Adicionalmente a criação de políticas voltadas para propriedades de médio e grande porte poderiam ser mais eficazes para estimular a diversificação e criar *spillover* necessário para as pequenas propriedades aumentarem a renda não relacionada ao tabaco. O segundo ensaio analisou o impacto da redução do consumo global no comércio de tabaco por meio do Modelo de Problema Misto de Complementaridade (PMC). Os resultados do modelo apoiam a ideia de que subsídios não são reportados no mercado de tabaco e que o declínio no consumo mundial levará a uma queda na produção brasileira de cerca de 5,6% e uma diminuição no excedente do produtor de US $897 milhões. Os achados reforçam a necessidade de políticas de diversificação agrícola para os produtores brasileiros de tabaco no curto prazo. O terceiro e último ensaio analisou as características do mercado brasileiro de cigarros. Com base em dados da Pesquisa Nacional de Saúde - PNS 2013, este estudo investiga características que afetarão o tempo de consumo do cigarro. Características relacionadas às condições sociais e econômicas foram analisadas para entender como isso influencia o tempo de consumo. Os resultados mostraram que as pessoas que são menos propensas a parar de fumar são homens mais velhos, solteiros, com baixa renda e menos anos de escolaridade. Eles também não consomem bebidas alcoólicas, não praticam exercícios físicos e têm doenças pulmonares. Portanto, a fim de diminuir os gastos com saúde pública, as políticas de saúde brasileiras poderiam se concentrar naquelas que provavelmente fumarão por muito tempo.

Palavras chaves: Tabaco, PRONAF, PCM, Cigarros, Sobrevivência.

ABSTRACT

Brazil is one of the greatest tobacco producers and the most prominent tobacco exporter in the world. Evidence of the negative effects of smoking on human health has led to an intense debate on control policies. This study has three essays that aim to analyze the effects of restrictive measures on regional production, as well as contribute to health policies regarding to cigarette consumption. The first essay analyzed the restriction on Brazilian agriculture loans, the National Program for Strengthening Family Agriculture – (PRONAF, in Portuguese). It concludes that the reduced national tobacco production is not associated with the restrictive policies it has been submitted to. However, PRONAF restrictions on tobacco have changed production financing and reduced government subsidies. Hence, policies focusing on medium-sized and large farms could be more effective to stimulate diversification and would create the spillover necessary for small farms to increase non-tobacco income. The second essay analyzed the impact of reducing global consumption and the impact on global trade through the Model of Mixed Complementarity Problem (MCP). The model outcomes demonstrate that there are government subsides not reported in tobacco market and the decline in world's consumption lead to a decrease in Brazilian production of about 5.6% and in producer surplus of US $897 million. The results reinforce the need for policies to diversify agriculture production in Brazilians tobacco farms in the short term. The third and last essay analyzed the characteristics of the Brazilian cigarette market. Based on data from the National Health Survey - PNS 2013, this study investigates characteristics that will affect the time of cigarette consumption. Characteristics related to social and economic conditions were analyzed to understand how it influences cigarette consumption time. The results showed that the people who are less likely to quit smoking are older, single men, with low income and fewer education years. They also do not consume alcoholic beverages, do not practice physical exercise and have pulmonary diseases. Therefore, in order to decrease public health spending, Brazilian health policies regarding tobacco use should focus on those who will likely smoke for a long time.

Keywords: Tobacco, PRONAF, MCP, Cigarettes, Survival.

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SUMMARY

1. PRESENTATION

Brazil is one of the leaders in the development of the Framework Convention on Tobacco Control (FCTC). However, the country is the most prominent exporter of tobacco in the world, and restrictive measures may have a negative impact on the Brazilian economy and the life of more than 100,000 tobacco farms. The literature in Brazil presents no evidence of such impact on the country's tobacco production, whereas other countries have conducted empirical studies about it related to the impact of restrictive measures in their territories.

Thus, the three essays in this study aim at contributing to the assessment of future of tobacco production, trade, and consumption in the country, as well as providing an empirical analysis for the development of effective and sustainable policies.

The first essay analyzes the restrictive policies for rural loans. To encourage diversification in agriculture, the Brazilian Central Bank established progressive restrictions on tobacco rural credit for small farms in the National Program for the Strengthening of Family Agriculture (PRONAF). It also addresses family farm structure in Southern Brazil, featuring its production evolution and the impact of tobacco production restrictions on rural credit. The study concludes that national tobacco production has not been reduced as a consequence of tobacco restrictive policies. However, PRONAF restrictions did change the financing of tobacco production. Moreover, migrating from PRONAF to other credit lines has reduced government subsidies. Hence, production diversification policies could be more effective if they focused on medium-sized and large farms, which would create spillover for small farms to replace their tobacco production in a natural fashion.

The second essay examines the impact of reduced consumption and changes in the global trade using the Mixed Complementarity Problem (MCP) model, which, in turn, is calibrated with information on the international tobacco market to estimate a scenario of reduced consumption based on the World Health Organization's tobacco predictions for 2025. The results confirm that there are unreported subsidies in the markets and that a decrease in consumption will lead to a decrease in both production and prices, which emphasizes the need for diversification policies in Brazil in the long term.

The third essay analyzes the impact of tobacco restrictive policies in the internal consumption market. Cigarette consumption is a worldwide epidemic, and its reduction is one of the most significant public health challenges. The FCTC agreements started in Brazil in February of 2005, and since their implementation, tobacco consumption has decreased.

However, despite the progress in tobacco consumption reduction, the entry of smuggled cigarettes in the country has hindered the effectiveness of anti-tobacco policies.

Based on data from the 2013 National Health Survey (PNS), this study investigates which characteristics affect smoking duration and will attempt to contribute to the creation of policies other than price regulation. The results of the research confirm that the people less likely to quit smoking are older, single men, with low income and few schooling years. They also do not consume alcoholic beverages, do not practice physical exercises and have pulmonary diseases. Therefore, in order to decrease public health spending, Brazilian health policies regarding tobacco consumption should focus on those who are likely to smoke for a long time.

2. IMPACT OF THE NATIONAL TOBACCO CONTROL POLICY (PNCT) ON TOBACCO PRODUCTION

ABSTRACT

Brazil is one of the greatest tobacco producers, just behind China, and the largest tobacco exporter in the world. Evidence about the negative effects of smoking on human health has led to an intense debate on control policies. Becoming a member of the Framework Convention for Tobacco Control (FCTC) in 2005 and the creation of the Brazilian Tobacco Control Policies (PNCT in Portuguese) in the same year contributed to the implementation of several measures to reduce the demand for tobacco in the country. To encourage agricultural diversification, the Brazilian Central Bank has gradually restricted credit for small tobacco farms in the National Program for the Strengthening of Family Agriculture (PRONAF in Portuguese). This paper analyzes the family farm structure in Brazil, presenting the productive structure of family farming and the impact of rural credit restriction on tobacco production. It concludes that the reduced national tobacco production is not associated with the restrictive policies it has been submitted to. However, PRONAF restrictions on tobacco have changed production financing and reduced government subsidies. Hence, policies focusing on medium-sized and large farms could be more effective to stimulate diversification and would create the spillover necessary for small farms to increase non-tobacco income.

Keywords: Tobacco, credit, PRONAF, PNCT, loans.

2.1 INTRODUCTION

Brazil is the second largest producer of tobacco and its most important exporter in the world. However, evidence of the negative effects of smoking on human health has led to an intense debate on control policies. Becoming a member of the Framework Convention for Tobacco Control (FCTC) in 2005 and the creation of the Brazilian Tobacco Control Policies (PNCT) in the same year contributed to the implementation of several measures to reduce the demand for tobacco in the country.

Most tobacco control policies have already been or are being implemented in Brazil. According to Levy, Almeida and Szklo (2012) a significant reduction in the number of smokers can already be verified as a result of the successful control policies. Consequently, there is a decrease in deaths from tobacco-related diseases, such as cardiovascular, respiratory and chronic lung cancer. Although reduced tobacco consumption has a direct positive impact on the health of smokers, restrictive policies have a negative effect on the tobacco production, for which reason there is a concern about effects of tobacco restricted activity in the performance of farmers in low and middle-income countries.

According to studies of Food and Agriculture Organization of the United Nations (FAO, 2003), the impact of restriction policies on tobacco demand would depend on countries' capacity to relocate resources to non-tobacco activities, which requires time and investments in different agricultural alternatives and labor market options. Most of the Brazilian production structure comprises small farms. According to Vargas and Campos (2005), small tobacco family farms in Southern states accounts for 92% of the labor used in agriculture. Therefore, FCTC policies need to be efficient in displacing this production and labor force, otherwise they may create unemployment and increase rural poverty.

Following in the footsteps of the international efforts to reduce tobacco dependence, the Brazilian government is focused on the agricultural diversification of small tobacco farms. As Portes, Machado, and Turci (2018) state, the initiatives to diversify the production of tobacco farms since Brazil became a member has been one of FCTC's greatest challenges due to the economic and social importance of the tobacco agriculture in the country.

The National Program for Diversification in Tobacco-Cultivated Areas (PNDACT, in portuguese) was established in 2005 as one of the PNCT measures to reduce the growers' economic dependence on tobacco. The program provides research projects, training and technical assistance, and rural extension for production diversification. Also to stimulate culture diversification, the Brazilian Central Bank established in the same year a gradual restriction on

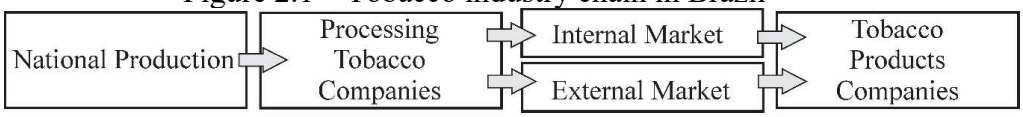
loans to small farms in the National Program for the Strengthening of Family Agriculture (PRONAF). The Brazilian rural credit has been the most important agriculture financial instrument and PRONAF is the most subsidized credit line.

This paper analyzes the family farm structure in Southern Brazil, presenting the productive structure of family farming and the impact of rural credit restriction on tobacco production. The first part presents a summary of the tobacco framework in Brazil and the PNCT production restriction policies. The second part discusses the methodology used to estimate the effects of credit restriction on the tobacco production and the last one estimates the impact of such restrictive policies on rural credit and farms in the country.

2.1.1 TOBACCO IN BRAZIL

According to the Food and Agriculture Organization Statistics (FAOSTAT) database, the 2014 Brazilian crop accounted for about 12% of the world's total production. In the first phase of the country's production, the green tobacco is sold by small farmers to tobacco-processing companies, most of which are multinationals based in Brazil (Figure 2.1). They are responsible for buying the leaf and producing raw material for tobacco products. At this stage of processing, the green leaf is separatedinto different categories of tobacco according to quality and type. Afterwards, the selected tobacco goes through cutting and conditioning. The next phase is the threshing of the leaves, a process that separates the most valuable blades of the stalks.

Figure 2.1 – Tobacco industry chain in Brazil



Source: Author (2018).

The tobacco industry in Brazil (tobacco processing and cigarette manufacturing) comprises small, medium, but mainly large international companies. There are 132 tobacco manufacturing companies in seven states of the country concentrated mostly in the Southern region. According to the Brazilian Annual Social Information (RAIS in Portuguese), tobacco manufacturing generated more than 11 thousand jobs in 2015, concentrated mainly in tobacco-processing companies. The country's cigarette factories are among the best equipped ones in the world. The cities of Santa Cruz do Sul and Venâncio Aires in the state of Rio Grande do Sul have the largest tobacco-processing complex.

According to the 2017 Brazilian Tobacco Yearbook, the 2016/2017 crop reached 706 thousand tones in 299 thousand hectares (Table 2.1) located in 574 municipalities in the Southern states of the country (Rio Grande do Sul, Santa Catarina, and Paraná), which together account for 98% of the tobacco production. Approximately 150 thousand families are involved in the tobacco production cycle (Table 2.1).

Since 1995 the tobacco production volume has grown 103%, even with no significant increase in the number of tobacco farms (13% increase from 1995 to 2017). The tobacco-cultivated area has also grown from 1995 and 2017, although only 49%. In other words, this evolution demonstrates that tobacco productivity has strongly increasedover the years, i.e. from 1.7 thousand tons per year in 1995 to 2.4 tons in 2017. The production per family has also increased from 2.6 to 4.7, whereas the area has been stable, peaking at 2.22 hectares in 2005 (Table 2.1).

Table 2.1 – Tobacco production in Brazil from 2005 to 2017.

Crop (year)	Total producer families (‘000)	Area (‘000) (ha)	Volume (‘000) (tons)	Volume per ha (tones)	Volume per family (tons)	Production area per family (ha)	R$/Kg
1995	133	201	348	1.7	2.6	1.51	**1.6**
2000	135	258	539	2.1	4.0	1.91	**2.0**
2005	198	439	843	1.9	4.3	2.22	**4.3**
2010	185	371	692	1.9	3.7	2.00	**6.4**
2015	154	308	698	2.3	4.5	2.01	**7.1**
2016	144	271	525	1.9	3.6	1.88	**10.0**
2017	150	299	706	2.4	4.7	1.99	**8.6**
Average	*168*	*332*	*689*	*2.1*	*4.1*	*1.97*	5.7
Max	*198*	*439*	*843*	*2.4*	*4.7*	*2.22*	10.0
Min	*133*	*201*	*348*	*1.7*	*2.6*	*1.51*	1.6
Standard Deviation	*21*	*62*	*128*	*0.2*	*0.5*	*0.15*	2.3

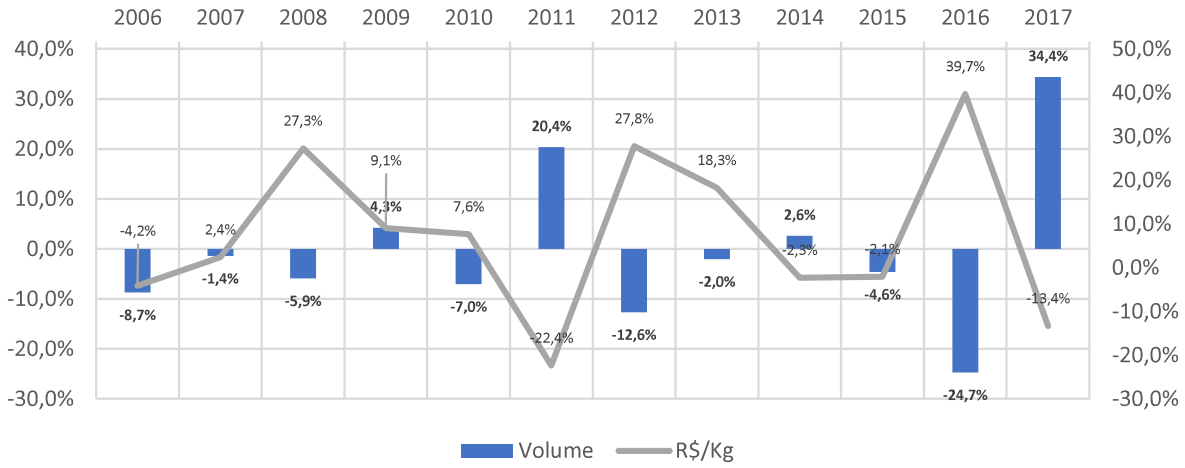
Source: Afubra database (2018).

If we analyze the annual variation of tobacco production, we may conclude that average productivity per hectare and per family has increased around 2.3% and 1.5%, respectively. The number of families, the area and total volume, however, have shown a negative annual variation average: -2.2%, -2.9%, and -0.5%, respectively. These numbers reinforce the fact that volume has been increasing based on productivity gains.

In the 1990s the Brazilian tobacco industry reached the status of largest tobacco exporter in the world. The country has shown not just large-scale productivity records but also high-quality products obtained with the use of seed technology and an integrated system. According to the 2015 Brazilian Tobacco Yearbook (BRAZILIAN TOBACCO YEARBOOK, 2015), in order to contribute to the continuity of such increase, tobacco production is organized in a system that integrates producers and the industry. The Integrated Tobacco Production System

(ITPS), a partnership between farmers and tobacco buyers, has become an essential tool of the sector. Tobacco companies select their producers and provide them with seeds, agrochemicals, and fertilizers through a purchase contract. After they buy the tobacco, these inputs are discounted from the tobacco crop total price. Thus, in other words, the quantity of crops is highly controlled by the industry through tobacco prices and the world's demand. Considering that tobacco is commercialized worldwide, its price and demand should have a behavior similar to those of other commodities. In periods of low supply tobacco prices increase in Brazil. Indeed, the price-production relationship shows that the national supply of tobacco is also a price driver. Between 2006 and 2017 it can be observed that during high prices there is a decrease in production in all years except for 2006, 2007, 2009, and 2015 (Figure 2.2).

Figure 2.2 – Price and production annual variation (%) - 2006 to 2017.



Source: Author (2018) based in Afubra database (2018).

Approximately 87 countries are suppliedwith Brazilian tobacco (COMEX STAT). In 2017 tobacco accounted for 0.92% of Brazil's total exports[1], 8.5% of the production in the state of Rio Grande do Sul and 4.3% of Southern Brazil total exports (COMEX STAT).

Brazil's tobacco leaf exports have grown consistently over the last 20 years, moving up from 313 thousand tons in 1997 to 442 thousand tons in 2017, peaking at 694 thousand tons in 2007 and US$ 3.2 billion in 2012 (Table 2.2). The worst result in tones was in 2000 (299 thousand tones) and the lowest amount was registered in 1998 (US$ 812 million) (Table 2.2). On average Brazil has exported US$ 1.8 billion and 504 thousand tons. In 2017 the country exported less but the amount is above average (Table 2.2). The Brazilian 2016/2017 crop shipments abroad were down 2.6% in dollar terms and 5% in tons comparing with those of

[1] Product code NCM 24011010 to 24012040

2015/2016. Such drop, nonetheless, did not affect the country's leadership in global exports. Whereas that year two countries stopped purchasing Brazilian tobacco, six new ones joined the list of importers, totaling 87 countries. Belgium and the United States also reduced their purchases of Brazilian tobacco.

Table 2.2 – Brazilian tobacco exports (1997 to 2017).

Year	**USD FOB ('000.000)**	**Tons ('000)**
1997	1,075.38	313.04
2007	2,192.56	693.91
2017	2,000.44	442.92
Annual Average	*1,895.87*	*504.06*
Max	*3,196.39*	*693.91*
Min	*812.87*	*299.74*
Standard Deviation	*813.18*	*116.51*

Source: COMEX STAT (2018).

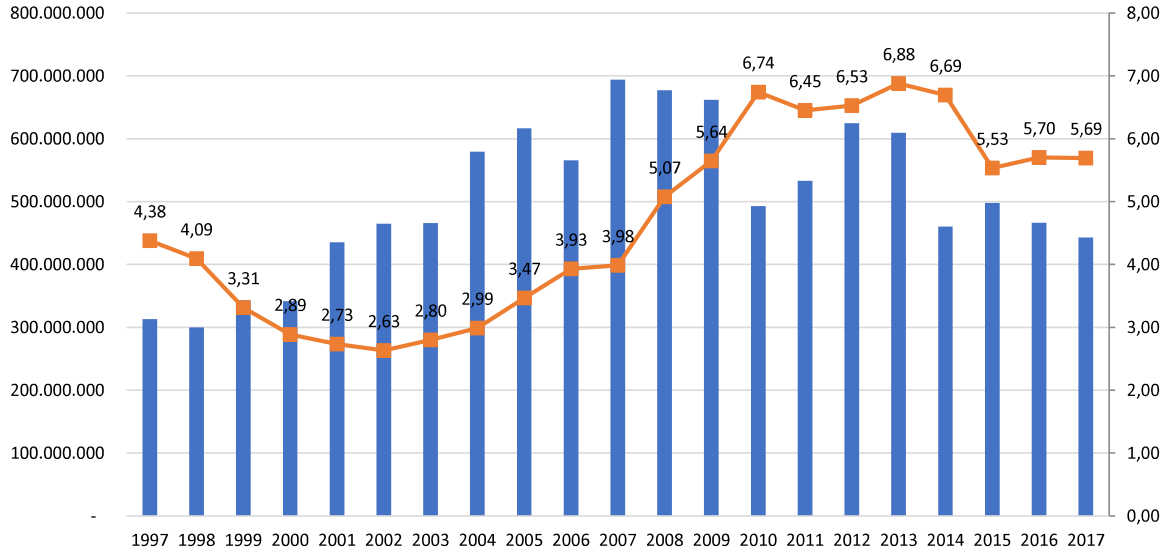
Most of the Brazilian tobacco exported is Virginia and Burley and tobacco wastes (COMEX STAT). Tobacco is dried in special ovens (flue-cured) for the Virginia variety and drying hangars (dark air-cured) for the Burley one. The others dry in open air (sun-cured). Virginia is the most common tobacco variety in the South, accounting for 67.3% of total volume exports in 2017 and 84.8% of the total amount, whereas Burley accounted for 8.7% of the volume and 10.6% of the amount (COMEX STAT). Tobacco wastes are materials such as tobacco dust used as primary inputs in cigarette manufacturing and represent 22.8% of total tobacco export volume and only 2.2% of its total amount (COMEX STAT).

Currently Belgium is the most significant market for the Brazilian tobacco because the country has one of the most importantports in the European Union. In 2017 Belgium accounted for 17% of the Brazilian exports and since 2006 it has been our top importer, except for years 2011 and 2012, when China was Brazil's largest importer (COMEX STAT). After the European market, the most important destinies of our production are China and the United States, which imported 13% and 9.8% respectively of the Brazilian tobacco in 2017 (COMEX STAT). In the long term, exports to Asia and Europe have increased but to North America they have decreased. Since 1997 the total amount exported to Belgium has grown 340% and to China, 2,148%. However, exports have decreased around 13% to the United States since 1997 (COMEX STAT). Such changes can be justified by the higher restrictions on tobacco importation in the United States, the development of the Asian consumption market, and the decrease of Africa's exports of the Virginia variety.

The production decline in countries such as the United States and Zimbabwe has made it easier for Brazil to grow faster worldwide. The entry of such relevant buyers as China,

Germany, Japan, the Republic of Korea, Russia, and countries in the Far East have also contributed to the larger Brazilian market share. Analyses based on international market monitors for the tobacco industry have projected a significant reduction in the sales volume of the four leading transnational tobacco companies, including those which coordinate the tobacco production chain in Brazil, and a relevant surplus in the global tobacco supply, generating a steep revenue fall of 30% for top tobacco leaf merchants (CAVALCANTE *et al*., 2017). Exported tobacco volume and price have been decreasing since 2014, which may be a reflection of the excess supply referred to (Figure 2.3).

Figure 2.3 – Tobacco exports (tons) and Virginia tobacco price (U$) - 1997 to 2017.



Source: COMEX STAT (2018).

Decrease in exports impacts tobacco companies' direct investments in the country and consequently farmers' chances to maintain their production. Although tobacco generates a high profitability per hectare, rural exodus is stronger every year. A survey has shown that almost one third of producer families in 2013/2014 do not own the farms. About 47 thousand families produce tobacco in the system of partnership or leasing (BRAZILIAN TOBACCO YEARBOOK, 2014).

According to GUILHOTO *et al*. (2006), given the expressive value added by the industrialization process the tobacco culture is very important to rural families' income and to the economy of Southern Brazil. Tobacco production corresponds to 12% of the average GDP of the family agricultural sector and 7% when the total GDP of the agricultural complex is taken into account. Moreover, tobacco is responsible for the most significant difference between family agriculture and agribusiness in Rio Grande do Sul.

The Brazilian production structure is made up mostly of small farms (Table 2.3). The farm average size is 14.22 hectares and only 17% are devoted to tobacco production. Despite the small area, tobacco represents 40% of farmers' income on average and is 124% higher than that from other cultures, whichexplains how a small production can have such a high impact on farmers' revenues.

Table 2.3 – Tobacco farms characteristics - crop 2016/2017.

Data description	Crop 2016/17
Total area tobacco farms (ha)	1,757,271
Total tobacco farms	123.562
Area with Tobacco (ha)	298,530
Area with other cultures (ha)	1,004,530
Tobacco farms average size (ha)	14.22
Tobacco production average size (ha)	2.42
Other cultures production average size (ha)	8.13
Total revenue Tobacco (ha/Kg)	20,402
Total revenue other cultures (ha/Kg)	9,121
Average revenue tobacco (R$)	49,291.93
Average revenue from other cultures (R$)	74,151.58

Source: Brazilian Tobacco Yearbook (2017).

The Rural Census (IBGE, 2006) has verified that most tobacco farms (51.2%) have less than 20 hectares (Table 2.4). Compared with the size of other structures, such farms have produced the largest amount (approximately R$ 930 million) and the largest volume (353 thousand tones in 181 thousand hectares). Apart from tobacco, they grew other crops between tobacco harvests, the quantities of which, however, are not available in the census.

Table 2.4 – Tobacco Farms Census[2] - 2006.

N	Farms size range						Group share (%)
1	Bigger	than	0	to	Smaller than	0,1	0,1%
2	From	0,1	to	less	than	0,2	0,2%
3	From	0,2	to	less	than	0,5	2,2%
4	From	0,5	to	less	than	1	4,2%
5	From	1	to	less	than	2	4,6%
6	From	2	to	less	than	3	4,8%
7	From	3	to	less	than	4	5,2%
8	From	4	to	less	than	5	5,5%
9	From	5	to	less	than	10	**21,9%**
10	From	10	to	less	than	20	**29,2%**
11	From	20	to	less	than	50	**19,0%**
12	From	50	to	less	than	100	2,5%

[2] The estimates did not consider producers without area in the share.

N	Farms size range						Group share (%)
13	From	100	to	less	than	200	0,4%
14	From	200	to	less	than	500	0,1%
15	From	500	to	less	than	1000	0,0%
16	From	1000	to	less	than	2500	0,0%
17	From	2500		and	more		0,0%

Source: IBGE (2006).

Considering the economic importance of tobacco and farmers' dependence on tobacco income, the challenge for tobacco restrictive policies is to be able to provide a smooth transition to a new economy less dependent on tobacco production and consumption.

2.1.2 TOBACCO CONTROL POLICIES OVERVIEW

Evidence that smoking is harmful to health has made most countries adopt tobacco control measures. The FCTC is the most important world tobacco control agreement. It has brought together 192 countries to regulate tobacco consumption worldwide with measures covering health and environmental problems, including health treatment, health warnings, and the adoption of further control and restrictions regarding advertising, illegal trade and prices.

According to the Food and Agriculture Organization studies (FAO, 2003), the impact of restriction policieson tobacco demand would depend on the countries' capacity to relocate resources to non-tobacco activities, which requires investments in agricultural alternatives and labor market options. As Warner (2009) analysis, the tobacco industry estimates that 33 million people are involved globally in this market and they would have to be transfered to a new economic activity.

The main effort to control smoking has been raising taxes. According to studies conducted in such markets as China and other developing countries (TAYLOR *et al*., 2000, and TEH-WEI e*t al*., 2008), higher taxes have a direct impact on production. In China, reduced tobacco sales might generate social and financial losses if there is no alternative production for farmers to move to.

Tobacco control measures and their impact on tobacco demand in the last decadehave also caused a significant change in the global tobacco chain. Giger, Bamber and Gereffi (2014) show in their study that tobacco companies in this period have gone through mergers, acquisitions and joint ventures, which has led to a crucial spatial reorganization. They have moved to developing countries, especially in Asia and Latin America, to consolidate their position. In the same period of FCTC policies, there has also been a rise in industrial

concentration and an increase invertical integration between tobacco companies and producers. According to the authors, the tobacco industry is highly concentrated with a small number of companies with strong market power in the supply chain and small producers with small market power. Prowseand Moyer-Lee (2014) has demonstrated that the tobacco production chain has become more buyer-driven and vertically integrated due to a change in the pattern of demand and supply. The factors that havecontributed the most to increased vertical integration and globalization of the tobacco chain are: on the demand side, population growth and income, urbanization, and larger participation of women in developing countries' workforce; on the supply side, market liberalization, higher product differentiation, and strict process control and production standards.

The cigarette industry is concerned with the future of market consumption. In 2017 one of the most important players in cigarette production, Philip Morris, announced that it is designing a smoke-free future (FORTUNE, 2018). Their strategy is to use the traditional tobacco market for "harm reduction" products through the heat-not-burn technology. The new product is a method of delivering the tobacco experience by heating, rather than igniting it. According tostudies released by the US Department of Health and Human Services (FDA, 2018), the company stated that the benefit compared with the traditional products is to reduce many of the potentially harmful compounds that form at high temperatures when tobacco is combusted. Those new facts may allow the tobacco industry to produce finished goods without, or at least with fewer, legal constraints.

Brazil has pioneered in adopting several initiatives and contributing to the FCTC negotiations. The country stands out worldwide in the implementation of tobacco control measures along with Australia, Canada, Panama, Turkey and Uruguay. However, since the signing of the international treaty, conflicts related to economic interests have become more evident and caused difficulties to such implementation.

The ratification of the FCTC in Brazil was delayed due to a long confrontation between health departments and the tobacco production sector. As highlighted by Cavalcante *et al*. (2017), the tobacco industry had broadly campaigned that the Convention would ban tobacco cultivation and the country's adherence to the treaty would have a strong negative impact on the livelihoods of 200,000 tobacco-producing households. Only after two years of debates (2004 and 2005) did the Federal Senate approve the ratification of the FCTC (Legislative Decree n. 1,012). After doing that in October 2005, it created the PNCT, whose measures have been implemented in a greater or lesser degree in the country. According to INCA (2015),

cigarette consumption per capita in Brazil has decreased since 1980 (around 46% from 1989 to 2010).

Despite its social and economic importance in Brazil, mainly in the Southern region, and advances in sustainability, tobacco production has some negative aspects, which include social, environmental and health issues. Lecours *et al*. (2012) have reported that the main negative externalities of the activity are associated with the communities that participate in the tobacco production.

2.1.3 PRODUCTION RESTRICTION POLICIES IN BRAZIL

The National Program for Activities Diversification in Tobacco Growing Areas (PNDACT) established in 2005 in the PNCT aimed at reducing tobacco growers' economic dependence on this culture. Under the FCTC, the program acted by supporting rural extension, training, and research projects to implement strategies for product diversification, thus creating new opportunities for income generation (CAVALCANTE *et al*., 2017). The measures related to crop diversification are the main cause of tension since they have created a conflict between tobacco production representatives and tobacco policy defenders (PORTES, MACHADO AND TURCI, 2018). The tobacco production chain stakeholders have welcomed the economic aspects that favor farmers, such as greater profitability in contrast with that of other crops, the relative stability of tobacco demand and the support the industry provides to integrated production. The social sectors, on the other hand, have emphasized the damage to farmers' health, the intensive and unhealthy working system, and the their dissatisfaction with the activity and indebtedness to the industry.

As Portes, Machado and Turci (2018) affirmed, besides the discussion about the economic advantages of cultivating tobacco, two other conflicts have influenced the implementation of the restrictive policies. The first concerns advancing diversification in tobacco- growing areas, a need which the members of social sectors emphatically justify by the decline in global prevalence of smokers. From the standpoint of tobacco production-related sectors, diversification would imply adding other crops to tobacco-cultivated areas, preserving tobacco growth while there is demand. The second conflict involving tobacco farming is related to the government constraints to ensure advances in crop diversification, even with the PNDACT.

Despite such political conflicts its implementation, an initial analysis of the PNCT impact on tobacco production has not shown a clear cause-effect relationship. As mentioned

previously, the tobacco production exports can be more easily associated with demand and supply as well as to increased productivity and investment in innovation.

However, an important measure to stimulate agricultural diversification has been in effect to restrict rural credit to tobacco crops since 2001 (Table 2.5)[3]. In Brazil rural credit is granted as loans for agricultural activities subsidized by the government granted under specific terms of payment and lower interest rates than similar credit lines in the market. Rural credit financing policies have played a strategic role in tobacco production, especially in the states of Santa Catarina, Paraná and Rio Grande do Sul.

The main restrictions on tobacco rural credit lie in the National Program for the Strengthening of Family Agriculture (PRONAF). PRONAF was created in 1996 with the objective of transferring resources to family farmers at more affordable interest rates and terms to stimulate agricultural production. The program has the lowest interest rates in rural credit in addition to the lower default rates among the country's credit institutions. In 1999 it accounted for more than 86% of the tobacco loan agreements.

In 2001, however, the Brazilian Central Bank Resolution N. 2900 restricted the program for tobacco farmers and the following years saw increased non-tobacco product income as a PRONAF condition to grant loans. The policy proposal was to gradually restrict the investment in tobacco crops aiming at their replacement with new cultures.

Since the 2005 resolution, tobacco stakeholders have plotted to slow the evolution of restrictions on tobacco income. Subsequent resolutions ruled that tobacco farmers' income from non-tobacco crops should be limited to 20 percent of their total income so that they could be granted loans. Although the resolution guiding the Brazilian Central Bank rural credit for tobacco producers today is not directly applicable to tobacco costing, it no longer limits the percentage of non-tobacco income for granting loans to tobacco farmers (N. 4.584, dated June 29, 2017).

Table 2.5 – Summary of Brazil Central Bank resolutions

Brazil Central Bank Resolution	**Description**
Number 2.900, 31th of October 2001	Activities do not related to tobacco
Number 3.299, 15th of July 2005	I. 20% of income from non-tobacco activities
Number 4.107, 28th of June 2012	I. 25% of income from non-tobacco activities crop 2012/2013

[3] The resolution of the Brazilian Central Bank announces the National Monetary Council's decisions.

Brazil Central Bank Resolution	Description
	II. 35% of income from non-tobacco activities crop 2013/2014 III. 45% of income from non-tobacco activities crop 2014/2015
Number 4.136, 27th of September 2012	I. 20% of income from non-tobacco activities crop 2012/2013 II. 20% of income from non-tobacco activities crop 2013/2014
Number 4.339, 20th of June 2014	I. 20% of income from non-tobacco activities crop 2014/2015
Number 4.446, 20th November 2015	I. 20% of income from non-tobacco activities
Number 4.483, 03 May 2016	I. 30% of income from non-tobacco activities crop 2016/2017 II. 40% of income from non-tobacco activities crop 2017/2018 III. 50% of income from non-tobacco activities crop 2018/2019
Number 4.513, 24th August 2016	I. 20% of income from non-tobacco activities crop 2016/2017 II. 25% of income from non-tobacco activities crop 2017/2018 III. 30% of income from non-tobacco activities crop 2018/2019 IV. 40% of income from non-tobacco activities crop 2019/2020 V. 50% of income from non-tobacco activities crop 2020/2012
Number 4.584, 29th June 2017	Activities do not related to tobacco

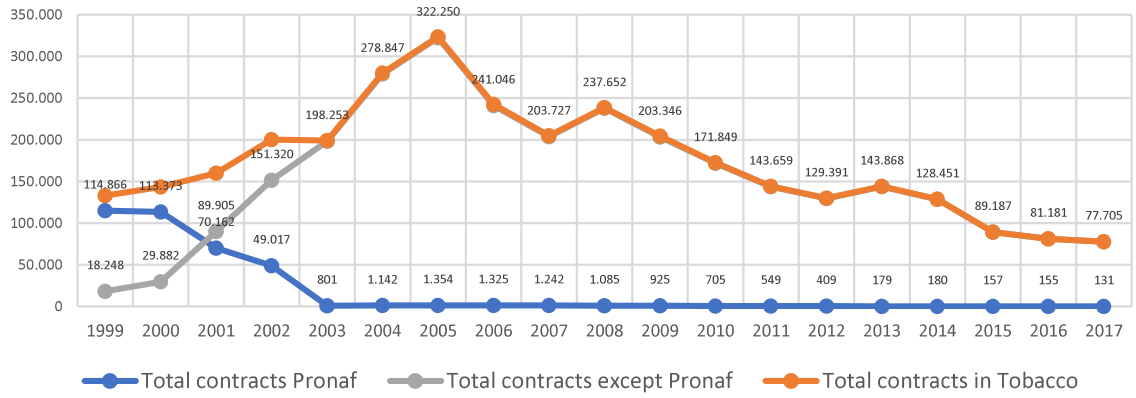
Source: Brazilian Central Bank (2018).

According to Cavalcante *et al*. (2017), tobacco companies build complex power relationships and strengthen themselves economically and politically. Their study claims that the political bias of the results is due to the support and financing of political candidates provided by such companies. They were elected for municipal, state and federal offices, which has strengthened the representation of Congressmembers who defend tobacco companies' interests. Tobacco multinationals also have an important role: obtain credit to finance such inputs as fertilizers and agrochemicals from financial institutions and the government itself. Banks do not have direct contact with tobacco growers, but with the companies that act as guarantors of the farmers taking the loans.

From 1999 to 2017 tobacco loans decreased from 17.6% (total number) and 16% (total value) to less than 1% (both total number and total value) (Tables A.1 and A.2). Figure 2.4 shows that as from year 2001 loans migrated from PRONAF to others. Interest rates in private rural credit lines can reach 8.5% p.a. and PRONAF's highest interest rates are 5.5% p.a. (CNA,

2017), 3% below those of the market because the program's credit is subsidized by the government.

Figure 2.4 – Number of tobacco rural credits contracts per program - 1999 to 2017.



Source: Author (2018) based on MATRIZ DE DADOS DO CRÉDITO RURAL (2018).

Since 2001 the government has provided fewer subsidies to tobacco production. However, one cannot affirm that the PNCT has encouraged diversification to non-tobacco cultures. The next section will verify the impact of tobacco income restrictions on the tobacco production structure.

2.2 METHODOLOGY

The tobacco income for each farm has been estimated based on tobacco production data from the 2017 Brazilian Tobacco Yearbook (Table 2.3) and census total production by farm size (Table 2.4).

Equation 1 estimates the $Numberoffarms_E$ based on the percentage of farms by census size ($Number\ of\ farms_N$) times the total number of farms from the 2017 Brazilian Tobacco Yearbook ($\sum Numberoffarms_A$). The estimation is based on the percentage of participation of each N from the census.

$$Number\ of\ farms_E = \left(\frac{Number\ of\ farms_N}{\sum Number\ of\ farms_N}\right) * \sum Number\ of\ farms_A \quad (1)$$

Equation 2 follows the same logic to estimate $Total\ production_E$, which is the total participation of production in each N-interval times the sum of the total production of tobacco and non-tobacco products ($\sum Total\ production_A$) from the 2017 Brazilian Tobacco Yearbook.

$$Total\ production_E = \left(\frac{Total\ production_N}{\sum Total\ production_N}\right) * \sum Total\ production_A \quad (2)$$

Equation 3 estimates the average tobacco production per N ($\bar{P}_E$), which is $Total\ production_E$ divided by the $Total\ number\ of\ farms_E$.

$$\bar{P}_E = \frac{Total\ production_E}{Total\ number\ of\ farms_E} \quad (3)$$

Average tobacco production per N ($\overline{TP}_E$)is then calculated using two criteria: If an average production $\bar{P}_E$ is higher than the maximum size of census data in the interval (Table 2.4), due to more than one harvest per year (e.g. corn, bins, and tobacco), but lower than the tobacco average production in Table 2.3, is considered the largest tobacco production size interval. In the remaining cases, tobacco production is considered the average one in the 2017 Brazilian Tobacco Yearbook (Table 2.3).

This assumption was made considering that the price of tobacco production is much higher than the non-tobacco one. Hence, producers with a very small area, i.e. smaller than average, tend to use all of it to grow tobacco. Also, since updated values of tobacco and non-tobacco production by size are not available, using average 2017 values is the best estimate.

The tobacco production average estimate allows for the calculation of total tobacco production, as in Equation 4, which is average $\overline{TP_E}$ times the $Number\ of\ farms_E$. Equation 5 estimates non-tobacco production by subtracting tobacco production from total production.

$$Tobacco\ production_E = \overline{TP}_E * Number\ of\ farms_E \quad (4)$$

$$Ntobacco\ production_E = Total\ production_E - Tobacco\ production_E \quad (5)$$

The tobacco income in Equation 6 and non-tobacco income in Equation 7 are also calculated based on the production price per hectare released by the 2017 Brazilian Tobacco Yearbook.

$$Tobacco\ income_E = Tobacco\ production_E * Tobacco\ price_A \quad (6)$$

$$NTobacco\ income_E = Non\ tobacco\ production_E * Non\ tobacco\ price_A \quad (7)$$

The impact of restrictive policies on tobacco production has been simulated. After estimating the tobacco income by farm size (Table 2.6), four scenarios were estimated with restriction policies and one with a reduction above the average dependence on tobacco income (around 40%), totaling five scenarios. Thus, if the estimated tobacco income in the interval is higher than the policy restriction to tobacco production, reduced production can be observed, whereas if the income is lower, increased production can be observed.

Table 2.6 – Tobacco income restriction scenarios

Income from non-tobacco activities	Description
1) 20%	Based on the PRONAF restriction. The Brazilian Central Bank Resolution N. 4.513, dated August 24, 2016.
2) 30%	
3) 40%	
4) 50%	
5) 60%	Restriction based on the average dependence on tobacco income (40%).

Source: Author (2018).

The results in the next section show an estimation of rural credit restrictions for each interval from the census and simulate how tobacco production behaves under income restrictions.

2.3 RESULTS AND DISCUSSION

As presented in the Methodology, the estimate utilizes the total of 123,562 farms and 1,303,060 hectares of production (Table 2.3). Nevertheless, as the participation of tobacco and non-tobacco production in each interval is unknown, the estimate is not exact. When compared with the hard data from the 2017 Brazilian Tobacco Yearbook, it underestimates the total tobacco production by -5.0% and overestimates non-tobacco production by 2%. Intervals with more dependence on tobacco income are 2-3 hectare farms, which will use most of the area to produce tobacco (around 58%). Farms larger than 2.5 thousand hectares present the lowest dependence on tobacco (2%) (Table 2.7). On average, dependence on tobacco in the estimate is 39%, which is close to the data in the 2017 Brazilian Tobacco Yearbook (40%).

Farms with 0.1 to 20 hectares (N = 1 to 10) dedicate more than 76% of their agricultural land to tobacco production. These intervals also have the greater number of farms (78%). Those above (N = 11 to 17) comprise 22% of the farms and 23% of the tobacco income (Table 2.7). Hence, most of the tobacco productionis smaller than the minimum size for agricultural holdings in the region, which is 20 hectares, according to the Brazilian National Institute of Colonization and Agrarian Reform (INCRA, in Portuguese).

Table 2.7 – Results of tobacco income estimation based on the Census 2006 (IBGE, 2006) and BRAZILIAN TOBACCO YEARBOOK 2017

N	$Number\ of farms_E$	$Total\ production_E$ (ha)	$\bar{P}_E$ (ha)	$\overline{TP}_E$ (ha)	$Tobacco\ production_E$ (ha)	$Tobacco\ Income_E$ (R$)	$NTobacco\ production_E$ (ha)	$NTobacco\ Income_E$ (R$)	**Tobacco income**
1	116	188	1.6	0.1	11.64	237,414.09	176.35	1,608,452.30	13%
2	252	302	1.2	0.2	50.40	1,028,248.61	251.30	2,292,120.72	31%
3	2,753	5,136	1.9	0.5	1,376.35	28,080,356.12	3,759.52	34,290,619.13	45%
4	5,169	22,393	4.3	1.0	5,169.15	105,460,975.96	17,224.02	157,100,270.76	40%
5	5,740	29,899	5.2	2.0	11,479.51	234,204,906.09	18,419.05	168,000,149.73	58%
6	5,928	56,511	9.5	2.4	14,323.10	292,219,798.95	42,187.80	384,794,912.63	43%
7	6,446	60,874	9.4	2.4	15,573.72	317,735,132.69	45,300.23	413,183,384.40	43%
8	6,742	71,181	10.6	2.4	16,289.20	332,332,277.11	54,891.32	500,663,715.06	40%
9	27,099	279,584	10.3	2.4	65,472.85	1,335,777,169.53	214,111.03	1,952,906,660.54	41%
10	36,125	421,910	11.7	2.4	87,280.33	1,780,693,384.34	334,629.77	3,052,158,148.24	37%
11	23,418	290,218	12.4	2.4	56,578.85	1,154,321,610.06	233,638.83	2,131,019,759.27	35%
12	3,066	45,116	14.7	2.4	7,408.77	151,153,628.24	37,707.12	343,926,635.41	31%
13	516	10,413	20.2	2.4	1,246.75	25,436,216.42	9,166.57	83,608,290.31	23%
14	150	3,124	20.8	2.4	362.59	7,397,468.85	2,761.18	25,184,713.30	23%
15	17	1,560	92.5	2.4	40.72	830,731.80	1,518.84	13,853,369.62	6%
16	10	1,244	119.2	2.4	25.21	514,262.54	1,218.73	11,116,031.18	4%
17	13	3,409	265.5	2.4	31.02	632,938.51	3,378.20	30,812,530.47	2%
Total	**123.562**	**1.303.060**			**282,720.15**	**5,768,056,519.91**	**1,020,339.85**	**R$ 9,306,519,763.08**	

Source: Authors

Table 2.8 compares tobacco and non-tobacco production data with scenarios considering income restrictions. Scenarios 1 to 4 show that PRONAF restrictions have not decreased tobacco production size.

In scenario 1, which portrays PRONAF restrictions from 2005 to 2016, tobacco income is restricted to 80% and non-tobacco income to 20%. These constraints, however, could allow an increase of 308 thousand hectares of tobacco, which accounts for more than 100% in the total amount of tobacco-cultivated area.

Total production of small farmers, with less than 20 hectares of agricultural land, has not been affected either, and restrictions could allow an increase of 218 thousand hectares of tobacco production. Currently, regardless of the fact that PRONAF provides the lowest interest rates available, the Program has granted only 131 loans to tobacco producers. According to Scenario 1, there are nearly 96 thousand properties that do not use PRONAF loans for non-tobacco activities.

In Scenarios 2, 3, 4, which show a progressive increase of non-tobacco income to 30%, 40%, and 50%, constraints could not decreased total production. In other words, even with the approval of more restrictive resolutions, there has been no reduction in tobacco production.

Total production could increase 234 thousand hectares in Scenario 2, 160 thousand hectares in Scenario 3, and 86 thousand hectares in Scenario 4, i.e. there is still room for tobacco production – more than 82%, 56% and 30%, respectively. The only estimated decreased production is for farms with more than 1 and less than 2 hectares (a decrease of 1.6 thousand hectares).

Scenario 5, which considers restrictions of 40% on tobacco income, a percentage higher than that of tobacco average income, there is stimulus to reduce tobacco production. The impact, however, is stronger on smaller holdings. Intervals 9 and 10 show greater impact, with reductions of 17 thousand and 16 thousand hectares, respectively. In larger properties, with more than 200 hectares, and those with less than 0.1 hectare, a decrease in tobacco-cultivated area has not been observed. Should restriction on non-tobacco income be of at least 60% production would decrease by 61 thousand hectares, which accounts for 20% of the cultivated area.

Table 2.8 – Results of the difference of the tobacco income estimate Table 2.7 and estimates of the restriction scenarios

N	Total reduction or increase in production (ha)				
	Scenario 01	Scenario 02	Scenario 03	Scenario 04	Scenario 05
1	60.74	51.70	42.65	33.60	15.51

N	Total reduction or increase in production (ha)				
	Scenario 01	Scenario 02	Scenario 03	Scenario 04	Scenario 05
2	79.80	63.52	47.25	30.97	-1.58
3	1,069.33	763.62	457.91	152.20	-459.22
4	5,126.36	3,839.42	2,552.48	1,265.54	-1,308.33
5	4,291.69	2,320.29	348.89	-1,622.51	-5,565.31
6	12,223.90	8,905.52	5,587.15	2,268.78	-4,367.97
7	13,086.94	9,504.35	5,921.77	2,339.19	-4,825.98
8	16,374.11	12,291.19	8,208.28	4,125.37	-4,040.46
9	63,482.50	47,363.08	31,243.66	15,124.24	-17,114.60
10	102,224.68	78,536.55	54,848.42	31,160.30	-16,215.96
11	72,245.44	56,142.41	40,039.37	23,936.33	-8,269.74
12	12,004.24	9,577.62	7,150.99	4,724.37	-128.89
13	3,029.08	2,494.61	1,960.13	1,425.65	356.69
14	915.02	755.32	595.62	435.92	116.52
15	535.07	463.10	391.12	319.15	175.20
16	430.84	373.83	316.83	259.82	145.81
17	1,202.01	1,047.88	893.75	739.62	431.36
Total	**308,381.75**	**234,494.01**	**160,606.28**	**86,718.54**	**- 61,056.94**

Source: Author (2018).

In a nutshell, restrictions on tobacco income currently do not affect tobacco production and are not effective to stimulate non-tobacco production. Only restrictions on tobacco production at a percentage above that registered for the average participation of tobacco income in a farm total production could reduce tobacco production. Additionally, the low number of PRONAF loans is not associated with restrictions on tobacco income. These facts may serve as an alert to the public authorities regarding the PNCT inefficiency and ineffectiveness.

2.4 CONCLUSION

Brazil hasachievedsignificant progress in the reduction of cigarette consumption. However, the impact of restrictive policies on production is not as discussed as that on health. Even though the country has structured policies to replace tobacco production, their effectiveness has not yet been assessed.

The restrictions of the National Control Policies created in 2005 have not been associated with the decrease in the Brazilian tobacco production. Oscillation in volumeis explained by increased productivity, changes in prices, and increased Asian market and reduced USA imports and Africa exports.

Nonetheless, PRONAF restrictions may have changed the financing of tobacco. In 1999 the program was responsible for 86% of the loans granted to farmers and in 2017, for less than 1%. Moreover, producers have migrated from PRONAF to other credit lines because the government reduced the subsidies for tobacco production. The PNCT policy to reduce tobacco dependence through the Central Bank Resolution n. 4,513 has not been effective. This resolution and the ones before that have not been able to stimulate non-tobacco production. As the estimates have shown, even the most restrictive resolution has caused tobacco production to increase in all intervals.

Even with the PRONAF restrictions, rural credit is still very important to small farms, gradual increase to 50% of non-tobacco income (as in Resolution n. 4,513) would impact farms from 1 to 2 hectares. As Panzutt and Monteiro (2015) showed, family agriculture has a critical social role in mitigating rural exodus and social inequality in both the countryside and the cities. The PNCT income restriction has had a negative effect on small farms since they may not find a way to diversify their crops and keep the same level of income that tobacco provides. Their reduced income could increase rural exodus and unemployment and still not affect tobacco production.

Changes in restriction conditions, however, could stimulate non-tobacco production and restrictions would not be so harmful to local economy. The 2017 Brazilian Tobacco Yearbook shows that the profitability per hectare of non-tobacco activities is significantly smaller than those related to tobacco and a large area is required for farmers to generate the same income. Restrictive policies should thus focus on stimulating non-tobacco activities in larger farms to achieve the expected diversification. By replacing their crops, large and medium-sized farms would create spillover, thus allowing small farms to replace their tobacco production naturally and with a higher profitability.

However, it is important to emphasize the methodology limitations, once it uses the 2006 size distribution and only average results are considered. In addition, once average tobacco and non-tobacco size productions are used in the estimates, difference in intervals may affect results. Moreover, considering the influence of tobacco corporations on agricultural loans, the reasons for PRONAF under utilization should be deeply investigated.

Future studies could provide more accurate results regarding tobacco income by farm size with the publication of the 2017 Agricultural Census. Also, other methodologies such as difference-in-difference might be applied to assess the impact of tobacco production policies by comparing information from before and after them.

Taking into account the world's trend to reduce tobacco product consumption, it is crucial to build an alternative scenario for tobacco producers. Nowadays, even with technical diversification programs, there is no financial encouragement for the production of non-tobacco crops. Finally, cigarette sale reduction may cause social and financial losses if farmers cannot grow alternative crops in time.

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APPENDIX A – INFORMATION OF TOBACCO RURAL CREDIT CONTRACTS

Table A.1 – Information of tobacco rural credits contracts - 1999 to 2017.

	PRONAF			Pronamp			Rural Credit without program specified			Rural Credit Total		
Year	**General**	**Tobacco**	**% Tobacco Contracts**	**Total Pronamp**	**Total contracts Pronamp in Tobacco**	**% Tobacco Contracts**	**Total Program not specified**	**Total Program not specified Tobacco**	**% Tobacco Contracts**	**Total contracts**	**Total contracts in Tobacco**	**% Tobacco Contracts**
1999	651,220	114,866	17.64%							739,230	133,114	18.01%
2000	709,372	113,373	15.98%							761,516	143,255	18.81%
2001	647,505	70,162	10.84%							750,564	160,067	21.33%
2002	637,264	49,017	7.69%							860,747	200,337	23.27%
2003	722,843	801	0.11%							1,132,800	199,054	17.57%
2004	785,733	1,142	0.15%							1,376,592	279,989	20.34%
2005	748,499	1,354	0.18%							1,377,211	323,604	23.50%
2006	728,915	1,325	0.18%							1,203,405	242,371	20.14%
2007	685,983	1,242	0.18%							1,129,612	204,969	18.15%
2008	636,780	1,085	0.17%							1,112,984	238,737	21.45%
2009	652,902	925	0.14%							1,027,681	204,271	19.88%
2010	541,962	705	0.13%							936,672	172,554	18.42%
2011	485,263	549	0.11%							850,901	144,208	16.95%
2012	469,472	409	0.09%							832,066	129,800	15.60%
2013	438,048	179	0.04%	107,342	30,446	28.36%	255,842	113,422	44.33%	801,232	144,047	17.98%
2014	426,111	180	0.04%	129,633	35,193	27.15%	225,250	93,258	41.40%	780,994	128,631	16.47%
2015	380,004	157	0.04%	97,311	5,253	5.40%	208,324	83,934	40.29%	685,639	89,344	13.03%
2016	357,295	155	0.04%	93,853	6,053	6.45%	182,765	75,128	41.11%	633,913	81,336	12.83%
2017	319,731	131	0.04%	77,099	753	0.98%	171,925	76,952	44.76%	568,755	77,836	13.69%

Source: Author (2018) based on MATRIZ DE DADOS DO CRÉDITO RURAL (2018).

Table A.2 – Information of tobacco rural credits contracts - 1999 to 2017.

	PRONAF			Pronamp			Rural Credit without program specified			Rural Credit Total		
Year	**General (R$) ('000.000)**	**Tobacco (R$) ('000.000)**	**% Tobacco Contracts**	**General (R$) ('000.000)**	**Tobacco (R$) ('000.000)**	**% Tobacco Contracts**	**General (R$) ('000.000)**	**Tobacco (R$) ('000.000)**	**% Tobacco Contracts**	**General (R$) ('000.000)**	**Tobacco (R$) ('000.000)**	**% Tobacco Contracts**
1999	1,318.11	215.26								4,907.96	254.94	5.19%
2000	1,457.59	199.61								5,417.43	248.08	4.58%
2001	1,499.10	169.70								6,160.47	364.02	5.91%
2002	1,485.43	126.36								8,151.55	469.85	5.76%
2003	1,865.69	1.03								12,948.87	822.20	6.35%
2004	2,524.84	1.86								15,962.64	904.82	5.67%
2005	2,790.91	2.53								14,737.78	858.21	5.82%
2006	2,997.63	2.71								14,783.48	755.22	5.11%
2007	3,246.39	2.87								18,538.86	601.01	3.24%
2008	3,995.75	2.76								23,575.71	769.24	3.26%
2009	4,249.37	2.49								25,619.27	764.26	2.98%
2010	4,288.16	2.29								26,581.13	597.67	2.25%
2011	4,691.11	1.96								29,437.40	437.51	1.49%
2012	5,349.32	1.65								35,036.68	444.52	1.27%
2013	6,146.83	1.25	0.02%	6,534.86	64.73	0.99%	39,357.96	466.08	1.18%	45,892.82	530.81	1.16%
2014	6,932.94	1.75	0.03%	8,979.55	101.16	1.13%	45,311.87	408.94	0.90%	54,291.42	510.10	0.94%
2015	7,433.96	1.74	0.02%	9,649.51	25.68	0.27%	46,651.72	375.19	0.80%	56,301.23	400.86	0.71%
2016	7,906.83	2.24	0.03%	10,448.97	37.22	0.36%	48,413.74	406.07	0.84%	58,862.71	443.29	0.75%
2017	7,710.68	2.57	0.03%	10,316.39	7.82	0.08%	46,924.54	398.62	0.02%	57,240.94	406.44	0.71%

Source: Author (2018) based on *MATRIZ DE DADOS DO CRÉDITO RURAL (2018).*

3. INTERNATIONAL TOBACCO TRADE: MODELLING THE EFFECTS OF REDUCED CONSUMPTION ON THE BRAZILIAN PRODUCTION

ABSTRACT

Evidence on the harmful effects of smoking on human health has led to an intense debate about tobacco consumption. The Framework Convention for Tobacco Control (FCTC) established a series of measures aimed at reducing tobacco products. Brazil is the largest tobacco exporter in the world and demand reduction has been a great concern to tobacco stakeholders in the country. This study analyzes the impact of consumption decrease and changes in global trade through the model of mixed complementarity problem (MCP) focusing on the Brazilian market. The model was calibrated using information about the international tobacco market and estimated a scenario of demand decrease based on the World Health Organization forecast for 2025 and a scenario of the free market. The model outcomes support the idea that there are unreported subsidize and the decline in world's consumption leads to a decrease in production of about 5.6% and a decrease in producer surplus of US $897 million. The results reinforce the need for policies to diversify agriculture for Brazilian tobacco producers in the short term.

Keywords: Mixed Complementarity Problem, MCP, Tobacco, FCTC.

3.1 INTRODUCTION

Tobacco is an ancient culture. It originated in America and has grown in more than 100 countries around the world. Brazil is one of the most important tobacco producers and the most significant tobacco exporter. According to the Food and Agriculture Organization of the United Nations (FAO), the Brazilian crop accounted for a total production of 862 thousand tons in 2014 (about 12% of the world's total production). The greatest tobacco producer, however, is China, with the most excellent consumer market and nearly half of the world's tobacco farmers (an estimated 15 million) (WARNER, 2000).

Studies about the future of the international tobacco market have projected that subsidies and incentives for tobacco production in developed countries are declining (FAO, 2003). At the same time, production in developing countries is rising, even with the worldwide unanimity on reducing tobacco consumption.

Evidence that smoking is harmful to health has made most countries adopt tobacco control measures. The Framework Convention for Tobacco Control (FCTC) is the most critical tobacco control agreement worldwide. It brings together 192 countries and works to regulate tobacco consumption and production with measures covering health and environmental problems. In 2005, the year in which the FCTC came into force, there were 1,134 billion smokers. Ten years later, this number was reduced by 20 million. If countries maintain tobacco control at the current intensity, an additional 20 million fewer smokers are projected for the period 2015–2025 (WTO, 2018).

Reduced demand has generated concern about the effects of decreasing tobacco activity for farmers in low and middle-income countries. Thus, as the second greatest producer and greatest tobacco exporter in the world, Brazil is deeply affected by changes in the tobacco market. This study aims to analyze the impact of reduced demand for tobacco products and how tobacco trade tariffs have affected the Brazilian economy.

The study describes and evaluates the major tobacco producing and consuming regions of the world. Additionally, it estimates tariff and non-tariff barriers in regions using the mixed complementary problem (MCP) model. Trade flows and equilibrium prices have been calculated and producer and consumer surplus per country/region have been analyzed. Finally, the impact of reduced demand and trade barriers on prices, production, and consumption has been verified considering the Brazilian tobacco stakeholders.

Therefore, the first section analyzes tobacco market features worldwide as well as the Brazilian production. Subsequently, the MCP methodology is presented, and different scenarios

are analyzed: consumption reduction, free trade, and elasticity sensitivity. The last one presents the conclusion about how demand reduction affects the Brazilian market and alternatives for the future.

3.1.1 TOBACCO MARKET FEATURES

Asia and America are the most important tobacco producers worldwide. They accounted for more than 88% of the total world's crop in 2014 (FAOSTAT - Unmanufactured Tobacco). The rest of production is from Europe, Africa and around 0.04% in Oceania. However, the production share in 2012, 2013 and 2014 increased in Africa and undeveloped countries. These regions exhibit strong tobacco sectors, but according to Warner (2000), in most countries, tobacco manufacturing employment is below 1%, and only a few countries have 10% or more of total government revenues from tobacco taxation.

According to Sonmez (2014), tobacco production has shifted from developed to underdeveloped countries, because the cigarette production and consumption decline in developed countries. Also, the economies of underdeveloped countries are highly tobacco dependent and more vulnerable to tobacco restriction adjustments and international regulation pressures.

Lecours *et al*. (2012) reported that reduced market power of farmers against the tobacco industry had stimulated a cycle of farmers' indebtedness with the tobacco buying industries. Also, there is a concern about safety in labor during periods of peak demand on family farms, specifically with the excessive number of worked hours and child labor. In the environmental dimension, the main problems associated with tobacco production are related to the pollution and sedimentation of rivers, reservoirs and irrigation systems due to reduced vegetation cover and soil erosion. Regarding human health, it stands out for the frequent intoxication due to use of pesticides and Green Tobacco Sickness (GTS)[4].

In reason of control restrictive measures and the potential impacts on tobacco demand, in the last decade, there were significant changes in the global tobacco chain. Goger, Bamber, and Gereffi (2014) show that tobacco companies in this period have made mergers, acquisitions and the establishment of joint ventures, with a critical spatial reorganization[5]. In the reorganization

[4] Problems arising from the absorption of nicotine through the skin due to exposure and handling of tobacco leaves

[5]Currently, it is possible to restrict the worldwide cigarette market in five big companies which operates worldwide (Chinese National Tobacco Co. (CNTC), Philip Morris International (PMI), British

process, there was a relocation of companies, consolidating their positions in developing countries, especially in Asia and Latin America.

Prowseand Moyer-Lee (2014) also demonstrated that tobacco production chain has become more buyer-driven and vertically integrated due to changes in patterns of demand and supply. On the demand side, the factors that have most contributed to increasing vertical integration and the globalization of tobacco chain are population and income growth, urbanization and increased participation of women in workforce in developing countries. On the supply side, market liberalization, increased product differentiation, and strict standards of process control and production. According to studies conducted in markets such as China and developing countries (TEH-WEI et al., 2008 and TAYLOR et al., 2010), the increase in taxes also has direct impacts on production.

The progressive increase of tobacco production in the last developing countries reinforces the slow transition to alternatives agriculture production, due to the high returns of tobacco products, low investments, and specialized agricultural techniques. Also, the tobacco can be an essential source of foreign currency for underdeveloped countries. For example, Zimbabwe, exports almost all of its tobacco crop (TAYLOR et al., 2010). Besides the FCTC efforts due to the control of tobacco products, the Food Deficit Countries from 2012 to 2014 accounted for more than 19% of world's production, the net Food-Importing Developing Countries more than 11% and the Least Developed Countries 8%.

In Brazil, tobacco leaf exports have consistently grown over the last 25 years, 128,000 tons in 1980 to 461,000 tons in 2014, with a peak of 694,000 tons in 2007. In the 1990s, the Brazilian tobacco industry reached the status of the world's largest tobacco exporter. The country has shown not just records in productivity on large scale, but also high-quality products reached with seeds technology and the adoption of the Integrated Tobacco Production System (ITPS). Tobacco companies select producers and provide seeds, agrochemicals, and fertilizers through a purchasing contract. After purchase of the tobacco, the entry values are discounted from the total price of the tobacco crop.

The decline in production, in countries such as the United States of America and Zimbabwe, also facilitated the rapid growth of Brazilian exports in the international market. On

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American Tobacco (BAT), Japan Tobacco (JT), and Imperial Tobacco Group (ITG)) and have more than 80% of global cigarette production and consumption (EUROMONITOR INTERNATIONAL, 2009).

the other hand, the market also had a boost with the entrance of large buyers such as China, Germany, Japan, the Republic of Korea, Russia, and in Far East countries.

According to data from COMEX STAT, in 2014, the most important Brazilian tobacco market was European Union (42%) followed by Far East (28%); North America (10%); Eastern Europe (8%); Africa/Middle East (6%); and Latin America (6%). The majority of Brazilian exports are tobacco Virginia, tobacco Burley, and tobacco wastes (63%, 11%, and 24%, respectively). Virginia tobacco is the most common variety in the south, with 63% of the total tobacco export volume in 2014. Tobacco wastes are consisting of materials such as tobacco dust, is used as raw material in the manufacture of cigarettes, and account for 24% of tobacco volume exports. In the harvest of 2014/2013 compared to 2013/2012, Brazilian shipments abroad fell 24%, in dollar terms and tons. The drop, nonetheless, did not affect the country's leadership in global exports. During 2014, 13 countries stopped purchasing Brazilian tobacco, but meanwhile, seven new countries adhered to the list of importers, totaling 96 countries that bought tobacco produced by upwards of 162 thousand Brazilian family farmers.

Although Belgium and Holland have reduced their purchases by around 30%, compared to 2013, the European Union remains the primary destination for Brazilian tobacco (42%), followed by the Far East (28%). China also contributed to the reduction in shipments, which fell by 27% over the previous year. However, the country that more reduced its imports was the United States, with a 42% reduction. In 2014, Brazilian tobacco lost its competitive edge due to the unfavorable exchange rate during the first half of the year and competing countries, particularly in Africa, harvested more abundant crops.

USA share in the world cigarettes and tobacco consumption and exports declined sharply in recent years. Serletis and Fetzer (2008) discuss the factors that contributed to the decline of USA tobacco consumption and exports and indicate that the intense competition from underdeveloped countries, the decrease of domestic consumption, and the tobacco-saving technological advancements in cigarette manufacturing, are the primary responsibility for the fall. In 2004, the government ended the federal tobacco program, eliminating support for price and geographic and quantitative restrictions on tobacco production in the country. The program cessation expects competitive prices to increase the exports to international markets that demand better quality tobacco crops.

Despite the rearrangements of tobacco production, smoking is declining in almost all regions of the world, except in the African and East Mediterranean regions, where trends appear to be flat (Table 3.1). Also, smoking prevalence has a negative gap between the projected goal and the WHO target in all regions except in America. In other words, the smoking reduction

has been slower than projected. Countries such as Brazil, however, have been showing positive numbers in reducing smoking and implementing the FCTC agreements.

Table 3.1 – Estimative of smoking prevalence in 2015 by region and perspectives and targets of smoking in 2020 and 2025.

Region	estimated prevalence of smoking	Project prevalence of smoking		2025 Target (%)	Gap
	2015 (%)	2020 (%)	2025 (%)		
All	20.2	18.7	17.3	15.5	-1.8
African	10.0	9.4	9.0	7.4	-1.6
Americas	17.4	15.0	13.0	14.2	1.2
EasternMediterranean	18.1	18.3	18.7	12.6	- 6.1
European	29.9	28.0	26.3	22.4	- 3.9
South-EastAsian	17.2	15.8	14.7	13.2	- 1.5
Western Pacific	24.8	23.5	22.3	18.4	- 3.9

Source: World Health Organization – WHO (2018).

The ratification of the FCTC by Brazil, however, involved a long process of confrontation between health and the productive sector of tobacco. As emphasized by Cavalcante *et al*. (2017), the tobacco industry had invested in a broad movement to spread the idea that the Convention would ban tobacco cultivation and that the country's accession to the treaty would have a strong negative impact on the livelihoods of 200,000 tobacco-producing households.

Only after two years (2004 and 2005) of debates, the Federal Senate approved the ratification of the WHO-FCC in October 2005 (Legislative Decree no. 1.012). By ratifying the Convention and creating the National Tobacco Control Policy (PNCT, in Portuguese), many of its measures have been implemented in the country. Since 1989, however, the Ministry of Health, through its National Institute of Cancer José Alencar Gomes da Silva (INCA), articulates national actions for the control of smoking.

The next section discusses the methodology for estimating the impacts of declining demand on international tobacco trade.

3.2 METHODOLOGY

The proposed methodology simulates the elimination of commercial transactions costs, tariffs, and subsidies. Indeed, there is no trade without these costs, as some are inherent and unavoidable in business transactions, such as commodity financial arbitrage or transportation insurance. However, the objective is to test the potential impacts that transaction costs pose on international trade and to simulate free trade and other scenarios.

Alvim (2010) applied the methodology of partial equilibrium models for the dairy market in Brazil. Like the tobacco market, the dairy market goes through a series of business practices that can be detailed and evaluated by the methodology. The Mixed Complementarity Problem (MCP), presented by Rutherford (1995, 2002), Ferris and Munson (2000) and Bishop, Nicholson, and Pratt (2001), was developed from the presentation of the optimization problem with constraints in the form of inequalities. The model has already has been used by Alvim (2003 and 2010), Alvim and Waquil (2004) and Oliveira and Silveira (2013) for Brazilian agribusiness models.

The method consists of a system of simultaneous linear and, or non-linear equations, presented in the form of inequalities. Equations are derived from supply and demand functions of the products considered in each analyzed region.

The MCP assumes that products are homogeneous and considers the supply and demand functions of each region, transport costs between regions, and the presence of barriers to trade. The objective is to estimate quantities produced and consumed, trade flows and price levels in equilibrium. Thus, we can estimate the welfare levels, measured by the producer's surplus and consumer surplus, as well as the variations of gains or losses occurring from different simulated scenarios.

The set of equations presented below corresponds to the MCP and represents the conditions for obtaining prices, produced and consumed quantities, and the trade flows between regions, regarding tariffs and subsidies implemented in markets. Complementarity lies in the fact that the price of a good must be zero whenever there is an excess in the supply of the good. The result, the optimal solution, is obtained from the convergence of equations (01), (02) and (03). The economic explanation is that if $q_i^s > \sum_j^J X_{i,j}$, there is an excess supply in region i. In a competitive market, the rational person will not be willing to pay for the additional supply of the product of this region, so the price of region i tends to zero and $\varphi_i = 0$. Alternatively, if $q_i^s = \sum_j^J X_{i,j}$ there will be a willingness to pay for the greater supply of the product and $\varphi_i > 0$, that is, prices will be upwards. The rise in prices attract new suppliers, increasing the production

of the commodity and directing the market to an excess supply where the quantity offered will exceed the trade flow or the flow will exceed the quantity demanded $q_i^s > \sum_j^J X_{i,j}$. This situation will lead to low market prices whose limit is $\varphi_i = 0$ and will be repeated until the moment of the trade flow is equal to the quantities offered and demanded of the regions i e j $q_i^s = \sum_j^J X_{i,j}$and $\sum_i^I X_{i,j} = q_j^d$, satisfying the inequalities of the problem.

To MCP convergence (Equations 01 to 03) is included a fourth equation (Equation 04) in estimating the costs of commercial transactions and in allowing the calibration and validation of the model. The method uses the propositions of Paris, Drogué and Anania (2010), which developed a trade calibration model based on Karush-Kuhn-Tucker (KKT) conditions. The authors use the specifications of the studies of Samuelson (1952) and Takayama and Judge (1971), introducing in the mathematical programming formulations an adjustment variable for the solutions of the optimization problems.

The complementarity condition given by equation 04 determines that the market price of the region of demand j (λ_j) must be less than the supply price of region i (φ_i), plus the costs $(t_{ij})$of taking the commodity to the demand region (subsidies and the tariff percentage corresponding to the product) which depends on the policies of each country. If this sum exceeds the market price of region j, the trade flow of the product from the supply region i to the demand region j will happened. Thus, the condition where the sum of prices and costs exceeds the consumer's willingness to pay $(\gamma_{i,j})$ should lead to a fall in trade, and excessively high costs may restrict trade flows between regions.

The variable costs of commercial transactions $(\gamma_{i,j})$ is the only variable in the model that that assumes positive or negative values (free). Negative values can occur, according to Paris, Drogué and Anania (2010), due to the effect of trade policies, such as subsidies that, when higher than the costs of commercial transactions, make this variable negative. The positive variables are conditioned by inequalities and the free variables by equations, according to Ferris and Munson (2000).

In the first estimation phase are estimate the costs of commercial transactions, quantities, prices, commercial flow. The variable of the commercial transactions cost between producing region i, and consumer j is a variable endogenous to the model and is defined as $\gamma_{i,j}$. The mathematical expression of MCP in the first phase, to obtain the cost variable of commercial transactions, is given by equations 01 to 04.

$$\sum_{j}^{J} X_{i,j} \leq q_i^s \varphi_i \geq 0 \qquad \left[q_i^s - \sum_{j}^{J} X_{i,j}\right] \varphi_i = 0 \tag{1}$$

$$q_j^d \leq \sum_{i}^{I} X_{i,j}\, \lambda_j \geq 0 \qquad \left[\sum_{i}^{I} X_{i,j} - q_j^d\right] \lambda_j = 0 \tag{2}$$

$$X_{i,j} = \overline{X}_{i,j} \gamma_{i,j} = free\left[X_{i,j} = \overline{X}_{i,j}\right] \gamma_{i,j} = 0 \tag{3}$$

$$\lambda_j \leq \varphi_i + t_{i,j} + \gamma_{i,j} X_{i,j} \geq 0 \qquad \left(\gamma_{i,j} + \left(t_{ij} + \varphi_i\right)\left(1 + tar_{i,j}\right) - \lambda_j\right) X_{i,j} = 0 \tag{4}$$

In equation 01 to 04:

q_j^d Quantity demand in the region j (endogenous variable).

q_i^s Quantity supplied in the region i (endogenous variable).

$X_{i,j}$Trade flow between the region i and region j (endogenous variable).

$t_{i,j}$ Transportation cost from the region i to the region j (exogenous variable).

$tar_{i,j}$ Tariff of the product from the region i to the region j (exogenous variable).

φ_i Lagrange multiplier: shadow-price in the producing region i (endogenous variable).

λ_j Lagrange multiplier: shadow-price in the consuming region j (endogenous variable).

$\gamma_{i,j}$ Lagrange multiplier: shadow-price in the producing region i and in the consuming region j (endogenous variable).

In the second phase of the problem, the transaction costs variable generated in the first phase ($\hat{\gamma}_{i,j}$) is introduced into the model. At this stage, this variable is considered as exogenous. In this way, the quantities and prices of supply and demand are estimate, or, the quantity of commercial flow becomes endogenous variable. The mathematical expressions of MCP in the second phase are identical to those of the second phase, except for equation 04, which is replace by 05 since now $\gamma_{i,j}$ becomes exogenous $\hat{\gamma}_{i,j}$.

$$\lambda_j \leq \varphi_i + t_{i,j} + \gamma_{i,j} X_{i,j} \geq 0 \qquad \left(\hat{\gamma}_{i,j} + \left(t_{ij} + \varphi_i\right)\left(1 + tar_{i,j}\right) + S_i - \lambda_j\right) X_{i,j} = 0 \tag{5}$$

The optimal solution is obtained from the convergence of the complementary equations (1), (2) and (5) in this second phase. From the results obtained in this phase, the base and alternative scenarios can be created.

a. Database

The MCP model was estimated using different sources of date about tobacco in production, trade, prices, elasticity, transport cost, and tariffs (Table 3.2). Considering the importance on the tobacco trade market and availability of data were selected seven regions and

countries. Thus, total tobacco trade, consumption, and production is divided between Brazil, China, USA, Europe Union and the Rest of the World (RW).

The total production and consumption of each place was estimated according to the average of the production and trade. The average intends to minimize any variability caused by losses in crop or economic oscillations. We considered tobacco as one only variety, in reason of data availability. However, there are at least three different tobacco varieties with different prices.

The study used only official data from governmental sources. If we consider the Brazilian information, for example, as stated in Iglesias *al.* (2007) in the occupation and income survey of official data and private estimates there are contradictory points. This happens especially in reason of the importance of the illegal market in the tobacco economy.

Table 3.2 – MCP model calibration data source.

Variable		**Description**
Production (Kg)	Food and Agriculture Organization of the United Nations (FAOSTAT).	Tobacco unmanufactured average of crops 2012, 2013 and 2014. In reason of losses during the steering process, we consider 89% of tobacco total production to have more realistic estimative in the trade flows.
Trade flows (Kg)	United Nations International Trade Statistics Database (COMTRADE DATABASE).	Tobacco and manufactured tobacco substitutes or Unmanufactured tobacco (Commodity code 240120). Average importing and exporting flows in 2013, 2014 and 2015.
Elasticity	Analyzing the impact of changes in tobacco trade barriers and cigarette taxes on developing countries. -A Global Simulation Model Approach (MUSONA, 2016).	Industry supply and composite demand elasticities were obtained through The Agricultural Trade Policy Simulation Model (ATPSM).
Prices (USD)	United Nations International Trade Statistics Database (COMTRADE DATABASE).	Average of the total imported amount (US$) divided by the total quantity (China, Europe Union and Rest of the World), or of total exported amount divided by the total quantity exporting (Brazil and USA,) 2013, 2014 and 2015.
Transportation cost (USD/ ’000 tons)	The Organization for Economic Co-operation and Development (OECD, 2018) and the United Nations International Trade Statistics Database (COMTRADE DATABASE).	Dataset Maritime Transport Costs 2007 (OECD, 2018) divide by the total exporter or importer (COMTRADE, 2018) and by the distance between the references ports (Santos, Shangai, Los Angeles, and Rotterdam).

Variable		Description
Tariffs	Market Access Map (MACMAP).	Tariffs in 2016. Commodity code 240120.

Source: Author (2018).

After calibrating the model with market information, the scenarios will simulate a reduction in demand, free market, and sensitivity analyses.

b. Scenarios

In the scenario of demand reduction, the consumption trend estimated by WHO (2018) to 2025 is used (Table 3.3). In America, the reduction from 2015 to 2025 is from 17.4% to 13%, or a decrease of 4.4%. Thus, the projected prevalence considers a reduction of 25.2%, a demand shock of 74.8% in the base scenario. The objective of the scenario is to understand how trade and prices will respond to declining in consumption. Also, how the changes can affect Brazilian production and the prices for the external market.

Table 3.3 – MCP scenario of demand shock: WHO consumption forecast to 2025.

Country/Region	Base Scenario	Projected prevalence in 2025 (demand shock)
Brazil	1	0.748
China	1	0.855
USA	1	0.748
Europe Union	1	0.880
Rest of the world	1	0.857

Source: Authors (2018).

In the simulations, we also verify how free market affects production and prices, and a sensitivity analysis of elasticity. The simulations were performed using the General Algebraic Modeling System (GAMS) through the Path solver.

In the next section, we present the values considered for the MCP model, results and analyzes for each scenario.

3.3 RESULTS AND DISCUSSION

a. Calibration

In the first part of the MCP net exports, production, prices, elasticity, transport cost, and the import tariffs were estimated for model calibration.

Information on net exports considers the average of exports less the average imports of selected regions in the years 2013, 2014 and 2015. Through these values, consumption and trade flow are estimated. Any error in the data released by countries generates divergent information among the reports, due to significant divergences that we do not consider Zimbabwe (an important tobacco producer) in the estimates.

Countries and regions domestic consumption is production minus the net exporting, and importing values (Table 3.4). Brazil, China, and the USA are considered net exporters and the other regions are net importers.

Among countries, Brazil is one of the largest tobacco producers, just behind China and the most prominent tobacco net exporter in the world. According to data from FAOSTAT, the Brazilian harvest in 2014 was responsible for about 12% of the total world's production. China has the highest volume production and is a net exporter to Europe Union and the rest of the world. Also, the country has the second highest consumption among the regions represented by the national stock and domestic consumption. The USA is also net exporter with positive flows to China, The Europe Union and RW and net imports from Brazil. The Europe Union is a net importer with net imports from all the regions. Finally, the RW is a net exporter to Europe Union and a net importer to other regions.

Table 3.4 – Tobacco trade matrix: net exports, production and consumption averages – 2013, 2014 and 2015.

Country/ Region	Trade ('000 tons)					Production ('000 tons)
	Brazil	**China**	**USA**	**European Union**	**Rest of the World**	
Brazil	**367.48**	47.18	41.32	106.06	186.63	748.67
China		**2,814.23**		19.81	67.53	2,901.58
USA		14.86	**236.09**	39.24	24.87	315.06
EU				**190.53**		190.53
Rest of the World				68.04	**5,283.33**	5,351.37
Consumption ('000 tons)	367.48	2,876.28	277.41	423.69	5,562.36	

Source: Author (2018).

As for prices (Table B.1), the calibration considers the average of the total quantity of exports divided by the total volume exported. Importing regions, however, consider importing

values. For elasticity, transport, prices (Table B.2), and tariffs (Table B.3) for "Rest of the World," we consider the parameters of the Europe Union. The estimated price per thousand tones is the average of the total imported amount divided by the total quantity imported into the net importing countries (Europe Union and Rest of the World), and total exported divided by the total quantity exporting (Brazil, China, and the USA).

The cost of transportation to Brazil, China, EU and, Rest of the World was based on the cost per nautical mile for the USA, and the USA was based on the cost per nautical mile for China.

In the calibration model is estimated the transaction cost with the market equilibrium prices (shadow-prices) based on observed data, as described (Table 3.2). The estimated variable represents the cost required for model calibration (PARIS *et al*., 2011). The objective is to correct distortions between the estimated data and the observed data. In this respect, the estimated model represented the market, since there was no variation in between the estimated and observed data.

The cost of commercial transactions (Table 3.5) shows that the highest value is for China to Europe Union US$1,278.00 per ton. The lowest values are in the exports from the USA to Brazil. Analyzing the exporting countries is possible to see that all the locations except China have negative transactional costs. These results reflect subsidies that are not specified but can represent taxes subsidies to export industry or even credit to farmers or industry. These values, not reported in tobacco data, have an impact on prices and market equilibrium.

In Brazil, the drawback regime is an example of a subsides not considered in the model. It was established by art. 78 of Decree-Law no. 37, of 1966 (MDIC) and provides for the suspension, exemption or restitution of taxes imposed on imports in cases related to subsequent export. It is, therefore, a legitimate incentive to export used by transnational companies for the import of raw material or even finish goods and export tobacco.

Table 3.5 – MCP phase I - transactional cost results ('000 US$/Tons)

Country/ Region	Brazil	China	USA	European Union	Rest of the World
Brazil	0.000	-2.107	-2.153	-0.309	-0.560
China	0.784	0.000	0.243	1.278	1.028
USA	-3.013	-4.154	-0.001	-2.319	-2.570
European Union	-1.120	-2.327	-2.479	0.000	-0.776
Rest of the World	-0.835	-2.052	-2.072	-0.255	0.000

Source: Author (2018).

Taking into account the results, the model is adjusted correctly. The next phase simulates different scenarios to understand changes in production, consumption, and price.

b. Base and alternative scenarios

The results of the second phase of the model generate the baseline scenario that serves as a reference for alternatives. In all scenarios, the same trade variables presented previously were used. To test the validity of the baseline scenario, the data were compared with the results obtained in the first phase. Table 3.6 shows the calibration of the model, or the second step of the methodology, with transactional cost $\hat{\gamma}_{i,j}$estimated from the base scenario. The variation between the base scenario and the phase I, indicates the quality of the calibration of the model.

In table 3.6 the results of a phase I show variation below 2.5% for price, consumption, and production (the maximum production variation is -0.6%, consumption 0.6%, and prices -2.5%.). Thus, the model is well calibrated with real world condition and can be used to estimate the scenarios. According to Alvim (2010), the model can be validated in the base scenario since the results in the real world are consistent with those estimated by the model.

Table 3.6 – MCP phase II – calibration results.

Country/ Region	Production ('000 Tons)			Consumption ('000 Tons)			Prices (USD)		
	Phase I	Base scenario	Δ	Phase I	Base scenario	Δ	Phase I	Base scenario	Δ
Brazil	749	747	-0.2%	367	369	0.4%	6.37	6.31	-0.9%
China	2,902	2,894	-0.3%	2,876	2,894	0.6%	4.90	4.84	-1.3%
USA	315	313	-0.6%	277	279	0.5%	8.24	8.04	-2.5%
Europe Union	191	191	0.2%	424	422	-0.4%	6.57	6.62	0.8%
Rest of the World	5,351	5,360	0.2%	5,562	5,541	-0.4%	6.32	6.37	0.8%

Source: Author (2018).

In the first scenario, (Table 3.7), a demand shock was applied according to WHO forecasts to 2025. As a result, the model calculates a new equilibrium with a reduction of about 0.5% in world production and consumption. In Brazil, the impact on production is 5.6%, and the consumption decrease of 20.6%. The high decrease in internal consumption for Brazil and USA is the result of a higher expectation of anti-smoking campaigns for America compared to Asia and Europe.

The gradual increase in anti-smoking campaigns has already shown the fall in prices and production. Due to policies, it is expected that the trade will continue to reduce the volume supplied by domestic grower and producers. As a consequence, the prices will become higher over the years (TAYLOR et al., 2000). However, with lower demand in the model, there is a price fall, and Brazil as the most magnificent exporting region reduce prices by 24.1%. In the rest of the world, the estimated impact is around 24%, and the highest impact is to the greatest producer, with a drop of 31.6% in China.

Table 3.7 – MCP phase II – Demand shock - WHO forecast.

Country/ Region	Production ('000 Tons)		Consumption ('000 Tons)		Prices (U$)	
	WHO	Δ	**WHO**	Δ	**WHO**	Δ
Brazil	709.26	-5.6%	304.68	-20.6%	5.13	-24.1%
China	2,746.50	-5.6%	2,821.16	-2.0%	3.72	-31.6%
USA	302.20	-4.3%	217.91	-27.3%	6.97	-18.1%
Europe Union	182.83	-4.2%	413.34	-2.5%	5.35	-22.9%
Rest of the World	5,125.61	-4.4%	5,309.31	-4.8%	5.10	-24.0%

Source: Author (2018).

Paris, Drogué, and Anania (2010) indicate that when all the variables translate the entire scenario observed, trade flow $\overline{X}_{i,j}$ is perfectly calibrated. Although, there are several optimal solutions, results just show only one equilibrium scenario (Table 3.8). In fact, there are other possible equilibrium trade scenarios between countries, what can be pointed out as a limitation of the methodology.

In the simulation, there is a complete cessation of Brazilian national consumption and reduction in exports to the Europe Union. The outcome shows that tobacco export is more efficient than internal consumption and there is an increase in exports to the RW (Table 3.8). Also, considering that demand reduction is lower in Asia than in the other regions is expected that the flow change from Europe Union and America to Asia.

Table 3.8 – MCP phase II – a variation of WHO forecast scenario.

	Base scenario	**WHO**	Δ
br.br	334.621		
br.us		217.912	
br.ue	231.256	230.513	**-0.3%**
br.rw	181.056	260.831	**44.1%**
ch.ch	2,894.319	2,746.503	**-5.1%**
us.br	34.433	227.548	**560.8%**
us.us	278.743		
us.ch		74.652	
ue.ue	190.819	182.83	**-4.2%**
rw.br		77.132	
rw.rw	5,359.705	5,048.48	**-5.8%**

Source: Author (2018).

According to economic theory, trade barriers to tobacco increase the total supply in the market and, at the same time, increase the quantity supplied by domestic growers and producers. Hence, prices for tobacco are likely to be higher than they would in the absence of the trade barriers. However, empirical research indicates that the liberalization of tobacco-related trade has contributed to global increases in cigarette smoking and other tobacco use, particularly in low-income and middle-income countries (TAYLOR *et al*., 2000).

The scenario of the free market (Table 3.9) was estimated as an exercise, as current tobacco policies around the world are raising taxes rather than the reverse. The table present production, consumption and prices results without tariffs and the variation compared to the baseline scenario. The outcomes indicate that the reduction of trade barriers incentivize consumption and increases the volumes and prices exported, except RW consumption (reduction of -0.9%). The impact to Brazil is positive for production, consumption and prices, 1.9%, 4.9 and 10.1%, respectively. Thus, tobacco free trade can generate positive effects in Brazilian local economy despite the possible health effect. The USA has the highest impact on consumption (10.4%) and is more affected by free trade due to highest tariffs (Table B.3).

Table 3.9 – MCP phase II – scenario free market result.

Country/ Region	Production ('000 Tons)		Consumption ('000 Tons)		Prices (U$)	
	Free Market	Δ	Free Market	Δ	Free Market	Δ
Brazil	763.50	1.9%	386.60	4.9%	6.89	10.1%
China	2,918.99	0.6%	2,924.17	1.6%	5.05	4.0%
USA	319.46	1.4%	309.60	10.4%	8.70	6.7%
Europe Union	193.56	1.6%	433.30	2.2%	7.11	10.1%
Rest of the World	5,370.67	0.4%	5,512.51	-0.9%	6.44	2.3%

Source: Author (2018).

Sensitivity analyses (Table 3.10 and 3.11) show a variation of 20% in supply and demand elasticity. The small variation of consumption, production, and prices corroborates with the results of the equilibrium model. The increase in elasticity (Table 3.10) generates a small increase in consumption and production, around 1%. For Brazil, more elastic supply and demand result in lower production and prices (0.9% and 3.2%) and higher consumption (1.7%).

Table 3.10 – MCP phase II – Sensitivity analyses (increase 20%).

Country/ Region	Production ('000 Tons)		Consumption ('000 Tons)		Prices (U$)	
	+20%	Δ	+20%	Δ	+20%	Δ
Brazil	741.66	-0.9%	373.90	1.7%	6.17	-3.2%
China	2,885.30	-0.6%	2,917.03	1.4%	4.79	-2.4%
USA	311.60	-1.1%	279.87	0.9%	7.93	-3.7%
Europe Union	191.61	0.6%	427.59	0.9%	6.73	2.3%
Rest of the World	5,483.78	2.4%	5,615.56	0.9%	7.00	9.7%

Source: Author (2018).

The decreases in elasticity (Table 3.11) also generate an increase in consumption and production, around 0.7%. For Brazil, less elastic supply and demand result in a smaller production and prices (0.6% and 3.10%) and higher consumption (1.1%).

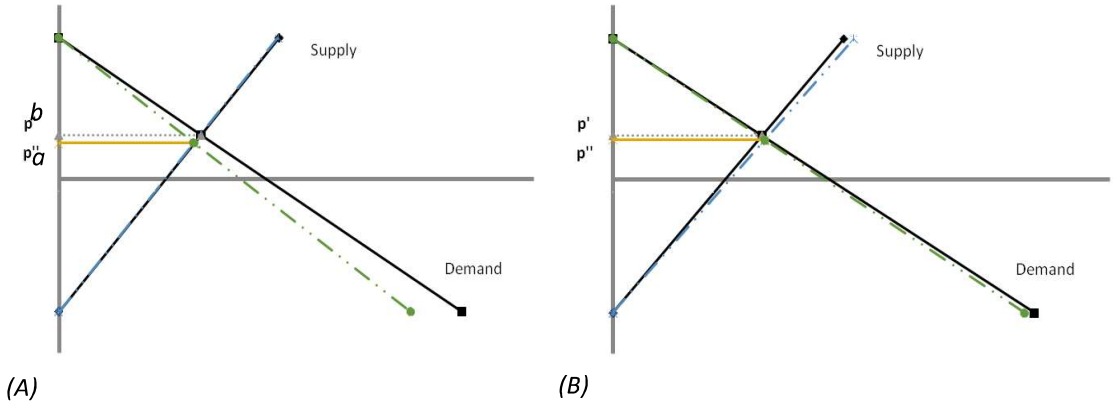
Table 3.11 – MCP phase II – Sensitivity analyses (decrease 20%).

Country/ Region	Production ('000 Tons)		Consumption ('000 Tons)		Prices (U$)	
	-20%	Δ	-20%	Δ	-20%	Δ
Brazil	744.17	-0.6%	371.58	1.1%	6.18	-3.1%
China	2,889.54	-0.4%	2,906.34	1.0%	4.77	-2.6%
USA	312.66	-0.8%	279.11	0.6%	7.92	-3.9%
Europe Union	191.29	0.4%	426.07	0.6%	6.74	2.4%
Rest of the World	5,440.29	1.6%	5,594.84	0.6%	7.01	9.8%

Source: Author (2018).

Figures 3.1 and 3.2 present the graphical analyzes for Brazil of the scenarios: demand shock, free market, and sensitivity variation, respectively. The dotted line represented the new equilibrium $p''$of mentioned scenario and the solid line the baseline equilibrium p'. The demand reduction (figure 3.1 (A)) results in the contraction of the demand curve and as a result the reduction of producer surplus (area a). There is a 10% decrease in producer surplus and 11% in consumer surplus around US$ 897 and US$ 262 million, respectively (Table B.4). The free market generates a 4% increase in the producer surplus and 9% in the consumer surplus (Figure 3.1 (B)).

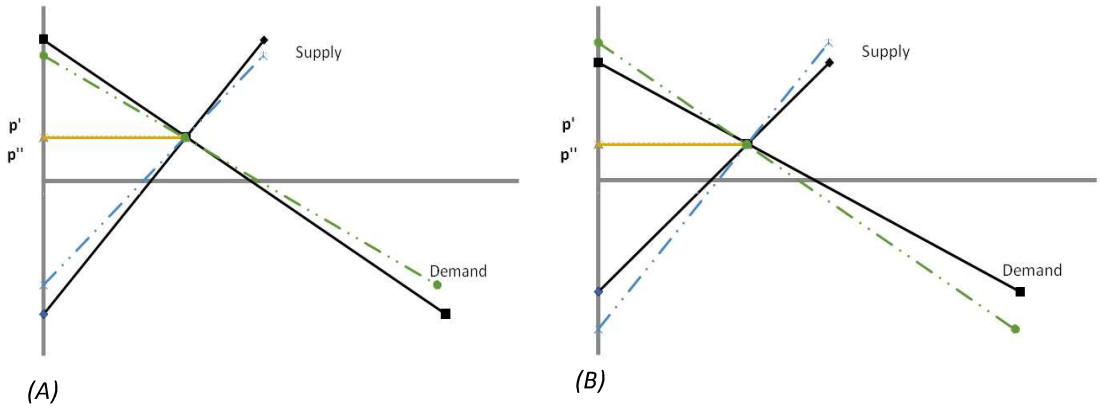
Figure 3.1 – Demand and supply curves: (A) demand shock and (B) free-trade equilibrium



Source: Author (2018).

Figure 3.2 is possible to identify changes in elasticity that generate a small variation in equilibrium price and quantities. However, there is a significant change in producer and consumer surplus.

Figure 3.2 – Demand and supply curves: sensitivity analyses elasticity (A) +20% and (B) -20%



Source: Author (2018).

Taking into consideration the importance of tobacco for the Brazilian economy, the three scenarios: demand shock (reduction), free market, and sensibility analyze to elasticity showed a significant impact in the country economy. The next session presents conclusions about the scenarios described.

3.4 CONCLUSION

The consumption of tobacco products and evidence of the negative effects of smoking on human health have led to an intense debate on tobacco in the world. The Framework Convention for Tobacco Control (FCTC) sets a series of measures aimed at reducing the demand for tobacco. Because of this, there is a concern about the effects of declining tobacco activity on the performance of farmers in low and middle-income countries, such as Brazil.

The scenario of demand reduction considers the WHO's projection for cigarette consumption for 2025 and the effects for the world and Brazil on production, consumption volume, and price. The country can reduce production by around 5.6% and consumption by 20.6%, with a greater effect on prices, with a reduction from around 24.1%. The new equilibrium with demand reduction reduced the Brazilian producer surplus by 10% and consumer surplus by 11%. The outcomes corroborate the findings of Serletis and Fetzer (2008) and TEH-WEI et al., (2008) on the impact of the reduction of consumption in the USA and China, respectively.

The results in the free market scenario for Brazil show a positive variation in prices and production. However, as stated in TAYLOR et al. (2000) and TEH-WEI et al., (2008) the liberation of the tobacco market may increase cigarette consumption, a scenario that is the opposite of the FCTC policy objectives in the country.

For sensibility analyze to elasticity there are small variations in consumption, production and price equilibrium, but the impact in consumer and producer surplus is around 20% for regions or countries. The outcomes corroborate with for the validity of the model findings.

The model, however, has three important constraints, considering equilibrium outcomes, elasticity, and information constraints. First, since the model shows only a possible equilibrium between countries, it is possible that demand shocks result in other flows that also represented equilibrium. Second, elasticity is given in all scenarios, but changes in the market affect the elasticity of demand and supply. As the study by Prowseand Moyer-Lee (2014) indicated, the tobacco market is restricted to five companies that may have coordinated action on changes in demand and supply. Finally, data restriction is an important barrier to a deeper analysis of the African market and tobacco varieties.

Therefore, besides restrictions, the model has important insights about the future of Brazilian tobacco. The projections reinforce the importance of diversification in tobacco production, taking into account the changes in the world market through anti-smoking campaigns. Even with a slow transition, the drop in consumption will affect the Brazilian

market in the coming years, with a negative impact on the surplus of producers and consumers. The second insight is the existence and importance of subsidies to maintain price competitiveness in the country. Nevertheless, to futures studies, it is crucial to verify the impact of Africa on the production flow and deeply investigate the differences considering tobacco types and quality issues.

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APPENDIX B – CALIBRATION INFORMATION AND SURPLUS.

Table B.1 – Price and elasticity.

Country/ Region	Prices (USD/ '000 tons)	Elasticity	
		Demand	Supply
Brazil	6.37	0.46	0.25
China	4.90	0.5	0.2
USA	8.24[6]	0.2	0.25
EU	6.57	0.2	0.2
RM	6.33	0.2	0.2

Source: Authors based in FAO (2018), Comtrade (2018), and (Musona, 2016).

Table B.2 – Price per nautical mile.

Country/ Region	Brazil	China	USA	European Union	Rest of the World
Brazil	-	213	143	105	105
China	213	-	194	358	358
USA	143	194	-	391	391
European Union	105	358	391	-	102
Rest of the World	105	358	391	102	-

Source: Authors based in OECD (2018) and Comtrade (2018).

Table B.3 – Tariffs.

Country/ Region	Brazil	China	USA	European Union	Rest of the World
Brazil	-	0.1	0.63	0.08	0.08
China	0.14	-	0.63	0.08	0.08
USA	0.14	0.1	-	0.08	0.08
European Union	0.14	0.1	0.63	-	0.08
Rest of the World	0.14	0.1	0.63	0.08	-

Source: Authors based in MACMAP (2018).

Table B.4 – Producer and consumer surplus outcomes.

Country/ Region	Phase I	WHO	Δ	Free Market	Δ	+20% elasticity	Δ	-20% elasticity	Δ
Producer Surplus **('000 000 US$)**									
Brazil	9,493.92	8,596.49	-10%	9,925.39	4%	7800.97	-22%	11,780.49	19%
China	35,367.14	32,028.71	-10%	35,974.87	2%	29290.26	-21%	44,064.41	20%
USA	5,124.52	4,783.42	-7%	5,333.55	4%	4227.99	-21%	6,384.94	20%
Europe Union	3,138.99	2,891.03	-9%	3,231.33	3%	2637.66	-19%	3,943.09	20%
Restofthe World	84,815.63	77,844.52	-9%	85,164.95	0%	74060.76	-15%	109,310.86	22%
Consumer Surplus**('000 000 US$)**									
Brazil	2,566.17	2,304.16	-11%	2,805.40	9%	2,194.15	-17%	3,251.14	21%
China	14,270.28	15,483.38	8%	14,561.19	2%	12,076.83	-18%	17,984.04	21%
USA	5,762.32	4,678.20	-23%	6,908.02	17%	4,840.22	-19%	7,221.41	20%
Europe Union	2,762.40	2,968.69	7%	2,909.22	5%	2,362.30	-17%	3,518.55	21%
Restofthe World	34,880.84	36,807.53	5%	34,522.63	-1%	29,854.55	-17%	44,454.77	22%

Source: Author (2018).

[6] The year of 2015 result in an average price of USD 29.00, in reason of that, we exclude the year from the average.

4. SMOKING IN BRAZIL: A SURVIVAL ANALYSIS BASED ON CONSUMERS' PROFILE

ABSTRACT

Cigarette consumption is a worldwide epidemic and its reduction is one of the major public health concerns. Brazil is among the leaders that have created the Framework Convention on Tobacco Control (FCTC), the first international public health treaty developed by the World Health Organization between 1999 and 2003. The agreement began in Brazil in February 2005 and since its implementation tobacco control measures have proven to reduce consumption. However, their effectiveness has been hindered by the entry of smuggled goods, which do not respect price regulation. Based on data from the 2013 National Health Survey (PNS) this study investigates which characteristics will affect smoking duration and will attempt to contribute to the creation of policies other than price regulation. The Kaplan-Meier method was associated with the Cox model to analyze social and economic characteristics and understand how they influence smoking duration. The results showed that the people who are less likely to quit smoking are older, single men, with low income and fewer education years. They also do not consume alcoholic beverages, do not practice physical exercise and have pulmonary diseases. Therefore, in order to decrease public health spending, Brazilian health policies regarding tobacco use could focus on those who will likely smoke for a long time.

Keywords: Cigarettes, health, Framework Convention on Tobacco Control, survival analysis

4.1 INTRODUCTION

According to the World Health Organization (WHO) consumption of tobacco products is the leading cause for chronic diseases such as cancer and diseases that affect the heart and the lungs. Tobacco products can be considered a global health epidemic since the annual global healthcare costs associated with smoking are U$422 billion, equivalent to U$ 56.34 per subject, which represent 5.7% of total health expenditure worldwide (WHO, 2017).

Evidence that smoking is harmful to health has made most countries adopt tobacco control measures. The Framework Convention for Tobacco Control (FCTC) is the most important world tobacco control agreement developed by WHO between 1999 and 2003. It brought together 192 countries to regulate tobacco consumption worldwide with measures covering health and environmental problems. Among the proposed measures, the FCTC stimulates health treatment, health warnings, the adoption of more control and restrictions on advertising, illegal trade and prices.

Brazil was one of the leaders in the creation of the FCTC, which entered into force in the country in February 2005. According to Portes *et al*. (2018), between 2011 and 2015, there were advances in regulation of tobacco products in legislation related to the promotion of smoke-free environments and warnings on cigarette packs and prices. Despite the advance in tobacco control in Brazil, smoking continues to be a serious public health concern in the country, with impressive numbers related to morbidity, mortality, and public health care costs.

In Brazil, cigarette smoking affects mainly the poorest populations who devote a significant portion of their income and health (BARROS *et al*., 2011) to the habit. In addition, the effectiveness of policies has been compromised by the entry of smuggled goods. Illegal cigarettes cannot be controlled by taxes and price regulation, the main instruments for reducing consumption today. As stated by Iglesias *et al*. (2017), the total proportion of illegal daily consumption increased from 16.6% to 31.1% between 2008 and 2013. The study has also observed that there is a pattern of decrease in cigarette smoking prevalence and increase in illegal consumption.

Hence, understanding the habits and conditions that perpetuate consumption of tobacco products is an important tool to evaluate the effectiveness of control policies. Based on data from the 2013 National Health Survey (PNS), this study investigates the characteristics that affect smoking duration. The results of the study aim at contributing to the creation of policies to tobacco control other than price regulation.

The study analyzed Brazilian people who used to consume tobacco products but at a certain point they quit smoking. The study applied the methodology of Kaplan-Meier survival analysis to social and cultural characteristics, which were then evaluated according to the Cox likelihood model. The methodology aims at classifying the features of the hazard rate over smoking duration, i.e. those that affected the hazard of quitting tobacco product use.

Therefore, the first part of the study presents a summary of the cigarette consumer market in Brazil and the restriction policies that have been implemented in the country. Subsequently, the Kaplan-Meier methodology and the Cox model are usedto analyze the hazard of smoking cessation. The PNS profiles of people who smoke and those who have quit smoking are also presented. Finally, the results of the survival models are presented and interpreted, and finally the conclusions are discussed.

4.1.2 THE CIGARETTE CONSUMPTION IN BRAZIL

According to data released by INCA (2014), official per capita apparent cigarette consumption in Brazil has fallen sharply, 65%, from 1980 to 2010. In a report on tobacco consumption trends, WHO (2018) estimated that about 18% of Brazil's population, i.e. approximately 25.5 million, smoked in 2010. Should control efforts continue at the same intensity, the organization's projections for 2025 is approximately 20.4 million, i.e. 12% of the population – a decrease not only in the number of smokers but also in the share of Brazil's population. WHO also revealed that 22% of the smokers in Brazil in 2010 were men and 13%, women by 2025 rates in the country are estimated at approximately 15% of male and 9% of female smokers.

The milestone amongst tobacco reduction policies in the country was the FCTC, which entered into force in February of 2005. Brazil contributed to the negotiations and pioneered in adopting various initiatives, but the implications of becoming a party to this international treaty brought domestic economic conflicts of interest to surface. There were delays to ratify it and difficulties to implement tobacco control measures in the country. As Cavalcante et al. (2017) highlighted, the tobacco industry invested in a broad movement to spread the idea that the convention would completely ban tobacco cultivation and that the country's accession to the treaty would have a heavy negative impact on the livelihoods of 200 thousand tobacco-producing households. Only in October 2005, after two years (2004 and 2005) of debates, did the Federal Senate approve the ratification of the FCTC (Legislative Decree n. 1,012). The ratification of the FCTC and the creation of the Brazilian Tobacco Control Policies made it

possible to implement many measures to a greater or lesser extent in the country. The FCTC represented a new level for commitment to tobacco control and began to support and guide such national policies as raising prices and taxes.

The increase in cigarette average prices is in accordance with smoking control as established in Article 6 of the FCTC, which deals with the importance of measures related to prices and taxes as effective instruments for the convention's purpose. Price increase is expected to have a major impact on younger population. Studies by WHO (2018) indicate that a price increase of 10% can reduce consumption of tobacco products by 5% in low and middle-income countries. Another effect is the rise in government revenues, which is very relevant considering its health expenditures caused by tobacco consumption. In Brazil is estimates are that smoking accounts for 7.7% of hospitalization costs and chemotherapy procedures paid by the Unified Health System (SUS) in 2005 (PINTO and UGÁ, 2010). Therefore, efforts to decrease cigarette consumption are directly relatedto public spending reduction.

In December 2011 the national price and tax policy changed the Tax on Manufactured Products (IPI in Portuguese) system and established minimum prices for cigarettes. According to the Brazilian Tax Authorities ("Receita Federal" in Portuguese), the minimum prices charged for twenty cigarettes have been progressively increasing since 2012. Up from R$ 3.00 to the current minimum R$ 5.00, any product that is selling at less is considered illegal. Also, in January 2016, a new *ad valorem* rate was defined for packages with 20 cigarettes to be in effect as from May 1stof the same year. This mechanism, according to the Brazilian Tax Authorities, was aimed at curbing the tax evasion that occurs in the manufacturing sector due to the predatory practice of prices that stimulate unfair competition in the sector as well as the collection of taxes necessary to meet public health expenditures on tobacco users.

According to the Tobacco Producers Association – AFUBRA (Afubra database 2018) Brazil registered its lowest cigarette consumption in 2016 since 2011 – a reduction of 45% (Table 4.1). In spite of such decline, tobacco-related tax collection grew 45%. The margin for the industry, retail and producers also changed in the last six years: the industry and retail margins increased by 480% and 81%, respectively, whereas the producer margin decreased 2.2%.

Table 4.1 – Annual Evolution of cigarettes consumption and revenues.

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Total (Tx + Margin)	**12,185.18**	**16,357.51**	**17,655.94**	**19,233.10**	**20,237.09**	**22,085.39**
Number of packs ('000.000)	4,869.83	4,449.85	3,795.91	3,620.96	3,150.39	2,654.39
R$/Pack (R$)	2.50	3.68	4.65	5.31	6.42	8.32

Source: Receita Federal (2018) and Afubra Database.

However, higher prices led consumers to change their purchasing habits, and consumption of cheaper brands increased. A management report of the company owning more than 70% of the Brazilian cigarette market (SOUZA CRUZ, 2014) says that the brands selling at a minimum price of R$ 5.00 had the largest increase of market share.

Another consequence of higher prices is the illegal market growth. The prevalence of illegal consumption was confirmed by the Brazil Adult Tobacco Survey – GATS INCA (2010) and Iglesias *et al*. (2017), who estimated the magnitude of illegal cigarette consumption before and after the implementation of the new tobacco taxation in 2012. The studies found a reduction in the prevalence of smoking and increased illegal cigarette consumption, regardless of gender, age, educational level, and the area of residence. Illegal daily consumption increased from 16.6% to 31.1% between 2008 and 2013.

The strategy of raising taxes increased government revenues, reduced legal smoking prevalence, and increased illegal trade, thus highlighting the relevant effect on user awareness, which in turn resulted in reduced tobacco consumption. Understanding the characteristics of the most susceptible group of consumers and the social and economic factors influencing the duration of the habit can be a very useful tool in the development of policies.

It is known that biological and genetic issues contribute to cigarette addiction. However, according to Rondina *et al*. (2007), this interpretation does not exclude the interference of other factors in the behavior of smoking. As Stratford and Govind (1994) mentioned, two different models analyze the consumption of addictive goods such as cigarettes: the “rational” and the “irrational” model. However, testing the behavioral predictions of these models was primarily restricted to experimental studies. To use consumer data, Douglas and Hariharar (1994) studied the decision to start smoking using the duration model. According to the article, which presents data from the 1978 and 1979, there is evidence that characteristics such as education, gender, and race are important determinants of both whether and when smoking is initiated. There is no evidence, however, that policies such as increasing the price of cigarettes are effective in reducing smoking start among teenagers.

In Kuo (2013) characteristics such as gender, education and income contribute to the hazard of smoking. According to his study, which used the Health and Retirement Study (HRS) panel database conducted by the University of Michigan, the results suggest that education, age, and financial planning have positive effects on quitting hazards. In Hersch (2005) study characteristics such as marital status can also contribute to how people respond to smoking

regulation. Married people are more conducive to smoking bans in all public areas except for closed workplaces, while those who were married before are more pro-ban restaurants and less ban-prohibitive in closed workplaces. Additionally, effects of gender, family income, and education vary by type of regulation.

According to Barros *et al*. (2011), the Brazilian cigarette consumers' profile from the 2008 Brazilian National Household Sample Survey (PNAD in Portuguese) shows that consumption is higher among individuals who are in the lowest decile of income. The public that is more dependent on the governmental health system, accounting for higher public expenditure on health. The prevalence of smoking is higher among men 18.8% than among women (11.6%). Age has a positive impact on the prevalence of smokers until the age of 59, and daily consumption has an inverse relationship with income. Based on statistical data concerning students and cigarettes in Brazil, Zanini et al. (2006) concluded that the of most smokers are in families whose making under four minimum wages, and about 64% of them are lower educated. In Bazotti*et al.* (2016), based on analysis of Brazil's Family Budgets Survey (POF, in Portuguese) of 2008–2009, tobacco consumers are older, earn low salaries and have less schooling than someone who does not consume tobacco. Authors also reinforces that knowledge about the population that consume tobacco products can increase the efficacy of more specific policies.

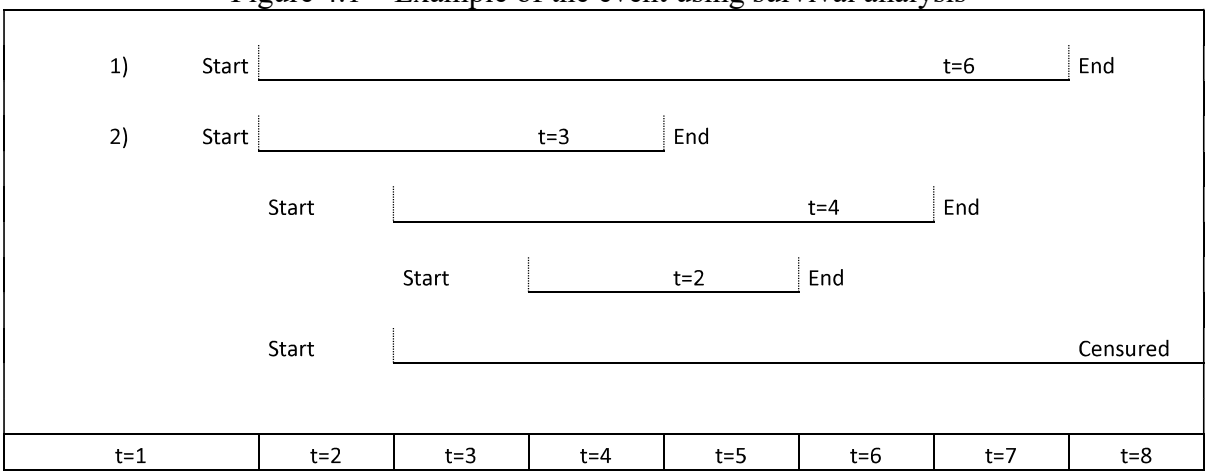
Considering the importance of profile characteristics such as gender and age, income, education and health habits in cigarette consumption time, the next section will address the methodology of survival analysis for smoking.

4.2 METHODOLOGY

The Kaplan-Mayer analysis survival method was used to study the characteristics of cigarette consumption. Survival analysis is commonly used in health research to assess the impact of medications on certain diseases (LEE and WANG, 2003). However, it has been used in analyses of such social issues as unemployment (TAYLOR, 1999), education (FRANÇA and SACCARO, 2016), and social policies (CONCEIÇÃO *et al*., 2016).

The most important variable in the Kaplan-Mayer method is the survival time of a certain characteristic or event. In Figure 4.1 it is possible to identify an example in which a sample of 5 individuals have different survival times (t) over a total interval of $t = 8$. The survival method does not consider censored information or data for which survival time is unknown. The number 5, for example, was censored because it presented an undefined survival time t>6.

Figure 4.1 – Example of the event using survival analysis



Source: Author (2018).

In the estimate of smoking survival habit, t is the total of years reported by the oldest person, and each observation of smoking time is considered until failure, or the event of smoking cessation. The people who have not stopped smoking are censored in the analysis because they do not have the event of failure, i.e. smoking cessation.

Thus, a survival analysis will consider two variables as a function of time, survival function and hazard function. The survival time t can be defined as a random positive variable with probability distribution $F(t)$ (equation 1) and the density probability function $f(t)$ (equation 2).

$$F(t) = P(T \leq t) \quad (1)$$

$$f(t) = \lim_{t \to 0} \frac{P(t \leq T < t + \Delta t | T)}{\Delta t} \quad (2)$$

The function $S(t)$ or survival will respond to the probability that an event P will survive more than a specific time t when compared to a given time$T$, $S(t) = P(T > t)$ or $S(t) = P(T > t) = 1 - F(t)$.

Theoretically, while t varies from 0 to infinity, the survival function can be represented as a smooth curve. For the survival analysis the most used method is Kaplan-Meier (KM), defined by equation 2, where N is the total of individuals in which survival time is available and r corresponds to the positive integers for which $t_n \leq t$.

$$S(t) = \Pi \frac{(N-r)}{(N-r+1)} \quad (2)$$

The hazard function, denoted by $h(t)$, is given by equation 3, which describes the instantaneous potential per unit time for the event to occur since it survived beyond time *t*. In contrast to the survival function, which focuses on not failing, the risk function focuses on failure, that is, the event elapses. Thus, in some sense, the risk function can be considered as providing the opposite side of the information given by the survival function or the $f(t)$ divided by $S(t)$.

$$h(t) = \lim_{t \to 0} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} \quad (3)$$

The log-rank chi-square test is used for large samples to compare different survival curves using KM . This statistical test, as well as others applied to KM curves, use observed versus expected observations in the categories analyzed. The categories for log-rank statistics are defined by each of the failure times ordered for the entire set of data analyzed.

There are different models for the study of survival analysis. One of the most used semi-parametric models is the Cox proportional hazard model, which uses the maximum likelihood method to estimate risk ratio. It provides the adjusted survival curves and the meaning of the proportional risk assumption. The Cox model estimates proportional failure rates according to equation 4. The vector X with p covariates, β the vector with p unknown parameters, and $\alpha(t|X)$, the failure rate function.

$$\alpha(t|X) = \alpha_0(t)\exp\{X'\beta\} \quad (4)$$

The main assumption of the model is the proportionality of the risk between the individuals, whose ratio is constant over time. Thus, the risk of an individual is any multiple of the risk function of any other individual, and the factor is the risk ratio $e^{\beta(x1+x2)}$ being x_1 an

individual who does not receive the treatment and x_2 the one who receives it. To validate the suitability of the model, it is necessary to test the hypothesis of proportional risks, which can be done by graphical approach or by the Statistical test of the Schoenfeld (1982) residuals.

For the analysis of smoking survival, data from the 2013 National Health Survey – PNS of were used (IBGE,2013). The PNS is a nationwide home-based survey that has a periodicity of 5 years. It comprises three questionnaires: the domicile, referring to the characteristics of the domicile; the one related to all the residents of the domicile; and the individual, to be answered by a domicile resident of 18 years of age or more. This paper has focused on the individual residents who answered that they were smokers or had been smokers at some point in their lives.

4.3 RESULTS AND DISCUSSION

PNS allows for feature comparison between two different groups associated with tobacco daily consumption:current smokers and former smokers. A total of 15,804 people were analyzed: 8,000 are smokers and 7,804 have quit smoking. The characteristics of the two groups are described in Table 4.2.

There is a greater proportion of young people among smokers: 12.7% are than younger than 27 years old, compared to 5.5% of former smokers. Between 28 and 37 years, smokers represent 21% compared with 12.2% of those who have quit smoking. Age distribution reflects that the largest proportion of people who have quitsmoking are older than those who still smoke. From 58 to 67 only 13% are smokers; 22.2% are former smokers. The results indicate that people start smoking young and quit the addiction at a more advanced age.

Regarding gender, smoking is more common among men: 57%. Considering that the proportion of men in the PNS is lower than that of women (48.3% versus 51.7%), the high prevalence of men among smokers corroborates the fact that men consume more tobacco. The percentage of men who have quit smoking is 3% lower than that of those who have not (54%).

Racial characteristics show that there are more white people who have quit smoking compared to those who still smoke, 41% and 36%, respectively. Black, yellow, brown, and indigenous have shown the opposite behavior: there are more of them who smoke. Regarding marital status, there is a predominance of single people among smokers, whereas most former smokers are married (46%). Divorced, separated and widow people also are more prevalent among those who have stopped smoking.

As far as education is concerned, there is not a great difference in the samples of smokers and former smokers. However, a higher prevalence of smokers and former smokers who have primary education (50% and 49%, respectively) has been observed.

With respect to income, the study adopted the SAE (2012) per capita income social stratification. According to their estimate, those who make less than R$ 441.00 per month are in the lowest stratum and those who make above R$1,019.00 are in the highest stratum. The percentage of former smokers making more than R$ 1,019.00 per month is higher than that of smokers, 40.5% and 33%, respectively, whereas the proportion of smokers making less than R$ 441.00 per month is higher: 26.7% against 19.4%. Thus, former smokers are those who have higher income.

When it comes to consumption habits, people who consume alcoholic beverages are more present among smokers, 59.8% compared to 32.2% of former smokers. The percentages of

healthy habits such as physical exercises are similar among smokers and former smokers: 20.5% and 27.2%, respectively.

Former smokers had the highest percentage of diagnosed hypertension:34.5%.Thef act is reasonable considering that smoking can increase the risk of diseases like hypertension, which force people to stop smoking. 2.5% of smokers and 3.2% of former smokers have been diagnosed with lung disease.

Overall, the most representative subject among smokers has the following characteristics is a 48-57 years old, brown, single, man, has primary education, R$ 441.00-R$ 1,019.00 of income, consumes alcoholic beverages, does not exercise, and has not been diagnosed with hypertension or lung disease. Among former smokers, this subject is a 48- 57 years old, brown, married, man, has primary education, more than R$ 1,019.00 of income, does not consume alcoholic beverages, does not exercise, and has not been diagnosed with hypertension or lung disease.

Thus, marital status, income and consumption of alcoholic beverages represent the most important differences between smokers and former smokers and are in line with the studies about consumption of addictive products. The rational and irrational models previously referred to have shown that characteristics influencing how people deal with risk are important in the decision of smoking or not. Life decisions, such as getting married, saving money and having healthy habits are important in individual risk choices.

Table 4.2 - Descriptive statistics of the variables of this study

Attribute	**Description**	**%**	
		Smokers	**Ex-Smokers**
Age	18 to 27	12.7	5.5
	28 to 37	21.1	12.7
	38 to 47	21.5	17.2
	48 to 57	24.2	22.9
	58 to 67	13.6	22.2
	68 to 77	5.5	13.7
	More than 78	1.6	5.9
Gender	Male	57	54
	Female	43	46
Race	White	36	41.3
	Black	11.6	9
	Yellow	0.8	0.9
	Brown	50.7	48.1
	Indigenous	0.8	0.8
Marital Status	Married	30.3	46.2
	Divorced/Separate or widowed	17.3	21.8
	Single	52.4	32.0
Education	Literacy/ Initial grades	15	16

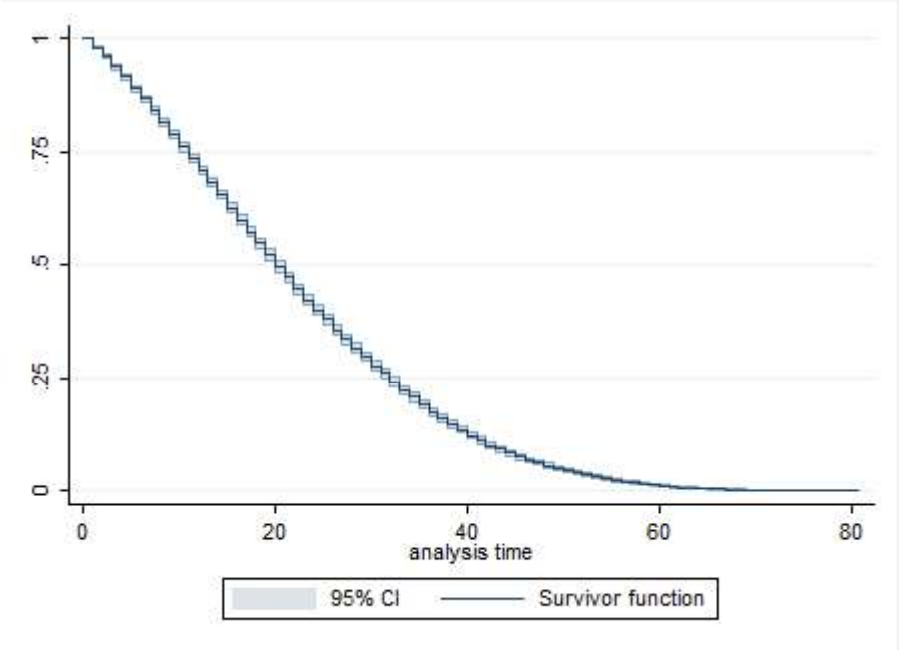
Attribute	Description	%	
		Smokers	Ex-Smokers
	Fundamental School	50	49
	High School	24	22
	University	10.8	12.5
	Master	0.5	0.6
	Doctorate	0.2	0.3
Income	Less than R$ 441.00	26.7	19.4
	From R$ 441.00 to R$ 1,019.00	40.3	40.1
	More than R$ 1,019.00	33	40.5
Alcohol consumption	Do not consume alcoholic beverages	40.2	62.8
	Consume alcoholic beverages	59.8	37.2
Physical Exercises	Practiced exercises in last three months	20.5	27.2
	Did not practice exercises in last three months	79.5	72.8
Hypertension	Have been diagnosed	19.8	34.5
	Have not been diagnosed	80.2	65.5
Lung Diseases	Have been diagnosed	2.6	3.2
	Have not been diagnosed	97.4	96.8

Source: Authors (2018), based on data from the 2013 PNS/IBGE.

In order to analyze whether the characteristics studied influenced smoking, one estimates smoking duration. In this study, it was calculated based on age of smoking on set, current age and how long it took the subject to quit smoking. A total of 15,501[7] observations were selected, among which 7,974 are still smokers and were therefore censored. This censoring is called right-censored (Gail *et al.*, 2012), which occurs when the study ends before the studied episode ends (smoking cessation in this case) or when the subject is withdrawn from the sample. Thus, the analysis considers only the behavior and habits of former smokers. Figure 4.2 shows duration of smoking, with the minimum period of cigarette consumption being one year, the maximum, 81 years, and the average duration 22 years. The survival curve shows a typical mild decline as time increases.

[7]Total of 303 observations were exclude in reason of survival time negative or less than 1 year.

Figure 4.2 – Kaplan-Meier analyses of cigarette consumption of smokers from PNS (2013).



Source: Author (2018).

The study used the log-rank chi-square test for the selection of variables that influence smoking duration. The method uses observed versus expected observations in the categories analyzed. As referred to in the methodology, log-rank statistics are defined by all ordered failure times. The testing method evaluateswhether or not KM curves for two or more groups are statistically equivalent.

The variables were chosen as follows: social profile, education, income, and health habits. Age, sex, race, and marital status were used to analyze social profile. In the health habits category, lung disease, hypertension, exercising, and alcoholic beverage consumption were analyzed.

Table 4.3 below shows the log-rank test results for the selected variables. In the analysis, Race did not present significant results (p=value 0.358). In other words, the KM curves for the groups are statistically equivalent, or there is no significant difference between the survival curves. The other variables, however, showed significant results and indicate different smoking duration in the sample.

Table 4.3 – Log-rank results for the selected variables.

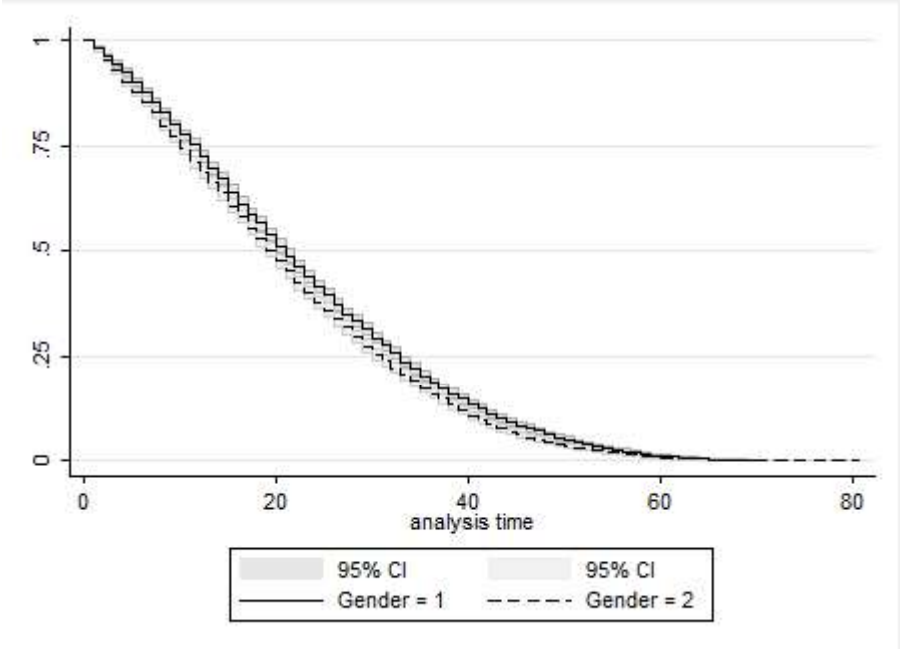
Attribute	χ^2	**P-value**
Age	6805.60	0.000**
Race	4.37	0.358…
Gender	18.49	0.000**
Marital Status	358.03	0.000**
Education	545.27	0.000**

Attribute	χ^2	P-value
Income	200.96	0.000**
Alcohol consumption	214.89	0.000**
Physical Exercise	182.68	0.000**
Hypertension	214.66	0.000**
Lung Diseases	64.32	0.000**

Source: Author (2018). ** Significant at 1% level * significant at 5% level.

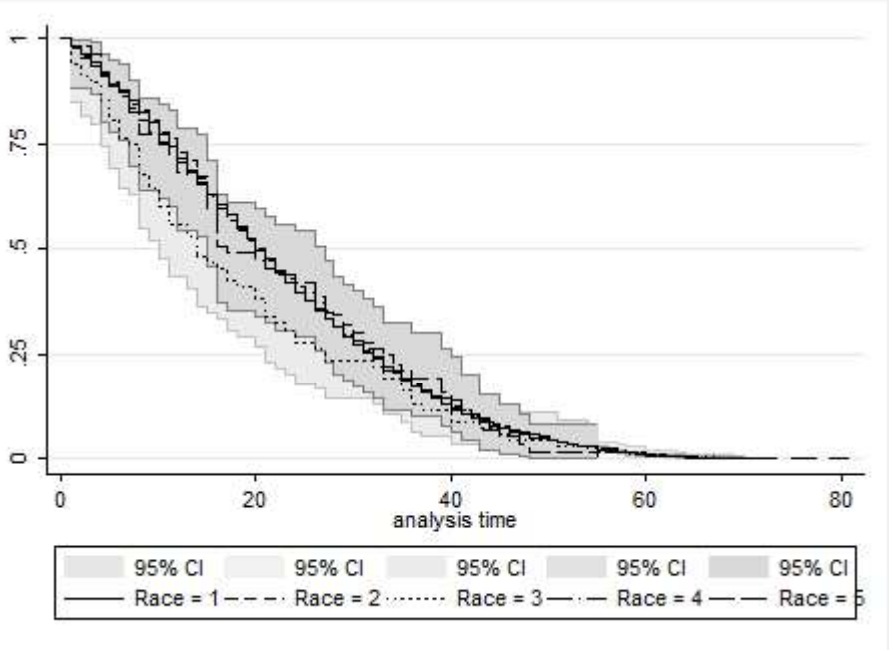
Figures 4.3 and 4.4 represent the KM curves for gender (Male =1, Female= 2) and race (White = 1, Black = 2, Yellow= 3, Brown = 4, Indigenous = 5). Based on the variable race, one may conclude that there is no difference between the smoking duration rates. However, for the variable gender, there is a significant difference in the smoking duration between the subjects. Women's duration of smoking is lower than that of men. Thus, one can find that women are more likely to smoke for a shorter period than men.

Figure 4.3 – Kaplan-Meier analyses of cigarette consumption: gender.



Source: Author (2018).

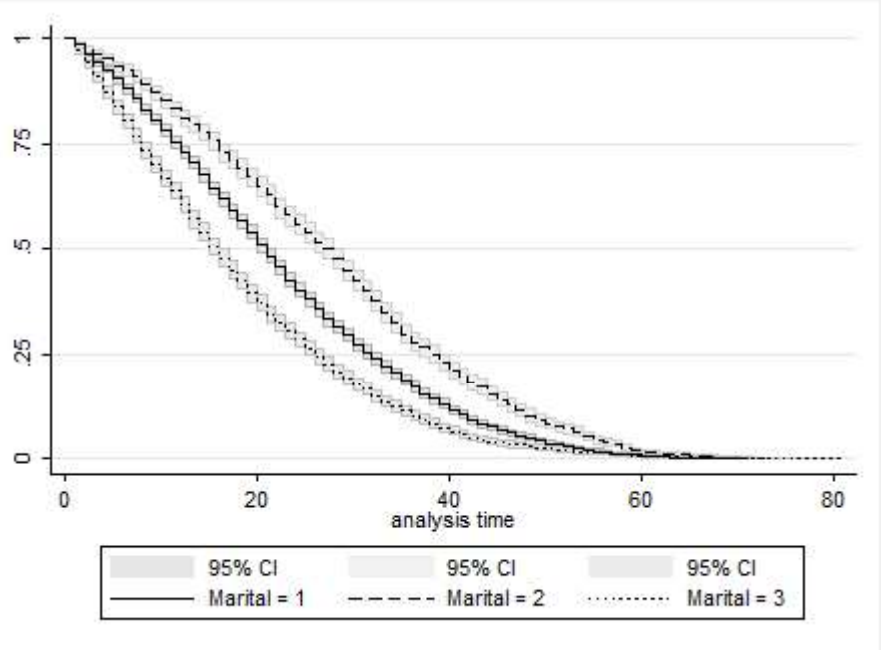
Figure 4.4 – Kaplan-Meier analyses of the cigarette consumption: race.



Source: Author (2018).

Regarding marital status in Figure 4.5 three different types have been considered: married = 1, divorced/separated/widow(er) = 2, and single = 3. In the graphical analysis, divorced, separated or widow(er) people have the greater duration of cigarette consumption. Single people have the lowest duration of smoking and married people are in between. The result can be evaluated in relation with different social practices at different ages. Single people are younger than those who are married, divorced, separated or widow(er).so considering that the average age to start smoking is 17, and the subjects in this category have not started smoking a long time ago, it is expected that they presented the shortest smoking duration.

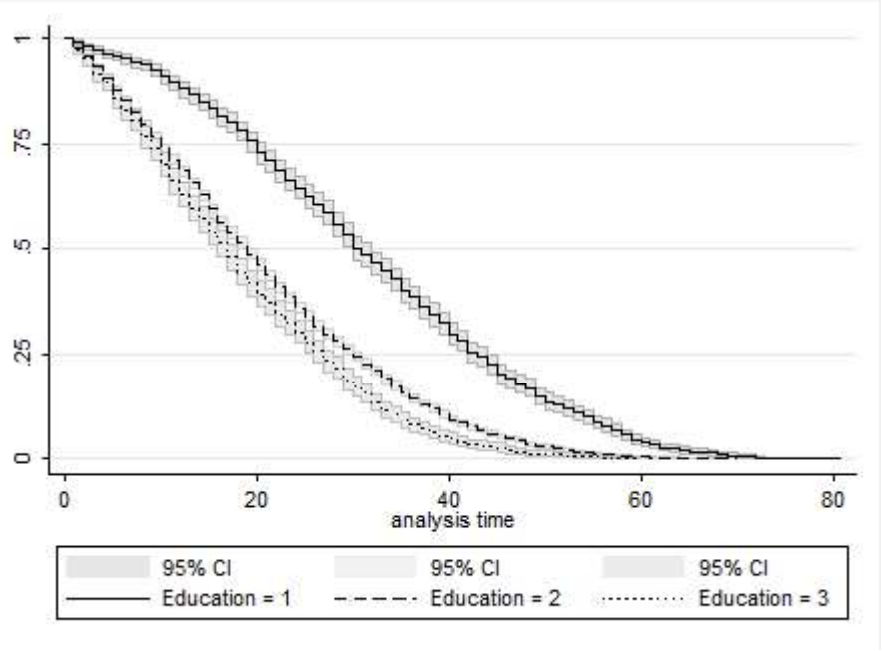
Figure 4.5 – Kaplan-Meier analyses of the cigarette consumption: marital status.



Source: Author (2018).

The results for the survival curves in education (Figure 4.6), and income (Figure 4.7) were significant. Three levels were analyzed in Education: Education 1=primary education; Education 2 =secondary education; and Education 3 =tertiary education. Figure 4.6 shows that the higher the education level, the lowest is the smoking duration. A large gap can be observed between people with less schooling (primary education) and people with more schooling (secondary and tertiary education).

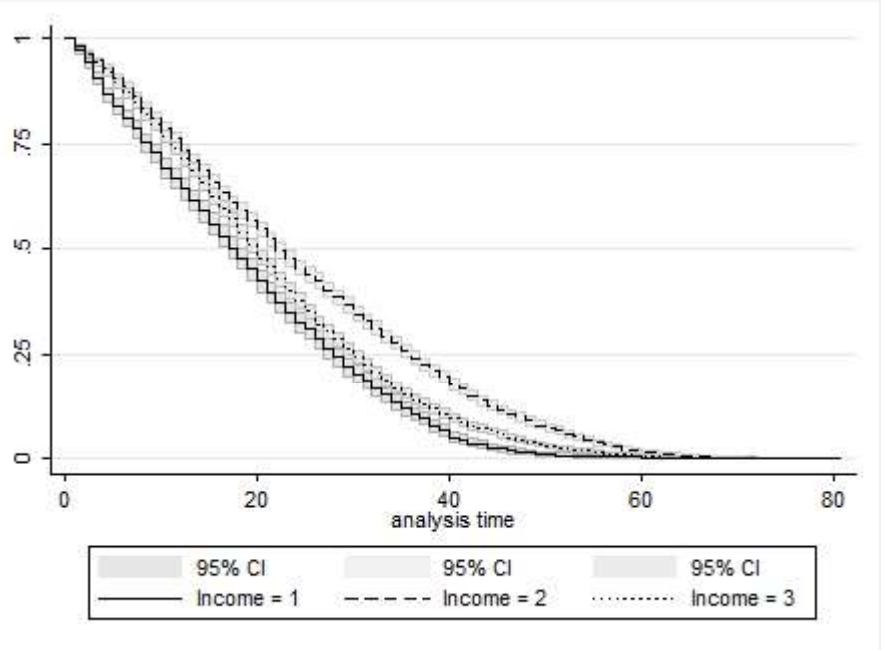
Figure 4.6 – Kaplan-Meier analyses of the cigarette consumption: education.



Source: Author (2018).

For the variable income, the following monthly categories have beenconsidered: less than R$ 441.00 = 1, from R$ 441.00 to R$ 1019.00 = 2; and more than R$ 1019.00 = 3 (SAE, 2012). The KM curves reveal that people with the longest smoking duration belong to the medium level of income. In contrast, those who have smoked for the shortest period are in the lowest level of income. The people with a higher level of income presented the shortest smoking duration. The position of the curves suggests that low income can be a restriction to tobacco consumption duration since the poorest people have the lowest duration rates, but the richest do not have the greatest ones. In other words, the results for middle and high income suggest that the higher the income, the lower the duration of smoking, except for the poorest. The result is aligned with the practice of price increase suggested by WHO (2018) to stimulate reduction in the consumption of tobacco products.

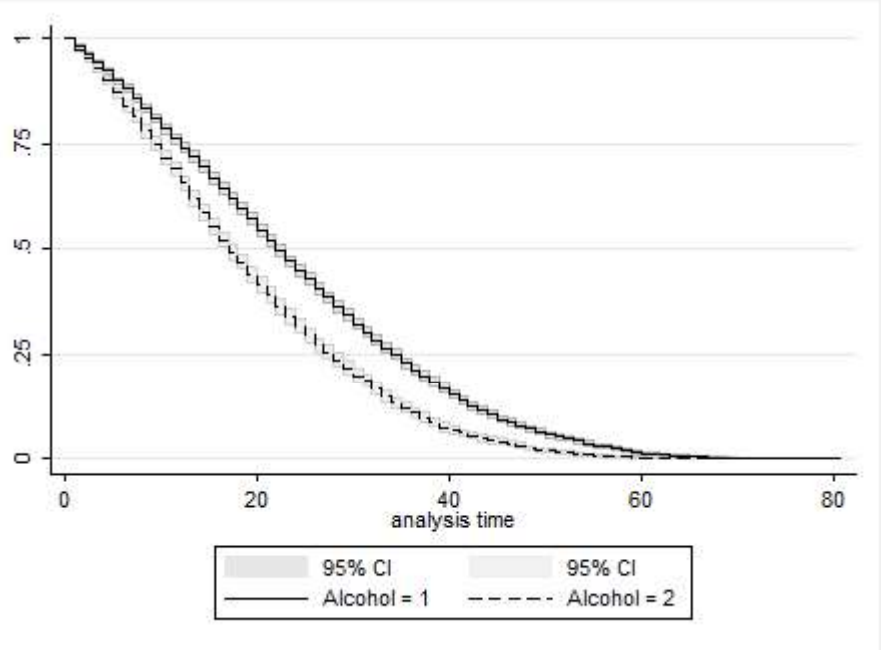
Figure 4.7 – Kaplan-Meier analyses of the cigarette consumption: income.



Source: Author (2018).

Regarding lifestyle characteristics, the alcoholic beverage consumption (Figure 4.8), and exercise practice variables (Figure 4.9) shows significant differences for smoking survival habit. For alcoholic beverage consumption, where Alcohol Consumption = 1, do not consume alcoholic beverage and Alcohol Consumption = 2, consumes alcoholic beverage. In the Figure 4.8 people who consume have a significant lowest smoking survival rates.

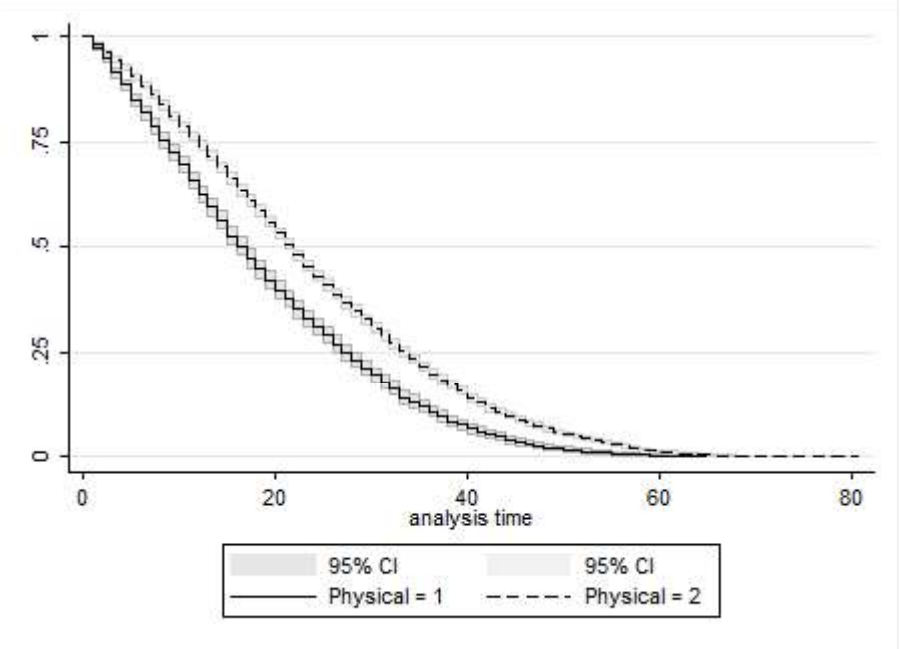
Figure 4.8 – Kaplan-Meier analyses of the cigarette consumption: Alcohol Consumption.



Source: Author (2018).

Practice of physical exercises also demonstrated a significant difference in the survival analysis. The Figure 4.9 considers, Exercise = 1, practiced physical exercise in the last 3 months and Exercise = 2 did not practice. People who exercise regularly have shorter smoking duration.

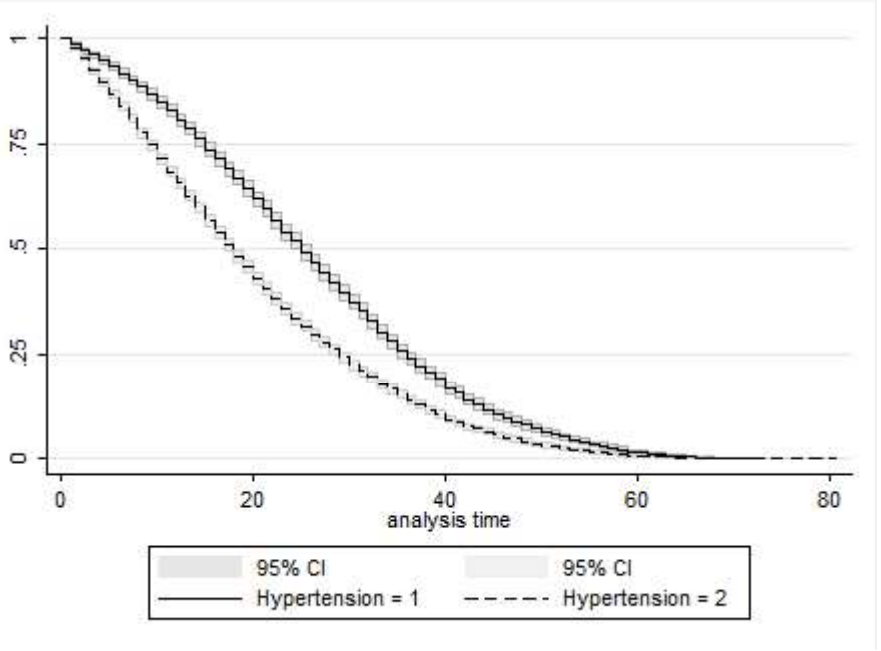
Figure 4.9 – Kaplan-Meier analyses of the cigarette consumption: physical exercise.



Source: Author (2018).

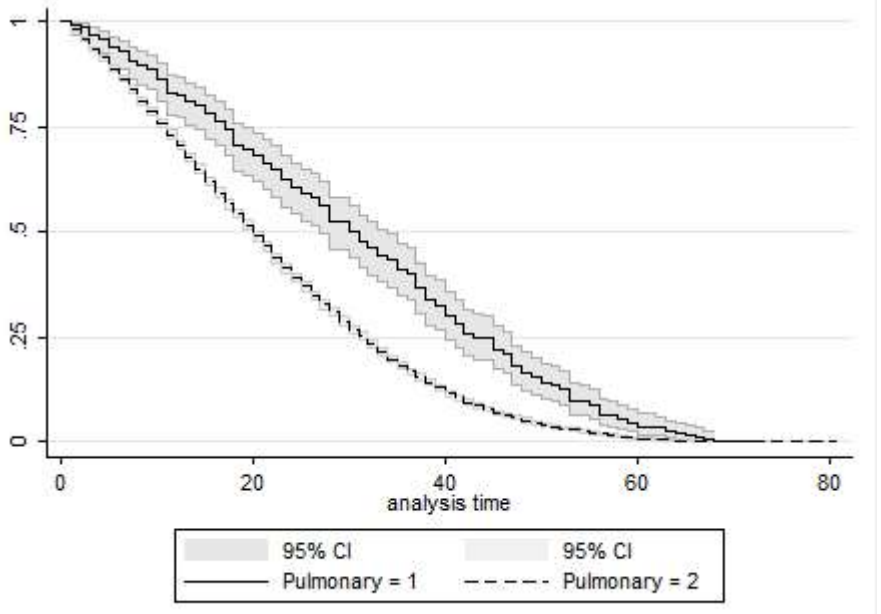
The variables related to health conditions (Figures 4.10 and 4.11) show that the existence of diagnosed lung diseases and hypertension are significant to increase smoking duration. Figure 4.10 shows that those who smoked for less time (pulmonary diseases = 1, a physician has already diagnosed another lung disease, and pulmonary diseases = 2, without a diagnosis) do not have diagnosed pulmonary diseases. The same was found for hypertension, i.e. people without diagnosed hypertension have a lower smoking duration (hypertension = 1, a physician has already diagnosed hypertension, and hypertension = 2, without a diagnosis). The results suggest that people might develop the diseases during the period they smoke cigarettes; therefore, those who have smoked for a long time have more chances of being diagnosed with them. According to WHO (2011) consumption of tobacco products is the main cause of heart and lung diseases.

Figure 4.10 – Kaplan-Meier analyses of the cigarette consumption: hypertension.



Source: Author (2018).

Figure 4.11 – Kaplan-Meier analyses of the cigarette consumption: Pulmonary Diseases.



Source: Author (2018).

By analyzing smoking curves, the study estimated the hazard of smoking cessation. The variable risk function was analyzed by the KM method and log-rank test using the semi-parametric model Cox. The results show estimated smoking cessation probability considering characteristics with significant survival time.

As discussed previously, $\alpha(t|X)$ gives an estimated hazard ratio for the effect of each variable. Thus, the study analyzed each item in order to verify the duration of smoking. Some characteristics were evaluated as dummies; so, for the smoking cessation hazard ratio, $\frac{\alpha(t|X=1)}{\alpha(t|X=0)} = e^{\beta}$. In other words, if e^{β} is 0.9, for example, the hazard ratio of the group $(t|X=1)$ is 90% of the chances of the other group $(t|X=0)$. Hence, the result is positive when the hazard rate is more that 100%, which indicates that the group will be more likely to quit smoking. For continuous variables: $\frac{\alpha(t|X+1)}{\alpha(t|X)} = e^{\beta}$; so, for an increase of 1 unit (month, day, year ...) in the variable, the failure rate is multiplied by e^{β}. If e^{β}= 1.20, the same increase in the variable increases by 20% the chances of smoking cessation.

The results of Table 4.4 show the estimate in the semi-parametric Cox model, considering the variables chosen using the log-rank analysis. The first column represents the exogenous coefficients whereas the second shows coefficient β and the third, the hazard ratio e^{β}. The p-value is the Wald test that demonstrates the significance of the variable. The LR line is the Likelihood Ratio test and Prob is the significance of the estimation.

Age has a negative impact on smoking cessation hazard, which is a negative result, considering that each year of increased age decreases the probability of smoking cessation by 6.6%. Thus, younger people have a higher probability of smoking cessation when compared to older ones. Considering that the addiction starts at age 17 on average, the longer it persists, the lower the chances of cessation.

Females are the ones with more hazard of smoking cessation: about 6% more than the men. When it comes to marital status, single people have from 14% to 4% fewer chances to stop smoking, compared to those of married people. The result was not significant for the divorced, separated or widow(er).

More years of education will significantly result in mores chance of smoking cessation. The chances of those who have the first level of secondary education and those with tertiary education are respectively 21% and 34% higher than those with a lower

education level. Taking into account income levels, the marginal effect is negative. An increase of one unit decreases the hazard of smoking cessation by 6%. Richer people ,therefore, have are more likely to quit smoking.

Concerning health habits, the consumption of alcoholic beverages was not significant. Practicing physical exercises, however, increases the chance of smoking cessation, whereas not exercising decreases it by 24%. Not having pulmonary problems also had a significant negative impact: 36% more chances of quitting. Hypertension, however, was not significant.

Thus, according to the results, the people who are less likely to quit smoking are older, single men with low income and little education. They do not exercise and have pulmonary diseases.

Table 4.4 – Cox estimates results.

Variable	**Coefficient (β)**	**Hazard ratio**	**Hazard ratio95% Conf. Interval**	
Age	-0.068***	0.934	0.932	0.937
	(0.001)	(0.001)		
Female	0.056**	1.058	1.006	1.111
	(0.025)	(0.027)		
Divorced/ Separated/ Widow	-0.034	0.966	0.908	1.027
	(0.031)	(0.030)		
Single	-0.088***	0.915	0.866	0.966
	(0.028)	(0.025)		
Income	0.055***	1.057	1.022	1.093
	(0.017)	(0.018)		
Fundamental to High School	0.197***	1.217	1.138	1.302
	(0.034)	(0.042)		
University or more	0.300***	1.345	1.228	1.483
	(0.048)	(0.065)		
Consume alcohol beverages	0.040	1.041	0.999	1.095
	(0.025)	(0.027)		
Do not practice Physical exercise	-0.149***	0.863	0.816	0.908
	(0.027)	(0.023)		
Do not have hypertension	-0.030	0.970	0.923	1.020
	(0.026)	(0.025)		
Do not have pulmonary diseases	0.306***	1.360	1.195	1.546
	(0.066)	(0.090)		
LR chi2(13)	**4701.20**			
Prob > chi2	**0.0000**			

Source: Author (2018). Standard error in parenthesis.*** Significant at 1% level ** Significant at 5% level * significant at 10% level.

The hypothesis of proportional hazards assumed by the Cox regression model is confirmed by the Schoenfeld test. It tests the proportionality of risks between the groups, which was not rejected at 1% significance (Prob> chi2 = 0.927) (Table 4.5).

Table 4.5 –Schoenfeld proportionality test.

Variable	**rho**	**chi2**	**Prob>chi2**
Age	-0.008	0.65	0.419
Female	-0.003	0.05	0.825
Single	0.004	0.1	0.751
Married	0.005	0.22	0.636
Income	0.002	0.03	0.855
Fundamental to High School	0.008	0.45	0.502
University or more	0.014	1.54	0.214
Consume alcohol beverages	0.010	0.83	0.364
Do not practice Physical exercise	-0.001	0.01	0.921
Do not have hypertension	-0.008	0.65	0.419
Do not have pulmonary diseases	-0.003	0.05	0.825
Global Test		5.07	0.927

Source: Author (2018). Standard error in parenthesis.** Significant at 5% level * significant at 10% level.

As a result, the main requirement for the Cox model was satisfied, which has validated the findings of the regression. The next session presents the final conclusions about the results described.

4.4. CONCLUSION

The FCTC agreement was implemented in Brazil in February of 2005, and its measures to control tobacco have reduced consumption. However, a stronger illegal market and the pressure from the tobacco industry have become important barriers to continue to reduce smoking in the country. Therefore, it was important to identify the characteristics that increase smoking duration, and which people make the most susceptible group to consumption.

Studies about cigarette consumption reveal that characteristics such as education, gender, and race are determinants of smoking onset and duration. Marital status can also contribute to how people respond to smoking regulations. The Brazilian profile of cigarette consumers based on the 2008 PNAD shows that consumption is higher among those who are in the lowest decile of income and among men. Additionally, age has a positive impact on prevalence of smokers until age 59, and the majority of student smokers are behind in their schooling.

According to the PNS, the most representative smokers are brown, single men aged 48-57 years with the first level of secondary school, income of R$ 441.00-R$ 1,019.00, who consume alcoholic beverages more often, do not exercise, and have not been diagnosed with hypertension or lung diseases. In the group of former smokers, the characteristics are virtually the same, except for marital status, income and alcohol consumption. Former smokers are more represented among those who are married, with an income of more than R$ 1,019.00 and they do not consume alcoholic beverages. The differences reinforce those studies that assume that lifetime characteristics are important in the decision to quit smoking.

The estimate of KM curves to study smoking duration differences was significant for all characteristics except race. Thus, the hazard of smoking cessation was estimated using the semi-parametric model Cox. According to the results, those with more hazard of quitting are younger, married women, with high income and education, who exercise and do not have any pulmonary disease.

Age had a negative effect in the chances of smoking cessation. Considering the age distribution of smokers, the results corroborate the importance of health campaigns for the youth to raise awareness about how harmful smoking is. With respect to gender, smoking duration is shorter for women and they have more chances to stop smoking. The

conclusion is supported by the difference in percentage of gender between smokers and former smokers.

Regarding marital status, single people are the majority in the smoker samples and their chances to stop smoking are significant lower than that of married ones. Separated/divorced/widow(er) people have a longer duration of smoking compared to that of married and single ones, but their chances of quitting the habit are not significantly different.

Education presented the greatest hazard to quit smoking. Thus, longer education had a high impact on smoking cessation, which corroborates studies about smoking in Brazil and abroad. The recent increase in education in the country can also account for the decrease in the number of smokers; however, this cause needs further studies.

When it comes to income, most of the people who stopped smoking are in richest ranges. However, an additional increase in income has a negative impact on the hazard of smoking cessation. In other words, the higher the income, the higher the chances to stop smoking. However, the survival curves have shown a longer smoking duration for middle-income people.

Habit-related characteristics reinforce the importance of healthy activities in order to quit smoking. People who exercise had high chances of smoking for a shorter time. Therefore, additional government policies to control tobacco consumption should focus on healthy habits in order to have a high impact on the number of smokers in the country. However, those who consume alcoholic beverages are the ones who have more likely to smoke for less time and they are not the majority among former smokers. Regarding diseases, those who do not have pulmonary ones have higher chances of smoking less. Besides the existence of hypertension not be significant to hazard it is significant in increase the survival of smoking.

Despite the results, the survival methodology has a limitation in the selection of variables, for which reason the Cox methodology was used, considering that the model does not impose a parametric form for the distribution of survival times. Additionally, it is important to emphasize that the analyses are based on current characteristics; thus, some could be different at the point of smoking cessation. For that reason, further studies considering different cohorts of smoking cessation could improve the validity of the results.

Through the analysis of the characteristics involving smoking in Brazil, one can conclude that some social and economic characteristics can hinder or facilitate the

implementation of smoking-control policies in the country. Even with a reduction in the number of smokers, smoking duration and the onset of the habit among the youth are an alert to the long-term efficacy of such policies. Additionally, further studies considering the hazard of smoking on set should be very useful to complement this one.

Therefore, better education and the promotion of healthy habits such as physical exercises can contribute to smoking cessation in Brazil. And, considering the limitations of our price policies, new policies based on smokers' behavior and social characteristics maybe more effective to reduce smoking and the number of smokers and consequently decrease public health expenditures.

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5. FINAL CONSIDERATIONS

Brazil and other developing countries are the most affected by the implementation of tobacco control measures. Restrictive policies may cause financial losses and a social impact if farmers have no alternative to tobacco production and trade. Then, considering the world's trend to reduce tobacco products, it is crucial to build an alternative scenario for current tobacco producers and the tobacco industry in Brazil.

The Brazilian Tobacco Control Program (PNCT) has been promoting agricultural technology diversification programs for tobacco producers. However, they are not financially helped to produce nontobacco cultures. The National Program of Division of Tobacco-Cultivated Areas (PNDACT)'s policy to reduce tobacco dependence via the Central Bank resolution n. 4.584, dated August 24, 2016, which determined that 20% of the farmers' income should be non-tobacco, has not had the expected impact on tobacco production. Although reduced production in the country cannot be associated with anti-tobacco policies, the new conditions for small farmers to obtain loans from PRONAF caused them to look for other, more expensive, but not restrictive, credit lines.

The tobacco family farms need to diversify their production because even though the reduction has been slow the decrease in tobacco consumption will affect the Brazilian market in the next six years and producers will continue to be negatively impacted. Also, indirect government subsidies to farmers are important to keep prices competitive while the transition to a non-tobacco culture is not complete in the country.

Based on the results about cigarette consumption in Brazil, one may conclude that more years of schooling and the promotion of healthy habits such as the practice of physical exercises can be an active contribution to smoking cessation in the country. Also, price policies in Brazil have a limited effect on smoking reduction. Thus, new policies based on smokers' behavior and social characteristics can be more effective to reduce the number of smokers and, consequently, public health expenditures.

Finally, the study concludes that FCTC and PNCT have a long way ahead of them to work on measures that can sustainably reduce the tobacco economy in the country. This is precisely why future studies about policy effects are essential for the development of alternatives for agriculture and industry.

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