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Economy-wide impact of a reduction in tobacco use in India

Rijo M John [1], Badri Narayanan,[2] Sumathi Chakravarthy,[3] Sindhu Bharathi,[3] Praveen Sinha,[4] Vineet Gill Munish,[4] Mark Goodchild [5]

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[1]Rajagiri College of Social Sciences, Cochin, Kerala, India
[2]Boston College, Chestnut Hill, Massachusetts, USA
[3]Infinite Sum Modelling LLC, Seattle, Washington, USA
[4]World Health Organization, New Delhi, India
[5]World Health Organization, Geneva, Switzerland

Correspondence to
Dr Rijo M John; rmjohn@gmail.com

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ABSTRACT

Background Public policy measures aimed at regulating tobacco use should consider the net gains for the nation, as the tobacco sector contributes to employment and tax revenue while also imposing substantial economic burden on the country. This study investigates the economy-wide impact of reducing tobacco consumption in India through the implementation of fiscal measures.

Methods The study uses a computable general equilibrium model based on the Global Trade Analysis Project model and database and augments the same with several country-specific information on tobacco products, to examine the macroeconomic impact of a targeted reduction in the consumption of bidis, cigarettes and smokeless tobacco by 10% by the year 2026 through the adoption of fiscal measures.

Results The model results suggest that the targeted reduction in consumption may result in a 0.14% reduction in the gross domestic product (GDP) and a 0.44% reduction in overall employment in the economy. However, after accounting for the averted premature deaths due to tobacco use, the results indicate a net 0.22% increase in GDP and a net increase in employment of about 1.36 million jobs (or 0.29% of the labour force) over 5 years. Further, the tax increase measures proposed in this model to achieve the targeted reduction in consumption would generate an additional US$2774 million in revenues to the exchequer.

Conclusion The impact of targeted prevalence reduction of tobacco use is a win-win for the country considering its positive macroeconomic impacts in terms of net increases in both GDP as well as employment.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Due to the contributions of the tobacco sector to both employment and tax revenue in India, debates on fiscal policies aimed at regulating this industry are often intensified. Arguments frequently emphasise the economic impact of the tobacco industry, highlighting concerns about potential job losses and reduced tax contributions.

WHAT THIS STUDY ADDS

⇒ Using a computable general equilibrium model, this study assesses the broad economic impacts of decreasing tobacco consumption in India through fiscal measures. The findings reveal that, considering the prevention of premature deaths from tobacco use, there is a net positive effect, with a 0.22% increase in gross domestic product and an addition of around 1.36 million jobs over 5 years. Moreover, the suggested tax increase measures in the model could generate an additional US$2774 million in revenue for the exchequer.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study underscores the comprehensive economic benefits associated with enforcing tobacco control measures. It suggests that fiscal measures for tobacco regulation can be crafted with a broader macroeconomic outlook, offering insights for policy-makers. The innovative methodology applied in this research presents potential value for replication in other countries heavily reliant on the tobacco sector.

INTRODUCTION

India, with 267 million people above 15 years of age using tobacco in some form[1] in 2017, is the second-largest consumer after China and constitutes approximately 19% of worlds' adult tobacco users.[2] India was also the third-largest producer of tobacco after China and Brazil in 2018 accounting for 12.3% of the world's tobacco production.[3] About 417 754 hectares in India are used for tobacco cultivation producing about 749 907 tons of unmanufactured tobacco[3] as of 2018. The gross value added (GVA) from tobacco manufacturing was INR287.96 billion in 2018–2019 which constituted about 1% of the total manufacturing GVA.[4] Employment in tobacco sector activities is estimated at 7.25 million.[5] Employment in tobacco manufacturing constituted only 0.2% of rural and 0.1% of urban male population (ages 15–59) and 1.1% of rural and 0.8% of urban female population in the same age group in 2-11-12.[6] Total excise tax revenues from tobacco amounted to INR217.19 billion in 2016–2017. However, it was about 5.8% of central excise tax revenues and only 1.3% of total gross tax revenues.[7]

Notwithstanding the contribution of tobacco sector to the national economy, tobacco use generates huge economic burdens on society. In India, about 930 000 people die annually on account of smoking attributable diseases[8] and 350 000 die on account of smokeless tobacco (SLT) use attributable diseases,[9] resulting in 3500 tobacco-attributable deaths per day. The economic burden associated with tobacco use is estimated to be Rs.1773.4 billion (1% of India's gross domestic product (GDP)) in 2017–2018, 74% due to tobacco smoking and 26% to SLT use.[10]

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In 2017, India overhauled its indirect tax system with the implementation of the goods and services tax (GST), which subsumed federal-level excise duties and state-level value-added taxes. However, in the 7 years since its introduction, tax rates on tobacco products have remained largely unchanged, increasing its affordability.[11] The tax share in the final retail price remains below the WHO-recommended 75%,[12] with approximately 51% for cigarettes, 22% for bidis and 64% for SLT.[11] Although taxation is recognised as one of the most cost-effective tools to regulate tobacco use,[12 13] it appears that tax policy is underused in India.

It is important that policies to regulate tobacco products such as taxation assess their net impact and examine whether it would lead to a net benefit to the economy and society at large. For example, a tobacco tax increase, apart from its direct impact on reducing consumption, can have indirect effects on consumption and production of various other products in the economy. For example, land and labour released from tobacco sector may be used in other sectors. Thus, it is important to examine the tobacco sector as part of the whole economy to better understand the economy-wide impact of tobacco control policies. The National Health Policy (NHP) 2017[14] envisages a 30% relative reduction in current tobacco use by 2025. While this is desirable from a public health perspective, there is a need to examine how such a reduction in tobacco consumption would impact rest of the economy, for example, via the flow of all economic transactions that take place.

The literature on the net impact of different tobacco control policies after allowing for multisectoral linkages has been limited. A study[15] in the UK found a net increase in employment when there was a decrease in tobacco consumption and spending. Input–output analysis was used in a study from Canada[16] which found significant reallocation effects following a consumption decline resulting from tobacco control legislation. Employment effects were found to be more pronounced in the public sector than in the private. Multisector computable general equilibrium (CGE) modelling study in Taiwan[17] found a new tax scheme would significantly reduce cigarette consumption and result in significant gains in health benefits. Using IO model, a study[18] from Indonesia estimated that a 100% tax scenario would be positive in terms of output produced by all sectors. A study from Bangladesh[19] found that reducing tobacco consumption and redirecting the decreased demand as a stimulus to other sectors of the economy led to a significant increase in GDP and national income. A CGE modelling study from Tanzania[20] estimated that a reduction in tobacco consumption would reduce employment in the tobacco sector but increase employment in other sectors. The overall decline in total economic output was minimal, estimated at −0.3%. Another study[21] from Vietnam used Input-Output (IO) tables to find that the net impact on the national output and employment would be positive for any increase in the excise tax on tobacco. An Argentine study[22] using CGE found a 15% rise in tobacco taxes could lead to a shift in jobs from tobacco-related sectors to other sectors in the economy. The overall impact on total employment was negligible, while health outcomes improved. A study from Pakistan[23] used CGE modelling to estimate the impact of increasing the tax burden on cigarettes to 70% of the retail price. This would result in an overall employment income increase of 0.5% in the economy. Additionally, it projected that overall household income, GVA and output would increase by 0.13%, 0.12% and 0.03%, respectively. A study from Mexico[24] used an applied general equilibrium model to examine the impact of increasing the specific component of the Excise Tax on Production and Services to 76% of the retail price. Findings suggest minimal loss of employment in the tobacco industry would be more than offset by job creation in the health sector.

There are only a few studies in India which examined the impact of different tobacco control policies on various outcomes of interest. One found the introduction of GST would make tobacco tax structure more complex and most states would experience a fall in tobacco tax revenue.[25] A cigarette tax increase of Rs.10 plus 10% ad valorem would lead to 1.5 million men quitting smoking, averting 665 000 deaths, and generating additional tax revenue of about Rs.4385 crores among other benefits.[26] A recent study examining the impact of the Government's National Tobacco Control Programme concluded that early implementation of the programme may not have led to reductions in tobacco use.[27] None of the studies, however, examined the multisectoral impact of these policies. This study fills that gap using a CGE model.

METHODS AND DATA

CGE is a framework in which the linkages between various sectors and the allocation of endowments/resources (such as land, labour and capital) are captured. This framework accounts for the fact that such resources are fixed in the short-to-medium term while sectors can expand and contract, depending on how much their production is needed by other sectors and by final consumers. The current study developed a full-fledged global multisectoral multiregional CGE model, which has comprehensive details on tobacco use and tobacco products/sectors. This is based on the Global Trade Analysis Project (GTAP) model and database,[28] which includes data on aggregated sectors such as crops and beverages/tobacco products. A detailed description and updated technical documentation on GTAP are available.[29 30] Moreover, a detailed explanation of the CGE model, the GTAP database, including its baseline and scenario design, is available in online supplemental appendix. For the purpose of more disaggregated product-wise analysis, we further augmented GTAP model with country-specific information on tobacco crop, tobacco products such as bidis, cigarettes and SLT, employment in tobacco sector, tobacco tax revenue, own-price and cross-price elasticities of tobacco products, and economic burden from tobacco use in India from a variety of secondary sources including India's IO table[31] with information on raw tobacco and tobacco product sectors.

The tobacco control policy scenario we considered for the CGE simulations was a uniform 10% reduction in consumption of bidis, cigarettes and SLT by 2026. The health benefits from this policy scenario in terms of number of deaths averted and consequent benefits to the economy coming from increased labour supply were also estimated in an extension to the CGE framework. The model achieved the targeted reductions in consumption through either a tax on raw tobacco or a tax on consumption. The former reflects the possibility that taxing at an earlier point in the supply-chain might increase compliance, particularly for informally produced goods like bidis and SLT. Although the model in this paper is time-agnostic for the simulation of consumption reduction, we assume the consumption reduction to happen over a 5-year period starting from the time of policy intervention. We used the own-price elasticities of −0.91 to −0.35 and −0.88 for bidi, cigarette and raw tobacco leaves, respectively, from existing literature.[32] Similarly, the income elasticity for bidi, cigarette and tobacco leaves is 0.39, 1.98 and 0.33, respectively. These values represent the average income elasticities for these products in rural and urban India.[33]

While the model simulates the resulting changes in production, consumption and employment the resulting impact in terms of deaths averted were estimated outside of the model. We first computed a number of current tobacco users and estimated the number of deaths at baseline assuming 33% of all users die prematurely, a very conservative assumption based on the existing literature.[34] We also used an alternative, less conservative scenario, assuming 50% premature deaths among tobacco users. On this 33%, we applied a mortality adjustment factor for 67%. It means, only 67% of the 33% premature deaths would be averted if they quit tobacco use as in existing literature.[34] We multiplied these estimated averted deaths with the labour force participation rate among the adult population (48.53%) for 2021 as obtained from the World Bank. The gain in labour force thus estimated was plugged back into the CGE model as a shock to the labour force in the model. Given that the estimated deaths averted are for the remaining life course of those quitting, it is important to annualise it to estimate the number of averted deaths which are potentially part of the labour force. For this, we first estimated the difference between average age of tobacco users under 65 years (39 years for SLT users and 42 years for smokers as estimated from GATS) and the age of being out of the labour force, assuming 65 years. An additional 2.5 years was added to this difference as the quitting is assumed to happen uniformly over the 5-year period during the consumption reduction. The total averted deaths are then divided by this number to estimate an annual number of averted deaths among those in labour force and apply for this number as a shock to the labour force in the CGE model to derive the resulting change in GDP for the policy shock scenarios over the 5 years.

RESULTS

Table 1 shows the size of tobacco sector in Indian economy as used for the macroeconomic simulation in the model. The combined contribution of bidis, cigarettes and SLT in the value of total production in Indian economy was 0.32% while that in the value of consumption was 1.05%. The combined contribution to the employment was at 2.2% and the sector's total share in taxes was at 0.99%. More than 87% of the employment contribution from tobacco sector came from the bidi sector while 91% of the tax contribution in tobacco sector was from cigarettes.

Table 2 shows the macroeconomic impacts of the consumption reduction on the key outcome variables. The target reduction in consumption is achieved either through a tax on consumption (scenario 1) or a tax on raw tobacco (scenario 2). The tax on consumption results in a 0.14% reduction in GDP and 0.44% reduction in overall employment. On the other hand, tax on tobacco would lead to a GDP reduction of 0.12% and employment reduction of 0.42%. Both GDP and employment impact appears to be similar irrespective of the method used to reach the targeted consumption reduction. However, tax increase is higher when the tax is imposed on tobacco consumption. While a tax on tobacco consumption generates an additional tax revenue of US$2774 million, tax on raw tobacco generates and additional tax revenue of US$2142 million both achieving the same targeted reduction in tobacco consumption. While the scenarios 1 and 2 increase tax, the actual increase of tax from tobacco sector was higher than the net increase. Cigarette is a major contributor to tax revenue because bringing down cigarette consumption requires a relatively higher tax imposition. This is because while the tax increases in the tobacco sector there is a simultaneous reduction in tax from other sectors due to changes in consumption that occurs in other sectors.

Table 3 shows the impact that alternative methods of achieving the target consumption reduction have on tobacco consumption and production. In the first scenario where we reduce the final consumption of bidi, cigarettes and SLT, there is a decline in production volume and production value. On the other hand,

Table 2 Changes in outcome variables in the overall economy due to a targeted reduction in consumption of bidis, cigarette and SLT by 10% by year 2026

	Taxing tobacco consumption	Taxing raw tobacco
GDP change (%)	−0.14	−0.12
GDP change (millions USD)	−4456.34	−3738.41
Production change (%)	−0.15	−0.11
Production change (millions USD)	−9132.20	−6819.17
Change in consumption (%)	−0.19	−0.14
Change in consumption (million USD)	−4437.87	−3288.38
Private consumption (%)	−0.23	−0.16
Private consumption (million USD)	−4533.78	−3171.20
Government consumption (%)	−0.03	−0.02
Government consumption (million USD)	−100.12	−65.22
Export (% change)	0.43	0.19
Exports change (millions USD)	2293.97	1030.37
Import (% change)	−0.21	−0.16
Imports change (millions USD)	−1309.93	−1030.45
Employment (% change)	−0.44	−0.42
Employment change (million jobs)	−2.07	−1.97
Tax revenue (% change)	0.79	0.61
Tax revenue (change in millions of USD)	2773.82	2141.81
Change in tax from tobacco sector	3051.21	1770.09
Change in tax from non-tobacco sector	−277.38	−371.72

GDP, gross domestic product ; SLT, smokeless tobacco.

Table 1 Baseline (2021) information on different tobacco products in the model: (in millions of USD unless specified)

	Bidis	Cigarettes	Smokeless tobacco	Tobacco sector	Overall economy
Production	4416.96	14 320.19	1475.99	20 213.14	6 263 965
Consumption	4744.93	14 518.54	1263.71	20 527.17	1 960 253
Employment (millions of jobs)	8.93	0.94	0.35	10.22	471
Export	6.51	97.59	288.04	392.14	531 092
Import	0.01	19.41	10.30	29.72	633 277
Tax revenue	427.04	5517.05	113.73	6057.82	609 988
Contribution to production (%)	0.07	0.23	0.02	0.32	100
Contribution to consumption (%)	0.24	0.74	0.06	1.05	100
Tax burden (%)	22	49.5	63.75		

Table 3 Impact on consumption and production in tobacco sectors under alternative policy implementation routes

	Bidis	Cigarettes	Smokeless
Change in consumption (value)			
Base value (million USD)	4744.93	14518.54	1263.71
Taxing tobacco consumption	3.58%	11.39%	3.78%
Taxing raw tobacco	3.58%	11.39%	3.78%
Change in consumption (volume)			
Taxing tobacco consumption	−10.00%	−10.00%	−10.00%
Taxing raw tobacco	−10.00%	−10.00%	−10.00%
Change in production (value)			
Base value (million USD)	4416.96	14320.19	1475.99
Taxing tobacco consumption	−8.39%	−7.73%	−6.79%
Taxing raw tobacco	1.96%	3.14%	1.64%
Change in production (volume)			
Taxing tobacco consumption	−8.32%	−7.72%	−6.66%
Taxing raw tobacco	−9.27%	−10.33%	−7.34%
Marginal increase in tax burden			
Taxing tobacco consumption	13.69%	21.50%	13.82%
Taxing raw tobacco	15.26%	30.25%	15.24%

All baseline numbers in this model are in millions of USD. Volume change is the value change in constant prices. Therefore, volume changes shown here are the same as value changes in constant prices.

Table 4 Sectoral impact* on employment due to a targeted reduction in consumption of bidis, cigarettes and SLT by 10% by year 2026

Sectors	Baseline jobs (millions)	Taxing tobacco consumption	Taxing raw tobacco
Bidi	8.94	−8.425	−9.347
Cigarette	0.94	−7.974	−8.372
Smokeless	0.35	−6.785	−7.569
Sugar cane, sugar beet	11.24	−0.657	−0.514
Sugar	0.75	−0.604	−0.523
Trade	30.34	−0.512	−0.393
Mineral products nec	1.95	−0.488	−0.384
Accommodation, food and services	6.21	−0.488	−0.323
Dwellings	0.20	−0.475	−0.312
Construction	46.26	−0.473	−0.365

*Only 10 sectors each with the highest and lowest decline in employment are shown.
SLT, smokeless tobacco.

in the second scenario, where we tax the raw tobacco, there is a decline in production volume, but an increase in the production value. In the first scenario, we are shocking the tobacco consumption value after taxes, the production price will not increase and so both production volume and value declines. On the other hand, in the second scenario, where we tax raw tobacco, the production value will increase as the price now also includes this new tax. So, the production value increases in scenario 2. Unlike production value, the consumption value is the value after taxes. So, when we shock the consumption volume, it drives the consumption prices increasing the consumption value in both scenarios. Also, it must be noted that the consumption value of cigarettes is higher than bidi and SLT in both scenarios. This is due to the own price elasticity of cigarette consumption which is much smaller in magnitude compared with both bidis and SLT. It means a given percentage increase in prices (due to a change in tax) will have a relatively smaller impact on consumption of cigarettes than on the consumption of bidis and smokeless. So, the consumption price should increase at a higher extent than for bidi and SLT to achieve the same reduction in consumption. Considering production value of cigarettes, a similar trend prevails and it is higher than the increase estimated for bidis and cigarettes. This is because we tax raw tobacco way before the production stage and so the production price of cigarette should increase to achieve the consumption decline whereas in the first scenario, the production value declines because we are only shocking the final consumption and the production prices may not increase.

The direction of change can be different for values of consumption and production as against the volume of consumption/production. This is because, even if the real consumption volumes decrease over the 5-year period, their monetary values could still turn out to be positive due to increased (inflation-adjusted) prices over the 5-year period. The total tax burden increases for all three tobacco products under both policy implementation routes compared with the baseline tax burden.

Table 4 shows the sectoral impact on employment without accounting for the additional health gains from tobacco use consumption reduction. As we can see, the target consumption reduction would lead to a loss in employment in bidi, cigarettes and SLT. There will be about 8.4%–9.3% decline in employment in the bidi sector full-time (approximately 640 000–709 000 job loss over the 5-year period) depending on the scenario chosen. Similarly, the loss of employment in cigarettes sector would be 8%–8.4% (approximately 74 000–78 000 job loss over the 5-year period) and for SLT would be 6.8%–7.6% (approximately 23 000– 26 000 job loss over the 5-year period). There is net growth and decline in employment in other sectors too. The overall impact on employment, without accounting for the health gains from consumption reduction, for all sectors combined was, negative, although low at 0.44% (approximately 2.06 million job loss over the 5-year period), as discussed in table 2.

The simulation estimates that 3.08 million deaths were averted due to a target 10% reduction in consumption. Because the estimate of averted deaths is based on the percentage reduction in consumption, the estimated number of averted deaths was the same whether we use scenario 1 or scenario 2 to achieve the consumption reduction. Table 5 shows what happens to the GDP if we are able to incorporate a fraction (48.53%, which is the labour force participation rate) of the averted deaths or saved lives resulting in consumption reduction as an increase in the available supply of labour force. As we can see, the gain in GDP over the 5-year period after accounting for averted deaths, and under the more conservative assumption on premature deaths among tobacco users, was positive at 0.36% which, in absolute terms, was US$11.43 billion and net gain was positive at 0.22%, which, in absolute terms, was US$6.99 billion. This net gain is the sum of GDP loss resulting from the original scenario (0.14%) and gain in GDP arising from accounting for the addition of saved lives into the labour force. Since the labour force participation rate was 49.5%, the increase in labour force was 1.2 million. One can see that the net gain is positive and is achieved within 5-year duration of the simulation itself. Since the overall impact on the employment was a loss of 2.06 million jobs over 5 years before accounting for the health gains, the net change in employment would be a gain of 1.36 million jobs over the 5 years term. If on the other hand, we used a relatively less conservative assumption of 50% tobacco users dying prematurely, we can

Table 5 Impact on GDP over 5 years due to additional health gains from the policy shock

	Rows	Outcomes with alternative assumption on premature deaths from tobacco use	
		33% users dying prematurely	50% users dying prematurely
Total change in GDP without assuming any lives saved (%)	(A)	−0.142	−0.142
Deaths averted over the 5-year period ('000)	(B)	3080.03	3696.04
Increase in labour force due to deaths averted (%)	(C)	0.730	0.84
Gross increase in GDP after accounting for averted deaths (%)	(D)	0.363	0.514
Net increase in GDP due to the policy shock after accounting for averted deaths (%)	(A+D=E)	0.221	0.372

GDP, gross domestic product.

see the net impact on GDP is even larger at 0.37% translates to US$11.76 billion and a net gain in employment for 1.51 million jobs over the 5-year term.

DISCUSSION

Recognising the harm caused by tobacco use, the NHP 2017, set out to achieve a 30% relative reduction in consumption of 'current' tobacco use by 2025. However, given the interlinkages of tobacco sector with the other sectors in Indian economy, it is important to examine whether various policy actions on tobacco control would lead to a net benefit to the country. This paper uses a CGE model to determine the macroeconomic impact of a targeted 10% relative reduction in consumption of bidis, cigarettes and SLT seeking to achieve these either through a tax on consumption of tobacco or a tax on the raw tobacco. To achieve a 10% consumption reduction, excise taxes would need to be increased by 10.98% for bidis, 28.57% for cigarettes and 30.30% for SLT. The results indicate that such a reduction in the consumption of all three tobacco products results in a 0.14% reduction in the GDP and 0.44% reduction in overall employment in the economy. Once we account for the gains in employment as a result of an increase in the number of deaths averted due to reduction in tobacco use consumption, it results in a net 0.22% increase in GDP and 1.36 million net increases in employment over the 5 years. The same will result in a 0.37% increase in GDP and 1.51 million net increases in employment over the 5 years if we take a slightly less conservative approach of assuming 50% of all tobacco users die prematurely. This study underscores the benefits of actively pursuing fiscal policies to control tobacco use in India, with positive outcomes in terms of net increases in GDP as well as overall employment in the country. Its findings are consistent with similar results we reviewed earlier from other countries. It is also important to note that the model is time agnostic. So, the effects estimated in the model are assumed to be valid for the 5 years from the time the policy changes come into effect irrespective of the assumed baseline.

While this study applies a novel approach to the analysis of the economy-wide impact of targeted reduction in consumption of tobacco products in India, the study has certain limitations. First, the model examines a concurrent increase in tax burden across all three tobacco products or an increase in tax on all raw tobacco depending on the scenario chosen for the target consumption reduction. If taxes are not increased on any one of the products as has been done in case of bidis in India post the introduction of GST, the results may not hold. The model rather highlights the need for a simultaneous tax increase on all tobacco products. Second, the model assumes that tax increases have a 100% pass through effect and increase the prices by the same rate. Although it is not necessary, it has been observed that tobacco industry, often, increase prices by more than the increases in tax. In such cases, the consumption impact estimated in the model is understated. Third, our estimates of deaths averted and the subsequent positive shock on the labour force are conservative since we used a very conservative assumption that only 33% of all tobacco users die prematurely compared with many studies assuming 50%. Fourth, this study incorporates the health gains only in the form of averted deaths into the CGE modelling framework to examine its impact on GDP. However, reduced disabilities, morbidities and increased productivity on account of reduction in tobacco use can have an additional impact in terms of improving labour productivity which will also positively impact GDP. This study did not fully explore how the allocation of extra government revenues from tobacco taxation towards growth-enhancing programmes, like health and education, might improve growth prospects. To this extent, the gains in GDP as estimated in this report are rather conservative. Fifth, in the absence of estimates of consumption elasticities for different tobacco products in India, the model makes a simple assumption that prevalence elasticity constitutes half of the own-price elasticity as per available evidence from the international literature. Sixth, the model achieves the target reduction in consumption through a certain increase in tax burden either on consumption of tobacco products or on the row tobacco. It does not examine the impact of changing different components of taxes. In India, the tax on tobacco has different elements including excise tax, GST and compensation cess.[25] A given percentage increase in each of these components will have different effects on the final price and tax burden. Hence, the tax increases warranted will differ according to the particular component of the tax that is increased in order to get the required tax increase for the target reduction in consumption. Finally, we assume standard neoclassical economic tenets like perfect competition, constant returns to scale and specific (although highly flexible) functional forms, which may or may not hold true in reality for tobacco and other sectors. Notwithstanding these caveats, the CGE modelling offers several insights into the potential tobacco control policies that India could adopt and their relative outcome in terms of changes in employment, output and GDP.

CONCLUSION

Tobacco industry has always exaggerated the importance of tobacco sector in the Indian economy, sometimes even with the help of published, non-transparent, reports.[35] However, it has never considered the positive gains from tobacco control policies and the resulting health gains at the macroeconomic level. This study finds that the macroeconomic impact of target consumption reduction of tobacco achieved through tax increases either on the consumption of final tobacco product or on the raw tobacco is positive and will increase GDP once health gains from reduced consumption are taken into account. Due to the lack of the major increase in taxes on tobacco products since the time GST was introduced in India in 2017, except for marginal increases in 2021 and 2023, tobacco products have become increasingly more affordable over the past few years.[36] For the government of India to stay on its target of achieving significant reductions in tobacco use consumption, it is imperative that tobacco taxes are increased more significantly and simultaneously for all tobacco products and on a regular basis. As this study shows, such tax increases will be a win-win for the country considering its positive macroeconomic impacts over time resulting from net increases in GDP as well as overall employment.

Contributors RMJ and BN conceived the research idea and finalised the methods. BN, SC and SB carried out the model simulations. RMJ wrote the first draft. All authors contributed to the interpretation of results, multiple revisions and finalising the manuscript. RMJ is the guarantor.

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ORCID iDs
Rijo M John http://orcid.org/0000-0002-4525-6507
Mark Goodchild http://orcid.org/0000-0002-1826-1343

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Economy-wide impact of a reduction in tobacco use in India

Rijo M. John, Badri Narayanan Gopalakrishnan, Sumathi Chakravarthy, Sindhu Bharathi M., Praveen Sinha, Vineet Gill Munish, Mark Goodchild

APPENDIX

COMPUTABLE GENERAL EQUILIBRIUM MODEL

Computable General Equilibrium (CGE) models have been widely used by the global research community to answer pressing policy questions. In a nutshell, the CGE model is a framework in which the linkages between various sectors and the allocation of endowments/resources (such as land, labor and capital) are captured. This framework accounts for the fact that resources are fixed in the economy while sectors can expand and contract, depending on how much their production is needed by other sectors and by final consumers. For each sector, a typical CGE dataset comprises the inputs needed for production, in terms of factors as well as materials used from production of other sectors, imports, and details of where the output goes: domestic or exports. What happens in one sector has the potential to affect the whole economy, not only through its own share in the economy but also through its forward and backward linkages with other sectors. In other words, tobacco may be a small sector vis-à-vis the size of the Indian economy, but if we account for its linkages with other sectors in the economy, it can be very significant.

Starting from the premise that consumption is reduced by X% in N years, a Partial Equilibrium (PE) model approach would translate such reduction in terms of change in aggregate consumption of tobacco in N years, by accounting for per-capita income growth and elasticity of tobacco consumption with respect to income and prices. Such a model captures the supply-demand linkages in the tobacco sector, by accounting for production, consumption, exports and imports in raw and processed tobacco. There are behavioural equations in production, private consumption, exports and imports, as well as market clearing conditions to equate supply with demand. These are based on data on different variables outlined here as well as elasticities some of which were estimated from data and some of which were taken from the literature. Employment effects are then captured by assuming a simple multiplier on output.

This is too simple an approach and has the limitations of not being comprehensive enough in an economy-wide sense, and also even within tobacco markets, since it ignores the intermediate inputs involved in production of tobacco and its products. Further, effects on other sectors as well as broad macro-economic effects are also not captured in this model. It also ignores international effects, emanating from the rest of the world.

To address the limitations above, we develop a full-fledged global Computable General Equilibrium model, which has comprehensive details on tobacco and tobacco products sectors. This is based on the GTAP model (Hertel, 1997) and database, further augmented significantly using country-specific data on tobacco crop and tobacco products, from various national and international sources of data as explained in our report.

Such a model captures supply-chain effects, macro-economic aspects, economy-wide equilibrium constraints, linkages between different sectors and countries, as well as emission and land use effects of different commodities. We can also capture the potential substitution of tobacco for other crops in the case of the former's decline. We shall model the tobacco control policy in terms of reduction in production and trade of this sector.

For the CGE analysis in the study, we developed a full-fledged global multi-sectoral multi-regional CGE model, which has comprehensive details on tobacco and tobacco products/sectors. This is based on the Global Trade Analysis Project (GTAP) model and database[34], which includes data on aggregated sectors such as crops and beverages/tobacco products. For the purpose of more disaggregated product-wise analysis—separate analysis on cigarettes, bidis and smokeless tobacco—we further augmented the GTAP model with several country-specific information on tobacco crop, tobacco products, employment in the tobacco sector, tobacco tax revenue, own-and cross-price elasticities of tobacco products, economic burden from tobacco use etc. in India from a variety of published secondary sources.

Figures A1 and A2 illustrate some key aspects of the quantity flows and the price transmission channels in the model, respectively.[1] The model developed in this paper is an extension of the standard GTAP model (Global Trade Analysis Project, 2018). We define the sets SECT of sectors (indexed by k) and REG of regions (indexed by r in most cases and if the region is the source of exports/imports but by s if the region is destination of exports/imports). We turn now to a discussion of key components of the GTAP model.

[1] The unit of measurement for all variables explained in this section is percentage change.

International Trade

The change in imports of each region from each of the others is determined by three factors: (i) substitution among different sources, based on the differential between import prices from specific sources and the sum of import-augmented technical change and aggregate import prices $pimk_{k,s}$[2], multiplied by the elasticity of substitution of imports between the sources $\sigma_{M,k}$, which is the Armington elasticity for the sector as in GTAP Database, (ii) import-augmenting technical change, $amsk_{k,r,s}$, that lowers the effective price of a good in the destination market, and (iii) the import penetration as captured by change in composite imports of subsector commodity *k*, $qimk_{k,s}$: :

For all sectors k in SECT, regions r and s in REG:

$$qxsk_{k,r,s} = -amsk_{k,r,s} + qimk_{k,s} - \sigma_{M,k} * [pmsk_{k,r,s} - amsk_{k,r,s} - pimk_{k,s}] \quad (1)$$

Global transport margins are treated in the same manner as in the standard GTAP model, with the quantity of international trade, transport and insurance services required being a fixed proportion of the volume of goods shipped. Technical change in this sector is represented with the variable $atmfsdk_{k,r,s}$ is obtained by adding up the changes at different levels, which are directly translated from the aggregate changes in the corresponding variables. Trade and transport services are provided at a common price, *pt*, which represents a Cobb-Douglas aggregation of trade and transport services exports from all regions in the model. Deducting the rate of technical progress from this price change gives the percentage change in the commodity and route-specific transport margin, $ptransk_{k,r,s}$. The price linkages in the model also include export taxes $txsk_{k,r,s}$, export *fob* prices $pfobk_{k,r,s}$, and import *cif* prices $pcifk_{k,r,s}$ as shown in Figure A2. Changes in import tariff and export taxes are the policy variables here.

Domestic Consumption

There are three broad categories of consumption of products and services manufactured in a country: private households, government and firms. In addition, each of these categories of agents also consume imports that are aggregated across exporters, based on the descriptions in section a above. For private households, GTAP assumes CDE (Constant Difference Elasticity) functional form, which is flexible enough to have Linearized Expenditure Systems (LES) and Constant Elasticity of Substitution (CES) as special cases. For government to consume different products and for firms to

[2] The substitution effect for a particular flow *(k,r,s)* increases in divergence of import tariff for good *k* from regions *r* to *s*, from the weighted-average tariff of *s*. Since higher weight means lower divergence, this effect decreases in import-shares of region *r* in the total imports by region *s* of the good *k*.

consume different intermediate inputs, the functional form is CES. There is also a CES nest between domestic and imported products for each of these agent.

Domestic Production

Production function in GTAP involves 3 levels of nests: (1) There is a Leontief function on the topmost part of production system, wherein intermediate inputs as a composite single input and primary factors as another composite single input are complements. (2) Within the intermediate inputs, there is a CES function. (3) Within the primary factor inputs, there is a CES function. With the exception of land and natural resources, which can move only within agricultural and extraction sectors respectively, other factors are mobile across sectors. GTAP-E model, which focuses on energy and environmental aspects, modifies the system above to introduce substitution between energy sectors and capital input, while further introducing substitution (CES) between different types of energy sources to capture channels of emissions reduction.

Links between Production, Consumption and International Trade

The sub-modules explained above are linked with each other. The percentage change in sector-level domestic consumption, $qdmk_{k,s}$, with corresponding price change $pmk_{k,s}$, substitutes for imported subsector goods, $qimk_{k,s}$, with corresponding price change $pimk_{k,s}$. The CES elasticity between these two variables is $\sigma_{D,k}$, and this substitution takes place based on their respective price differentials from the sector-level domestic prices $pdk_{k,s}$, as illustrated by equations (2) and (3):

For all *k* in *SECT* and *s in* REG:

$$qimk(k,s) = qdk(k,s) - \sigma_D(k) * [pimk(k,s) - pdk(k,s)] \quad (2)$$

$$qdmk(k,s) = qdk(k,s) - \sigma_D(k) * [pmk(k,s) - pdk(k,s)] \quad (3)$$

Domestic market and import price changes are aggregated to domestic price changes by weighting according to their respective shares. $VDK_{k,r}$ is the total value of domestic consumption of goods corresponding to the sub-sector k in the region r, $VDMK_{k,r}$ is the value of domestic consumption of goods produced by the domestic sector k in the region r and $VIMK_{k,s}$ is the value of imports of goods produced by the sub-sector k to the region s.

For all *k* in *SECT* and *s in* REG:

$$pdk_{k,s} = \alpha D_{k,s} * pmk_{k,s} + \alpha M_{k,s} * pimk_{k,s} \quad (4)$$

where: $\alpha D_{k,s} = VDMK_{k,s} / VDK_{k,s}$ and $\alpha M_{k,s} = VIMK_{k,s} / VDK_{k,s}$

Finally, the total changes in supply and demand are equalized to ensure equilibrium, by equating the percentage change in total output $qok_{k,r}$ with the share-weighted sum of exports and domestic consumption for all sectors k in SECT and regions r in REG. When the slack variable $tradslackk_{k,r}$, is exogenized, this equilibrium condition determines the change in market prices, $pmk_{k,r}$ (output, $qok_{k,r}$, is determined by Equation (5).

For all *k* in *SECT* and *r in* REG:

$$qok_{k,r} = \beta D_{k,r} * qdmk_{k,r} + \Sigma_s \beta M_{k,r,s} * qxsk_{k,r,s} + tradslackk_{k,r} \quad (5)$$

Figure A1: Diagrammatic Illustration of the Quantity Flows in the Model[3]

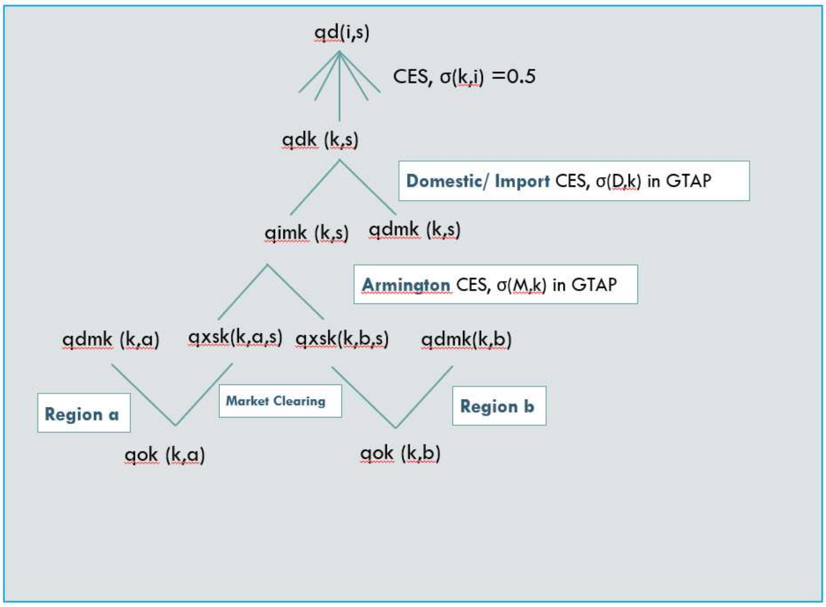

Figure A2: Illustration of Price Linkages in the Model

[3] Notations in Figures A1 and A2 follow standard GTAP notations[46]. In general, the variables starting with: '*q*' represent changes in quantities, '*t*' represent tax/tariff changes and '*p*' represent changes in prices. Those ending with '*k*' are at disaggregate level. In the variable-names, '*d*' stands for domestic, '*i*' for imports, '*x*' for exports, and '*o*' for output. Indices '*r*' and '*s*' denote source and destination regions, respectively; '*k*' denotes sectors.

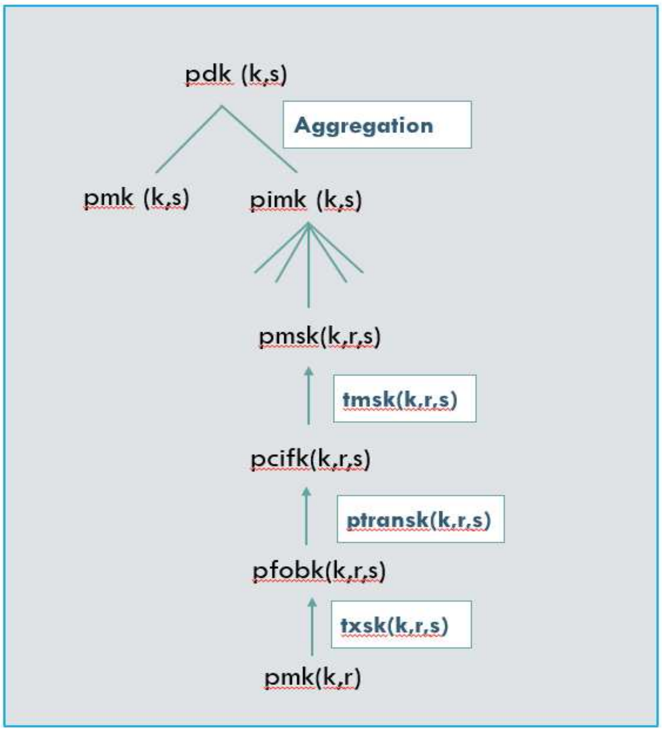

Figure A3 provides a simplified view of the accounting structure of GTAP model. Regional household receives all the income from tax revenue (TAXES) and factor payments (VOA), from the different agents in the economy, namely private households (PRIVEXP), producers or firms and government (GOVEXP). After spending all the revenues for private consumption and government consumption (based on a Cobb-Douglas Utility function that largely preserves the initial shares of PRIVEXP and GOVEXP in total regional income), the residual is savings.

Savings is then accumulated by 'Global Trust' across the world, and then distributed to different regions as investment (REGINV), based on their performance in terms of rates of returns. This is then added to the productive capital of the firms, which uses the different factors (VOA) and intermediate inputs – both domestic (VDFA) and imported (VIFA), to produce output. This output is then exhausted between private households (VDPA), government (VDGA) and also intermediate inputs across different firm types (VDFA). Of course, the households can also import (VIPA), and so can the governments (VIGA).

In Figure A3, the international transactions (with Rest of the World) are shown in red, while the domestic ones are shown in blue. Price linkages happen through this accounting framework; for example, the percent change in prices paid by the exporter before shipping the commodity to other countries are merely a sum of the percent change in market prices and export taxes (XTAX), while that in prices paid by the importer would include both the transportation cost and import tariffs (MTAX), on top of this export price. Investment in this model is governed by a mechanism of diminishing marginal returns to capital and recursive dynamics that captures adaptive expectations with error corrections in expected rates of return.

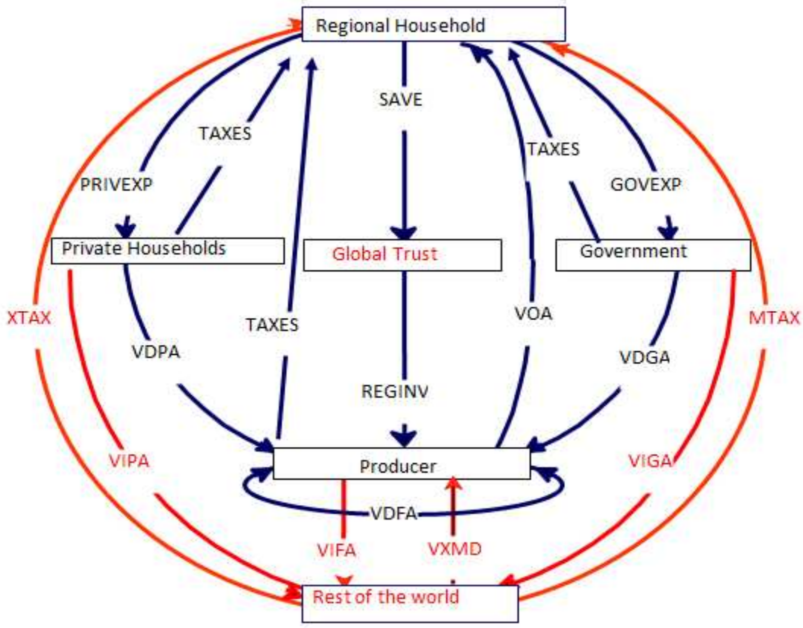

Figure A3: Simplified view of the Accounting Structure of the GTAP model

This model (GTAP) has been widely employed both in the academic and policy world to understand the ex-ante economic impacts of global shocks under different scenarios. At the risk of simplification, the simulations generated from the model offer a picture of how the economies would look when different shocks are administered. These models offer a convenient way to represent all the agents in an economy and their complex interactions with each other, thereby capturing the general equilibrium effects in the form of a mathematical system. When an economy in equilibrium is disturbed by shocks, how do those effects play out and what is the direction and magnitude of such effects? It goes without saying that the reliability of the results are entirely dependent on the fundamental assumptions made in the scenarios.

GTAP DATA BASE EXPLANATION

This appendix overviews the GTAP data construction, and how the data from the different sources are reconciled together. Data collected by one country is rarely consistent with data collected by another due to inaccuracies in the collection and compiling of data. An example of this is in the trade data, where the amount or value of exports one country claims to sell to another rarely matches what the other country claims to import or buy from them, even after transportation and other costs are taken into account. Even within the same country, the same data collected from two alternative sources may differ due to differences in how the data is being collected, interpreted, classified, and valued, notwithstanding the differences caused by errors and omissions. For example, GDP collected from the expenditure side never equals GDP collected from the production side, there is always a statistical discrepancy.

However, global economic analysis requires consistent and reconciled global data. The reconciliation of global datasets is laden with judgments about the quality of the alternative data sets being reconciled. In the case of the GTAP Database the externally collected trade, macroeconomic, ITC protection and IEA energy data are contributed based on international sources and are considered superior to the individual country data because they have gone through this standardization and reconciliation process, although little research has been undertaken to compare the sources.

Economic data for each country including the value of inputs and uses of production is provided as an IO table by a global network of contributors. The starting point for most contributors is an I-O table, supply and use tables, or social accounting matrix developed by the country's statistical office. Most tables require revisions to be made by the contributor to get the original table into a format ready for GTAP. Several constraints need to be satisfied by these IO tables, particularly in terms of signs, balance and other aspects such as treatment of re-exports, domestic/import splits, etc.

The contributed input-output tables which have already satisfied the guidelines for contributors, then go through a cleaning procedure and are pre-processed to produce consistent 65 sector tables. This pre-processing includes minor cleaning, disaggregation, development of

IO tables for composite regions and targeting the IO tables to the international datasets for agricultural production (OECD and FAO).

Those I-O tables which do not have full agricultural and/or non-agricultural disaggregation then go through the I-O disaggregation procedure. Agricultural IO tables based on FAO data are used to disaggregate agriculture. This ensures that the cost shares of the disaggregated agricultural commodities look reasonable. Non-agricultural disaggregation is done using the shares obtained from a ‘representative table’, which is generated as a GDP-weighted average of all contributed IO tables that have all 57 sectors to begin with. Disaggregation does not alter the aggregated totals; it merely apportions the cost and use structures while keeping the same totals.

Input-output tables are constructed for all composite regions – GTAP regions for which there are no contributed tables. This is done by matching each country within the composite region with a country for which we have an IO table. This matching is done using entropy method, by identifying the ‘match’ in terms of per-capita GDP within the same geographical region. This country’s IO table then act as a proxy for the missing country. Later all the proxy IO tables for countries in each composite region are aggregated to form the composite regions. At this stage of data base construction, all countries have a harmonized set of 65 sectors, which can be added up to the original contributed IO tables for each country.

A single procedure is used to achieve the next three objectives:

- The IO tables are updated to the reference year – Version 10, 2014.[4]
- The IO tables are adjusted to match the trade, protection, energy, and macro-economic variables in the global datasets.
- Changes in stocks are eliminated.

This adjustment procedure of fitting the I-O tables has been named after the program FIT that implements it. FIT applies entropy-theoretic methods to adjust an I-O table to various external constraints derived from the international data sets. The fitting procedure is applied after disaggregating the primary I-O tables and constructing composite tables for each country in a composite region. Thus the inputs into the procedure are a complete set of national I-O tables,

[4] The reference year of the IO table does not need to be the same reference year in the final GTAP Data Base. Bringing all IO tables, from different base years, to a common reference year is the first adjustment performed to the country data.

with all the 65 GTAP sectors, for 244 countries, and a set of international data sets and the outputs are the fitted I-O tables and an adjusted energy volumes data set.

The following targets are applied:

i. from constraints imposed by the GTAP data base structure: zero values for changes in stocks of domestic product and imports, by commodity;

ii. from the macroeconomic data set: values at purchasers' prices for GDP, aggregate private consumption, government consumption, and investment;

iii. from the trade data set, modified according to the energy data set: border values of exports and imports, by commodity;

iv. from the protection data set, modified and supplemented from the energy data set: import duty rates, by commodity; export subsidy rates, by commodity; non-commodity indirect tax rates, by industry; commodity tax rates on intermediate usage, by industry and commodity; and rates of tax on private consumption of energy, by commodity; and

v. from the energy data set: basic values for intermediate usage of energy, by energy industry and energy commodity; basic values for private consumption of energy, by energy commodity (the energy industries and energy commodities are aggregations of standard GTAP sectors).

The FIT program incorporates an I-O quantity model, an I-O price model, and an entropy-theoretic balancing procedure. Broadly speaking, the I-O quantity model serves to remove changes in stocks and adjust exports, consumption, and investment. It feeds these final demand changes backward through the I-O structure to determine new levels for intermediate usage and primary factor employment. The I-O price model feeds tax rate changes forward through the I-O structure to adjust basic and post-tax prices for intermediate usage and final demands. The entropy procedure adjusts taste and technology variables to meet the import and energy usage targets. The general rule in the fitting procedure is to adjust the national and composite I-O tables to the international data sets, rather than the other way around, with some exceptions in agricultural domestic support and energy data.

It should be noted that since the international data sets match the data base reference year, adjusting the I-O tables to the international data sets is also the method used to update the year to the base year. This also converts the IO table into the correct units and currency.

The data assembly module is where:

i. adjustments to value added take place;

ii. the factor payments data are adjusted to incorporate land- and capital-based payments;

iii. the various international data sets and domestic data bases are put together and final checks are made;

iv. additional data such as population, capital stocks, depreciation, and savings are included; and

v. additional datasets used in the standard GTAP model or its variants (e.g., sets, elasticities, energy volumes) and summary (e.g., time series trade data, tax rates) datasets are produced.

In terms of value-added, several adjustments are made. First, labor payment data are disaggregated into skilled and unskilled labor payments using payment shares generated in the estimation procedure. Second, factor employment data for primary agriculture and natural resource-based sectors are adjusted using primary factor shares as documented in the literature. In agriculture, external estimates of factor earnings shares are used; and for natural resource-based sectors a proportion of the earnings of labor and capital is reallocated to natural resources to achieve target supply elasticities.

We further take this dataset and make modifications for the following:

1. Incorporation of IO tables of ACU member countries, which are not captured in standard GTAP Data Base, based on datasets from the UN, World Bank and IFPRI: Palestine, Lebanon, Syria, Mauritania, etc.
2. Adjustment of import tariffs to ensure that the trade agreements concluded after 2014 and before 2020 are all taken into account in the dataset.
3. Adjustment of other taxes based on various data sources in the member countries' governments.

BASELINE PREPARATION

We use the GTAP database 10.0 (Aguiar,A. et.al., 2019) which has a reference year of 2014. Our first step is to update it to the year 2021, using macroeconomic data on GDP, consumption, investment, government, exports and imports, available from the World Bank and updated using an entropy optimization procedure named GTAPAdjust (Horridge, M. 2011). Data on the production of tobacco crops is obtained from the FAOSTAT and that on exports and imports of tobacco crops is extracted from the Commodity Trade Statistics of the United Nations. Input-output (IO) statistics to understand the production structure of tobacco products and raw tobacco were developed based on a combination of GTAP 10 Data Base that contains aggregates IO data for the sectors "Other Crops" (ocr) and "Beverages and Tobacco Products" (b_t) and India's IO table for the year 2015-16, which is the latest available. GTAP Data Base is a comprehensive global economic dataset constructed by assembling and reconciling data components from different data sources across the world, primarily publicly available from international organizations and governments. This is documented by various authors in the literature, including a detailed description and a brief technical updated documentation. We have briefly summarized it in Appendix 1. India's IO table has information on raw tobacco and tobacco product sectors separately. Own-price elasticity of cigarettes, bidis and smokeless tobacco is taken from the published Indian literature.

Because the study is focused on India, the 141 countries and regions in the model is aggregated into two regions- India and the Rest of the World and since it is essential to focus on unmanufactured tobacco and other products in the tobacco industry, it is required that the following two sectors in GTAP - Beverages and Tobacco (b_t), Other Crops (ocr) be disaggregated. Since the data components are from different sources and need not agree with each other, an important step after collection of the data is to assemble them together and split the GTAP sector "ocr" into "raw tobacco" and "other crops", and to split the GTAP sector "b_t" into beverages, bidis, cigarettes and smokeless tobacco. For this, we follow a procedure called "MSplitCom" (Horridge, 2005), which is a GTAP commodity-splitting algorithm[42]. Broadly speaking, this procedure entails the use of entropy theoretic methods to split the GTAP sectors based on the information provided. Therefore, the model now accommodates 69 sectors of which 65 sectors are already mapped GTAPAgg sectors and four new sectors are the result of disaggregate function. However, the exact data targets are not typically met because of the inconsistencies between the external data sources and GTAP data. For example, the total production of "b_t" sector may be 1 billion USD for a country, but the actual data for tobacco products alone may be 1.1 billion USD and beverages may be around another 1.1 billion USD. In such a case, the program would assume that both beverages and tobacco products may be half of the 1 billion USD total of "b_t sector, because the external data sources suggest that they are both equal. To rectify such problems, we carry out another procedure called GTAPAdjust. In this procedure, we re-apply all the targets mentioned in the previous paragraph for raw tobacco and all tobacco products – namely, production, IO data, exports and imports and rebalance the whole dataset so that all the supply and demand conditions are met. This is also based on entropy optimization theories.

The intuition of CGE models is based on an input-output structure where one single shock works its way through all inputs and prices to the outputs, employment, wages, prices, etc. A shock may be introduced in the form of a given percentage reduction in consumption of tobacco use. Similar analyses have been done earlier for other countries such as Tanzania[18], but they only focus on tobacco products as a group, without further disaggregation and they only consider a couple of prevalence reduction scenarios in a static sense, translating prevalence reduction into consumption reduction directly.

In this sense, the model is usually time-agnostic in a way, though we may consider the results of the scenarios as instantaneous if the policies are also assumed to be implemented instantaneously. However, for the simulation on consumption reduction as done in this report, we assume the prevalence reduction to happen in 5 years, from 2021 to 2026, and hence the results also may be interpreted to happen in this five-year period. The health benefits from the above policy in terms of the number of deaths averted and consequent benefits to the economy coming from increased labor supply are also calculated over the same time frame. As in John et.al[27], we assumed the price elasticity to be -0.91, -0.35 and -0.88 for bidi, cigarette and raw tobacco leaves respectively. The income elasticity for bidi is assumed to be 0.39, that for cigarettes is assumed to be 1.98 and for tobacco leaves, it is 0.33.

SCENARIO DESIGN

To model the consumption reduction, we assume all the consumption variables of tobacco sectors, captured by the variables *qpd (private consumption of domestic products), qpm (private consumption of imported products), qfd (Firms' intermediate input consumption of domestic products), qfm (Firms' intermediate input consumption of imported products), qgd (government consumption of domestic products) and qgm (government consumption of imported products),* to be shocked, by swapping it with the corresponding tax variables, which are denoted by the same names above, with 'q' replaced by 't'. In other words, the taxes adjust endogenously to take the shock to consumption implied by prevalence change, population change and income change. We keep the GDP variable '*qgdp*', output *'qo',* prices *'pm'*, employment *'qfe',* and all other prices and quantities in the model endogenous. For the tax scenarios, we keep all these quantities endogenous and instead hold all the tax variables exogenous and shock them.

The targeted reductions in consumption are achieved through taxation. This taxation is applied in two different ways in the model.

a. Tax on consumption
b. Tax on raw tobacco

Depending on the type of tax imposed the targeted consumption reduction has different impacts.

a) If the implicit tax is assumed to be applied to the consumption

All the variables discussed in this section are in percent change form, unless otherwise specified. Total consumption is the sum of consumption by households from domestic (*qpd*) and imported sources (*qpm*) and government (*qgd* and *qgm*). So in this scenario, our shock is effectively for *qpd* and *qpm* in the GTAP model for bidi, smokeless and cigarettes as per the estimated decline in consumption calculated above. We also shock *qgd* and *qgm*, but since the government is not a major consumer of tobacco, this is not an important shock and hence we do not discuss this here for the sake of brevity.

In the equations below, '*i*' denotes the commodity, '*s*' is the region/country. '*i*' in this model represents the Bidi, Cigarette, and Smokeless products and '*s*' represents India. *qpd* is the private consumption demand for domestic goods. It is determined by two aspects; aggregate private consumption that includes both domestic and imported commodities and the substitution between domestic and imported goods, based on the elasticity of substitution based on relative price changes in domestic with respect to overall prices. We may roughly interpret the former as the expansion effect and the latter as the substitution effect.

$$qpd\ (i,s) = qp\ (i,s) + ESUBD(i) * [pp\ (i,s) - ppd\ (i,s)] \quad \textbf{(6)}$$

qp (i,s) - private household demand for commodity i in region s.
pp (i,s) - private consumption price for composite commodities (domestic + imported)
ppd (i,s) - domestic price of i consumed by private households in s.
ESUBD(i) - Substitution parameter of domestic/imported commodities for all agents.

The domestic private consumption is calculated as a function of total private consumption (*qp*) and private consumption prices - where *pp* is the aggregate price and *ppd* is the domestic consumption price. *qpm* is the private consumption demand for imported goods. Similar to qpd, this is also determined by two aspects; aggregate private consumption that includes both domestic and imported commodities and the substitution between imported and domestic goods, based on the elasticity of substitution based on relative price changes in imported commodities with respect to overall prices.

$$qpm(i,s) = qp(i,s) + ESUBD(i) * [pp(i,s) - ppm(i,s)] \quad (7)$$

ppm(i,s) - price of imports of i demanded by private households in s

The private consumption of imported commodities is calculated as a function of total private consumption (*qp*) and private consumption prices - where pp is the aggregate price and ppm is the consumption price of imports. All the above-mentioned prices, pp, ppd and ppm are linked to market prices. First of all, the private consumption prices are determined as an initial consumption value-weighted aggregation of the domestic and import prices.

$$pp(i,s) = PMSHR(i,s) * ppm(i,s) + [1 - PMSHR(i,s)] * ppd(i,s) \quad (8)$$

PMSHR (i,s) - share of imports for private households at agent's prices in total consumption by private households.

ppd (i,s) is the price of domestic i to private households in s.

$$ppd(i,s) = atpd(i,s) + pm(i,s) \quad (9)$$

atpd is the actual tax on domestic traded commodity i purchased by private households in region r. *pm* is the market price of domestic commodity i in region r.

ppm (i,s) is the price of imports of i by private households in s and is linked to market prices as follows.

$$ppm(i,s) = atpm(i,s) + pim(i,s) \quad (10)$$

pim is the market price of imported commodity i in region r.

b) If the implicit tax is assumed to be applied only on the tobacco leaf which is a major input in the production of all the three products

Because in this scenario, implicit tax is considered to be applicable only on the raw tobacco leaves, we shock the variables qfd and qfm, that are associated with the consumption of the commodity (raw tobacco leaves) by firms. *qfd (i,j,s)* considers consumption demand for a domestic commodity i by industry j in region s. Here i refers to the raw tobacco leaves; j to each of the tobacco firms that produce bidi, cigarette and smokeless products; s refers to the destination region, which here in our model is India.

qfd is the firm's consumption demand of a domestic commodity. Similar to what we discussed in the context of private consumption, this is also determined by two aspects; aggregate firm consumption that includes both domestic and imported commodities and the substitution between domestic and imported tobacco used in production, based on the elasticity of substitution based on relative price changes in domestic with respect to overall prices of tobacco used in production. We may roughly interpret the former as the expansion effect in overall consumption of tobacco in production and the latter as the substitution effect between domestic and imported tobacco.

qfd(i,j,s) = qf(i,j,s) - ESUBD(i) * [pfd(i,j,s) - pf(i,j,s)] **(11)**

qf (i,j,s) is the aggregate demand for commodity i for use by firm j in region s
pf(i,j,s) is the firm's price for commodity i to be used in firm j in region s
pfd(i,j,s) is the firm's price for domestic commodity i to be used in firm j in region s

The consumption demand for domestic commodity by firms is calculated as a function of the total consumption demand for a commodity (i) to be used as an input in a firm (j) and consumption prices of the commodity - where pfd is the demand price for the domestic commodity (i) and pf is the aggregate demand price for the commodity i to be used in firm j.

qfm (i,j,s) considers consumption demand for imported commodity i by industry j in region s.

qfm(i,j,s) = qf(i,j,s) - ESUBD(i) * [pfm(i,j,s) - pf(i,j,s)] **(12)**

qf (i,j,s) is the aggregate demand of commodity i for use by firm j in region s
pf(i,j,s) is the firm's price for commodity i to be used in firm j in region s
pfm(i,j,s) is the firm's price for imported commodity i to be used in firm j in region s

qfm is the firm's consumption demand of an imported commodity. Again, this is also determined by two aspects; aggregate firm consumption that includes both domestic and imported commodities and the substitution between domestic and imported goods, based on the elasticity of substitution based on relative price changes in imported commodities with respect to overall prices.

The consumption demand for imported commodity by firms is calculated as a function of the total consumption demand for a commodity (i) to be used as an input in a firm (j) and consumption prices of the commodity - where pfm is the demand price for the imported commodity (i) and pf is the aggregate demand price for the commodity to be used in firm (j).

pf(i,j,s) = FMSHR(i,j,s) * pfm(i,j,s) + [1 - FMSHR(i,j,s)] * pfd(i,j,s) **(13)**

pfd(i,j,s) - demand price for domestic commodity i by firms in sector j of region s
pfm(i,j,s) - demand price for imported commodity i by firms in sector j of region s
FMSHR - share of firms imports in domestic composite, agent's prices

All the prices, *pf*, *pfd* and *pfm* are linked to market prices as given below.

pfd(i,j,s) = tfd(i,j,s) + pm(i,s) **(14)**

tfd(i,j,s) - tax on domestic commodity i purchased by j in s
pm(i,s) - market price of commodity i in region s

pfm(i,j,s) = tfm(i,j,s) + pim(i,s) **(15)**

tfm(i,j,s) - tax on imported commodity i purchased by j in s
pim(i,s) - market price of imported commodity i in region s

A Sample statement to shock the consumption of raw tobacco leaves that are fed as input to bidi is given below.

shock qfd("rawtob","bidi","Ind") = uniform -6.88;
shock qfm("rawtob","bidi","Ind") = uniform -6.88;

The aggregate private consumption by households of each of tobacco and its products (qp) is determined by the income effect and (own and cross) price effect, based on their corresponding elasticities:

qp(i,s) = EY(i,s)*y(s) + sum(j,TRAD_COMM,EP(i,j,s)*pp(j,s)) **(16)**

EY(i,s) – income elasticity of commodity i in region s

EP(I,j,s) – Price elasticity of demand of commodity I with respect to price j in region s

y(s) –income in region s

pp(j,s) –price of private consumption of commodity j in region s.

While the model simulation directly gives the resulting changes in production, consumption, employment etc. both at the macroeconomic and sectoral level the resulting impact in terms of deaths averted were estimated outside of the model.

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