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RESEARCH REPORT

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Modelling the economic effects of reducing the consumption of unhealthy commodities: An inter-sectoral input–output approach

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Abstract

Aims: Industry arguments against public health policies that reduce the consumption of unhealthy commodities often include the assertion that the policy will harm the economy by reducing production and costing jobs. However, this argument does not consider that consumers may spend money previously used for unhealthy commodity consumption on other products, benefiting other sectors and potentially offsetting those negative economic consequences. In this study we aimed to estimate the macroeconomic impacts of reducing consumption of alcohol, tobacco, confectionary and gambling, accounting for reallocation of spending from these commodities to alternatives.

Method: We developed the open-source Commercial Determinants of Health Input–Output (CDOHIO) model version 1.1.0. CDOHIO models inter-sectoral linkages in the United Kingdom (UK) economy using published input–output tables to estimate the macroeconomic outcomes of changes in the total national consumer expenditure on selected unhealthy commodities and the reallocation of this expenditure to other consumption. We modelled a 10% decrease in total consumer expenditure on (1) alcohol, (2) tobacco, (3) confectionary and (4) gambling, assuming that the reduced expenditure was reallocated entirely to other products. The comparator in each case was no change in expenditure. We analysed six economic outcomes: (i) output (the total value of production in the economy), (ii) tax receipts from employees, (iii) tax receipts from employers, (iv) full-time equivalent employment, (v) total net earnings to individuals, and (vi) Gross Value Added (GVA), which is the primary outcome measure used as a proxy for national Gross Domestic Product.

Results: For tobacco, confectionary and gambling, reduced spending was estimated to yield positive effects across all six measures. The total effect of a 10% reduction in confectionary spending was an increase in GVA of £0.389 billion (0.02%), for reduced spending on tobacco, +£1.859 billion GVA (+0.09%) and for gambling +£1.250 billion GVA (+0.06%). For alcohol, a 10% reduction in spending led to a small negative effect on GVA (−£0.134 billion, −0.01%), which is the net effect of positive effects of reduced

spending on off-trade alcohol (+£2.543 billion) and negative effects of reduced spending on on-trade alcohol (−£2.677 billion).

Conclusions: The potential negative macroeconomic impacts of reducing spending on tobacco, confectionary and gambling in the United Kingdom could be more than mitigated when consumers reallocate money spent on these products to other consumption. This is also the case for off-trade alcohol consumption, but not for on-trade alcohol consumption.

KEYWORDS
alcohol, economic modelling, food, gambling, input–output, tobacco

INTRODUCTION

One of the goals of public health policy is to reduce consumption of unhealthy commodities, such as alcohol, tobacco, ultra-processed high in fat, sugar and salt (HFSS) foods and gambling. Examples of recent and forthcoming policies in the United Kingdom (UK) include restructuring of alcohol excise tax [1], increases in taxation on tobacco, especially cheap hand-rolled tobacco [2], the Soft Drinks Industry Levy [3] and a levy on gambling operators [4]. Such policies have been shown to improve population health outcomes [5, 6]. A potential argument made by industry groups against such policies, however, is that these sectors support employment and contribute to the economy and, hence, additional regulation or taxation would harm the economy [7]. In response, public health advocates emphasise the benefits of a healthier population, including healthcare cost savings and increased workforce productivity [8, 9].

The current evidence base for public health policy decisions does not fully address industry claims that stricter regulations harm the economy. A recent study [10] showed there would be a dividend of over £10 billion to the economy of England if no one consumed tobacco, but did not model how that money might otherwise be spent by consumers and the net economic impact of those potential changes in spending. Other studies have modelled economic impacts of changes in alcohol [11, 12] and tobacco [13, 14]. A systematic review found no robust evidence of negative economic impacts of diet-related policy, and most available evidence is from industry-funded sources [15]. These existing studies typically examine unhealthy products separately and often use varying methods, making direct comparisons difficult. A comprehensive, methodologically consistent assessment of how public health interventions affect national economies would provide a clearer, more comparative understanding of their economic impacts.

Our approach to quantifying the macroeconomic impact of changes in spending on unhealthy commodities as a consequence of public health policies involves three main components of macroeconomic performance: (i) the impact on gross domestic product (GDP); (ii) the effect on government tax revenue; and (iii) changes in employment. The primary way to link shifts in the consumption of unhealthy products to these outcomes is through 'input–output' matrices [16]. Produced by national governments, these matrices illustrate the interconnections within the economy, enabling a comparative analysis of how changes in demand for various products affect the economy. If consumer spending on a particular commodity decreases, two outcomes are possible: (i) economic harm, which occurs if the economic benefits are lost without being replaced by the benefits of spending on other goods; and (ii) economic benefit, which happens if spending shifts to other goods that provide a greater positive impact on the economy than the original commodity. To make strong conclusions about the potential macroeconomic impact of public health policies, it is essential to explore different scenarios for how spending might be redistributed.

This study aimed to model the economic impact of reducing spending on certain commodities targeted by public health policies—specifically alcohol sold in the on- and off-trade, tobacco, confectionary and gambling, using input–output matrices from the UK Office for National Statistics (ONS) [17, 18], which describe statistical associations between sectors of the economy. We estimated the macroeconomic effects of a 10% reduction in spending on each commodity, assuming that this spending is redistributed across categories of consumption in a way that reflects current consumption patterns. Economic impacts were modelled in terms of output (the total value of production in the economy), government tax receipts, employment and net earnings. The main economic indicator of interest was gross value added (GVA)—a measure of productivity and proxy for GDP.

METHODS

Design

This study developed and used the Commercial Determinants of Health Input–Output (CDOHIO) model version 1.1.0, an open-source [19, 20] macroeconomic model using UK 2019 data. This model was used to simulate estimated changes in output, government tax receipts, employment, net earnings and GVA following decreases of 10% in total national consumer expenditures on alcohol, tobacco, confectionary and gambling. We assumed that consumers reallocated all the money saved from reduced expenditures on these commodities to other consumption. The model calculates the net effects on macroeconomic outcomes of changes in consumer spending patterns—the demand side of the economy. Importantly this does not represent a full economic impact assessment as it does not include improved

population health resulting from reduced absenteeism, presenteeism, unemployment and premature mortality because of reduced consumption of unhealthy commodities. All analyses were conducted using R Statistical Software [21]. The analysis plan was pre-registered on 4 September 2024 [22].

Modelling based on input–output matrices assumes that the statistical associations between elements of the input–output matrix remain fixed (i.e. do not change in response to a change in expenditure on different commodities). Additionally, the model assumes no constraints on supply (i.e. an increase in demand is always met by an increase in supply and prices do not change). The relationships between products in the input–output matrices are not causal estimates, and without standard errors we were unable to conduct probabilistic sensitivity analysis (PSA) to quantify parameter uncertainty. Instead, deterministic sensitivity analyses were used to assess the impact of changing the main structural assumptions. Here, we give an overview, summarised in Figure 1, of the data and methods used with full details given in the Appendix (pp. 1–20).

Data

The model was built using input–output matrices constructed from analytical tables [17, 18] published by the ONS, which described the structure of the economy in 2019 and related financial spending to economic output. Employment and earnings data, which form part of these outputs, were taken from the Labour Force Survey [23]. All data sources used to calculate the baseline total consumer expenditure on alcohol [24], tobacco [25, 26], confectionary [27] and gambling [28] are publicly available and listed in full in the Appendix (p. 5). The data on alcohol consumption and prices used to calculate spending are based on aggregated sales data published by Public Health Scotland and separated by on-trade (e.g. alcohol sold in public houses and restaurants) and off-trade (e.g. alcohol sold in supermarkets) [24]. Note that expenditure on tobacco includes estimates of the money spent on illicit tobacco—tobacco illegally imported and sold in the United Kingdom without paying excise duty.

Measures

Expenditure

The input–output matrix is made up of 105 products for which changes in consumer spending can be modelled. Spending is defined as total UK consumer expenditure in £ millions. For gambling, expenditure changes are 'gambling and betting services', defined as gross gambling yield (GGY), which is the total money gambled minus consumer winnings. For food, there are seven categories, based on broad groupings in the Family Food datasets [27]: (i) meat; (ii) fish; fruit and vegetables, (iii) oils and fats; (iv) dairy products; (v) grain mill and starch products; (vi) bakery and farinaceous products; and (vii) other. Changes in expenditure on confectionary are applied to (vi) other. For tobacco (excluding illicit tobacco, which does not contribute to the economy) and off-trade alcohol, the input–output matrix includes a joint 'alcoholic beverages and tobacco products' category to which changes in expenditure were

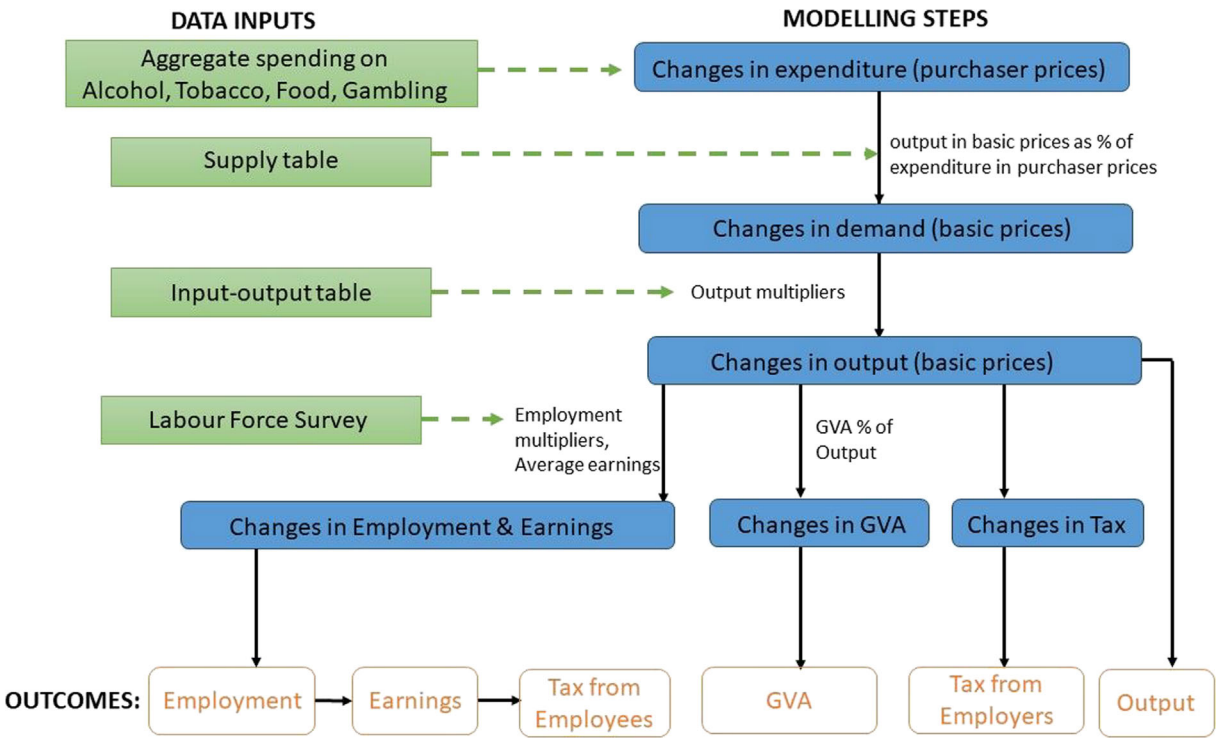

FIGURE 1 Methods: schematic showing modelling steps, data inputs and modelled outcomes.

applied. On-trade alcohol expenditure changes were separately applied to the 'food and beverage services' category, reflecting the highly integrated nature of alcohol into these services in the United Kingdom.

Outcomes

The six outcomes modelled were: (i) output; (ii) income tax receipts from employees; (iii) tax receipts from employers/businesses (including payroll taxes, corporation taxes, excise taxes and value-added tax); (iv) full-time equivalent employment; (v) total net earnings to individuals; and (vi) GVA. For each outcome, three types of effect were calculated: direct, indirect and induced. Direct effects are the changes in output required to match the changes in expenditure, for example, if £1 million more alcohol is purchased in input, £1 million more alcohol will be produced in output. Indirect effects are the effects of changing final demand on products in the supply chain, for example, increased demand for ingredients used in the manufacture of alcohol to produce more alcohol. Induced effects are the effects of changes in income resulting from former effects, for example, increasing employment through the supply chain, which generates income from the additional jobs and, therefore, more demand for all products. The sum of the three effects is the total impact.

Analyses

Modelling process

Changes in expenditure were calculated in retail prices (i.e. prices paid by the consumer) but converted into basic prices before being applied to the input–output model. Expenditure in basic prices is expenditure in retail prices minus direct taxes and imports. Only expenditures in basic prices influence the domestic economy, as this is the component of expenditure which is comprised of domestic inputs. For example, if you spend £100 on a product where half the cost (£50) goes toward taxes and imports, only £50 stays within the economy. However, if you spend that same £100 on a different product that only uses £25 for taxes and imports, then £75 stays in the local economy. Even though the amount spent remains the same, moving spending to the second product results in an extra £25 in the economy. The impacts on outcomes were estimated by multiplying a vector of changes in expenditure (in basic prices) on each product by the input–output matrix (Appendix p. 2). The result of this calculation is the change in output of each product. Changes in other outcomes such as GVA were then derived from the changes in output (Appendix p. 4). The total economic impacts were calculated by summing up the impact across all products.

Scenarios

We modelled four intervention scenarios, a 10% reduction in expenditure in each of (i) alcohol (in total and separately for the on- and off-trade); (ii) tobacco; (iii) confectionary; and (iv) gambling. The comparator in each case is no change. The reduced expenditure in each scenario is reallocated to spending on other products, according to the distribution of aggregate spending by households across consumption categories. In the base case, we assumed 100% reallocation of spending in proportion to existing spending across 36 consumption categories (see Appendix pp. 13–15 for a full list and description of the reallocation method), excluding the commodity itself. The effect on the results of assumptions about the amount and distribution of expenditure reallocation were then tested with sensitivity analysis.

Sensitivity analyses

We undertook three sensitivity analyses. SA1 varied the expenditure reallocation rate to determine a 'break-even' reallocation rate (i.e. the point at which the negative economic impacts of reduced spending on unhealthy commodities are exactly offset by the positive impacts of increased spending on other products). This is informative because it shows the amount of spending that would need to be reallocated to result in a positive economic outcome. A lower break-even reallocation rate indicates the respective commodity is less beneficial to the economy, because it means less reallocation is needed to offset negative impacts. SA2 explored the robustness of our results to assumptions about the distribution of reallocated spending across different alternative commodities, at a 100% reallocation rate. We modelled 36 versions of each scenario where, in turn, all reallocated spending is fully shifted to each of the 36 consumption categories. Finally, SA3 examined the sensitivity of results to changes over time in the structure of the economy by using input–output tables for other years. See Appendix pp. 21–28 for details of the sensitivity analyses.

RESULTS

Baseline economic impacts of unhealthy commodities

Table 1 shows the baseline impacts of alcohol, tobacco, confectionary and gambling on the UK economy, accounting for direct, indirect and induced effects. Combined, the four commodities represent £15.254 billion (0.76%) of GVA. The largest contributor to GVA (and all other outcomes) is alcohol (£10.346 billion, 0.52%) and the smallest is tobacco (£0.453 billion, 0.02%). Expenditure on illicit tobacco is excluded as it is sold illegally and has no impact on the economy. The four commodities make up a disproportionately large share of tax receipts from employers compared to the other outcomes (19.49% of the UK total), in part because of excise taxes on alcohol and tobacco.

Scenarios for reduced spending on unhealthy commodities

Scenario 1 models a 10% reduction in expenditure on alcohol of £4.804 billion in retail prices. Scenario 2 models a reduction in

TABLE 1 Baseline economic outcomes for the four unhealthy commodities and the UK economy in 2019.

	Alcohol	Tobacco	Confectionary	Gambling	National total	Unhealthy commodities as % of national total
Output (£m)	£19 361	£1218	£1690	£7328	£3 824 433	0.77
Tax receipts from employees[a] (£m)	£1115	£42	£39	£276	£201 773	0.73
Tax receipts from employers[b] (£m)	£32 351	£11 518	£874	£6925	£265 121	19.49
Full-time equivalent employment	372 170	5240	7072	49 330	28 326 070	1.53
Total net earnings to individuals (£m)	£6481	£148	£160	£1131	£717 559	1.10
Gross value added (£m)	£10 346	£453	£614	£3841	£2 000 157	0.76

[a]Income tax and employee national insurance contributions.
[b]Employer national insurance contributions, corporation taxes, payroll taxes (e.g. apprenticeship levy), excise duties and value added tax.

expenditure on both licit tobacco (£1.433 billion) and illicit tobacco (£0.138 billion) of 10%, for a total reduction of £1.571 billion. Note that reductions in expenditure on illicit tobacco have no negative economic impacts, but will yield positive impacts when the expenditure is reallocated into the formal economy. Scenario 3 reduces expenditure on confectionary by £0.403 billion. Finally, scenario 4 is a reduction in gambling expenditure of £1.472 billion.

Impacts on GVA of reduced spending on unhealthy commodities

The main results of the analysis are presented in Table 2. Note that for all scenarios, there is a positive direct effect on output. This is because, although overall consumer spending in retail prices remains unchanged (as all reduced spending is reallocated to other consumption), consumer spending in basic prices increases. This means a greater proportion of spending remains within the UK economy, for instance, it is spent on products for which imports and taxes (withdrawals from the economy) make up a lower proportion of the overall retail price, hence, overall domestic economic activity increases.

For each of the four commodities, the direct effect on GVA of reducing spending and reallocating all the spending to alternative products is positive. The 10% reduction in spending on alcohol leads to the largest increase in GVA (+£0.963 billion, 0.05%), followed by tobacco (+£0.606 billion, 0.03%), gambling (+£0.222 billion, 0.01%) and confectionary (+£0.113 billion, 0.01%). This indicates that consumption shifts to, on average, higher valued-added products in each scenario.

When indirect effects and induced effects are included, this leads to an increase in the estimated magnitudes of effect on GVA for tobacco (+£1.859 billion, +0.09%), confectionary (+£0.389 billion, +0.02%) and gambling (+£1.250 billion, +0.06%). However, for alcohol, the inclusion of these indirect and induced effects is estimated to lead to a small reduction in GVA (−£0.134 billion, −0.01%). Overall alcohol impacts are a combination of on-trade and off-trade, which have very different economic impacts (Appendix p. 17). The −£0.134 billion reduction in GVA is a combination of a −£2.677 billion reduction when modelling reduced spending in the on-trade only versus a +£2.543 billion increase for the off-trade only (Appendix p. 30).

Sensitivity analyses

Figure 2 shows the break-even reallocation rates (SA1) for the four scenarios. The lower the break-even rate, the lower the amount of spending that would need to be reallocated to result in a positive economic outcome. Tobacco has the lowest break-even rate for GVA of 4%, meaning that the impact on GVA of reduced spending on tobacco will be non-negative even if 96% of the money that was spent on tobacco is not reallocated to other consumption. For confectionary and gambling, the break-even reallocation rates are somewhat higher at 25% and 31%, respectively. For alcohol, the overall break-even rate is 103%, but underlying this (Appendix p. 31) is a much higher break-even rate for the on-trade (180%) than the off-trade (1%).

The results for SA2 (Appendix pp. 26–28) show that for tobacco and alcohol in particular, the main results are robust to the assumptions made about spending reallocation, but for confectionary and gambling the assumptions about spending reallocation are more important. The results were also largely robust to varying the year of the input–output table used in the analysis (SA3). The exception to this is the 2020 input–output table in the alcohol scenario, which for the on-trade in particular would have been impacted by changing economic activity during the coronavirus disease 2019 pandemic (Figure 3).

Impacts on other economic outcomes of reduced spending on unhealthy commodities

The results for the other outcome measures broadly follow a similar pattern as for GVA when including indirect and induced effects. For the tobacco, confectionary and gambling scenarios employment is estimated to increase (+31 450, +6817 and +22 544, respectively) with corresponding increases in total net earnings of employees (+£0.760 billion, +£0.167 billion and £0.552 billion). Likewise, in the alcohol scenario, the negative impact on GVA is reflected in estimated reductions in employment, earnings and tax receipts.

TABLE 2 Estimated impacts of a 10% reduction in unhealthy commodity spending on outcomes accounting for direct, indirect and induced effects[a].

	Absolute change in annual economic outcome				% change in annual economic outcome for the United Kingdom			
	Alcohol	Tobacco	Confectionary	Gambling	Alcohol	Tobacco	Confectionary	Gambling
Output (£m)								
Direct effects	£1467	£988	£120	£302	0.04	0.03	0.00	0.01
Direct + indirect effects	£2085	£1527	£110	£407	0.05	0.04	0.00	0.01
Direct + indirect + induced effects	***−£1706***[b]	£3690	£692	£2549	***−0.04***	0.10	0.02	0.07
Tax on employees (£m)								
Direct effects	£20	£39	£8	£13	0.01	0.02	0.00	0.01
Direct + indirect effects	£61	£66	£9	£14	0.03	0.03	0.00	0.01
Direct + indirect + induced effects	***−£64***	£203	£45	£150	***−0.03***	0.10	0.02	0.07
Tax on employers (£m)								
Direct effects	***−£949***	***−£406***	£111	***−£1***	***−0.36***	***−0.15***	0.04	***0.00***
Direct + indirect effects	***−£686***	***−£123***	£112	£19	***−0.26***	***−0.05***	0.04	0.01
Direct + indirect + induced effects	***−£3163***	£1175	£462	£1291	***−1.19***	0.44	0.17	0.49
FTE employment								
Direct effects	***−13 516***	7207	1350	2339	***−0.05***	0.03	0.00	0.01
Direct + indirect effects	***−9103***	10 754	1391	2923	***−0.03***	0.04	0.00	0.01
Direct + indirect + induced effects	***−29 638***	31 450	6817	22 544	***−0.10***	0.11	0.02	0.08
Net earnings (£m)								
Direct effects	***−£117***	£158	£30	£50	***−0.02***	0.02	0.00	0.01
Direct + indirect effects	£10	£251	£33	£62	0.00	0.04	0.00	0.01
Direct + indirect + induced effects	***−£479***	£760	£167	£552	***−0.07***	0.11	0.02	0.08
Gross value added (£m)								
Direct effects	£963	£606	£113	£222	0.05	0.03	0.01	0.01
Direct + indirect effects	£1258	£855	£113	£246	0.06	0.04	0.01	0.01
Direct + indirect + induced effects	***−£134***	£1859	£389	£1250	***−0.01***	0.09	0.02	0.06

[a]Direct effects are changes in output required to meet the changes in final demand, for example, if £1 million less alcohol is purchased, £1 million less alcohol will be produced. Indirect effects include the effects of changing final demand on products in the supply chain, for example, reduced demand for ingredients used in the manufacture of alcohol. Induced effects are the effects of changes in income resulting from the direct and indirect effects, through, for example, increased employment through the supply chain because of increasing demand for a product, which generates income and, therefore, more demand.
[b]Figures presented in bold italics indicate a negative economic impact estimate.

DISCUSSION

Our analysis shows that 10% reductions in consumer spending on tobacco, confectionary and gambling could bring net benefits to UK GVA (in the range of £0.389 billion–£1.859 billion) if the reduced spending on these commodities were reallocated to other consumption. We find a small negative impact on GVA for alcohol (−£0.134 billion). In each case these impacts are small in the context of the national economy, amounting to less than 0.1% of UK GVA. Estimated full impacts on employment, earnings and tax receipts reflect those found for GVA in each modelled scenario. Underlying the alcohol result is opposing effects from reducing spending in the on-trade (−£2.677 billion) and off-trade (+£2.543 billion). This highlights an important difference in the contributions of the different channels of alcohol sales to the economy. The results underline the importance of considering reallocation of spending when unhealthy commodity consumption is reduced and the assumptions made about that reallocation.

Our findings align with previous evidence showing economic harm associated with these commodities and the economic benefits associated with reducing their consumption. A review of the international literature found reduced tobacco consumption to have net positive economic impacts [29], and other studies have estimated increases in GVA and employment [13, 14], which are consistent with our findings. Previous analyses have found that increasing alcohol taxation can both improve health outcomes and stimulate economic activity [11, 12]. Although we find negative impacts on GVA of reduced demand for on-trade alcohol, we find positive impacts in the off-trade. As consumption of off-trade alcohol is proportionately higher among those drinking at levels sufficient to cause health harms

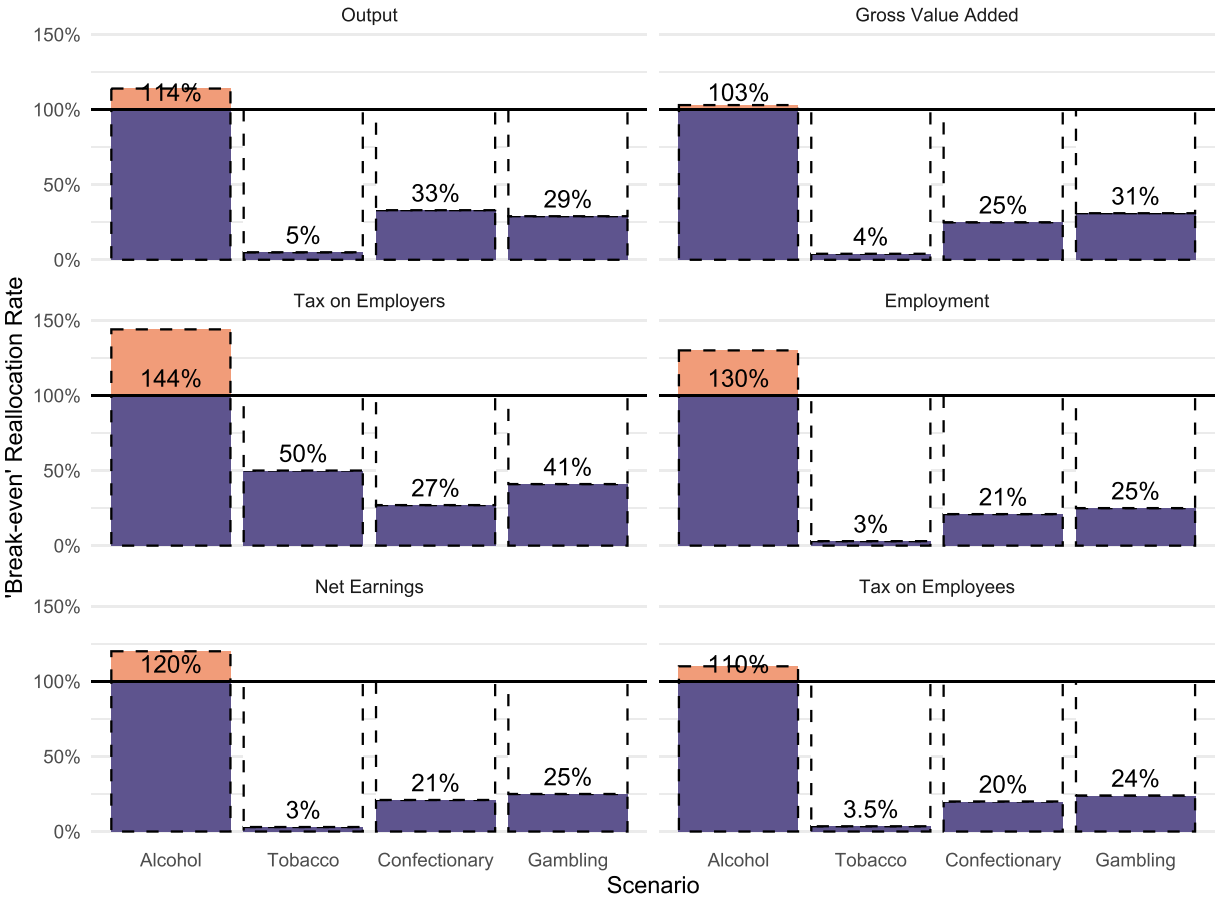

FIGURE 2 Sensitivity analysis: how low could the reallocation* of spending to other sectors be and the net economic impact still be positive? Estimates of the minimum reallocation rate from spending on alcohol, tobacco, confectionary and gambling required for a net positive economic impact. *When expenditure is reduced on an unhealthy commodity, we define the 'reallocation rate' as the percentage of the original spending that consumers switch to spending in other sectors of the economy. For example, if a person reduces spending on alcohol by £100 and increases spending on other goods by £36, then the reallocation rate is 36%. A reallocation rate >100% indicates total spending would have to increase for the economic impact to be neutral.

[30, 31], policies such as minimum unit pricing, which are targeted at this channel of alcohol consumption [32] are, therefore, likely to bring both health and economic benefits. Our findings for gambling are consistent with studies that have found online gambling has reduced economic activity by £1.3 billion per year [33] in the United Kingdom, and the excess direct cost to government because of harmful gambling is £412.9 million per year [34].

The analysis presented here covers important, but only partial economic effects and almost certainly underestimates the positive economic effects of reducing unhealthy commodity consumption because we do not incorporate health-related economic impacts. For example, alcohol consumption has been found to reduce labour productivity by increasing presenteeism [35, 36], absenteeism [37–39] and through premature mortality [40, 41]. Smoking [42] and obesity [43] have also been associated with absenteeism. A full economic impact assessment of reducing consumption of unhealthy commodities would need to incorporate the benefits of reducing ill-health and premature mortality and, therefore, increasing work productivity. Although the results here indicate a negative impact on GVA of reducing spending on alcohol, driven by the on-trade, this does not support the conclusion that alcohol is beneficial to the economy without considering these additional impacts. One recent estimate of the wider economic costs of alcohol in England is £5.06 billion in 2021/2022 [41].

The strength of this study is in illustrating the macroeconomic impacts of reducing consumer spending on a range of unhealthy commodities using a common methodology. The study builds on previous input–output analyses of single commodities [11–14] by using updated inputs, considering more outcomes and unifying multiple unhealthy commodities into a single model. Although the changes to demand for unhealthy commodities modelled are hypothetical, this framework can be used to model the effects of demand changes observed in response to public health policy. With the addition of estimates of the costs of delivering public health interventions, these methods can be used to add a macroeconomic component to evaluations of the cost-effectiveness of public health initiatives. Furthermore, the input–output methodology can also be used to estimate the additional economic effects of reinvestment by government of tax

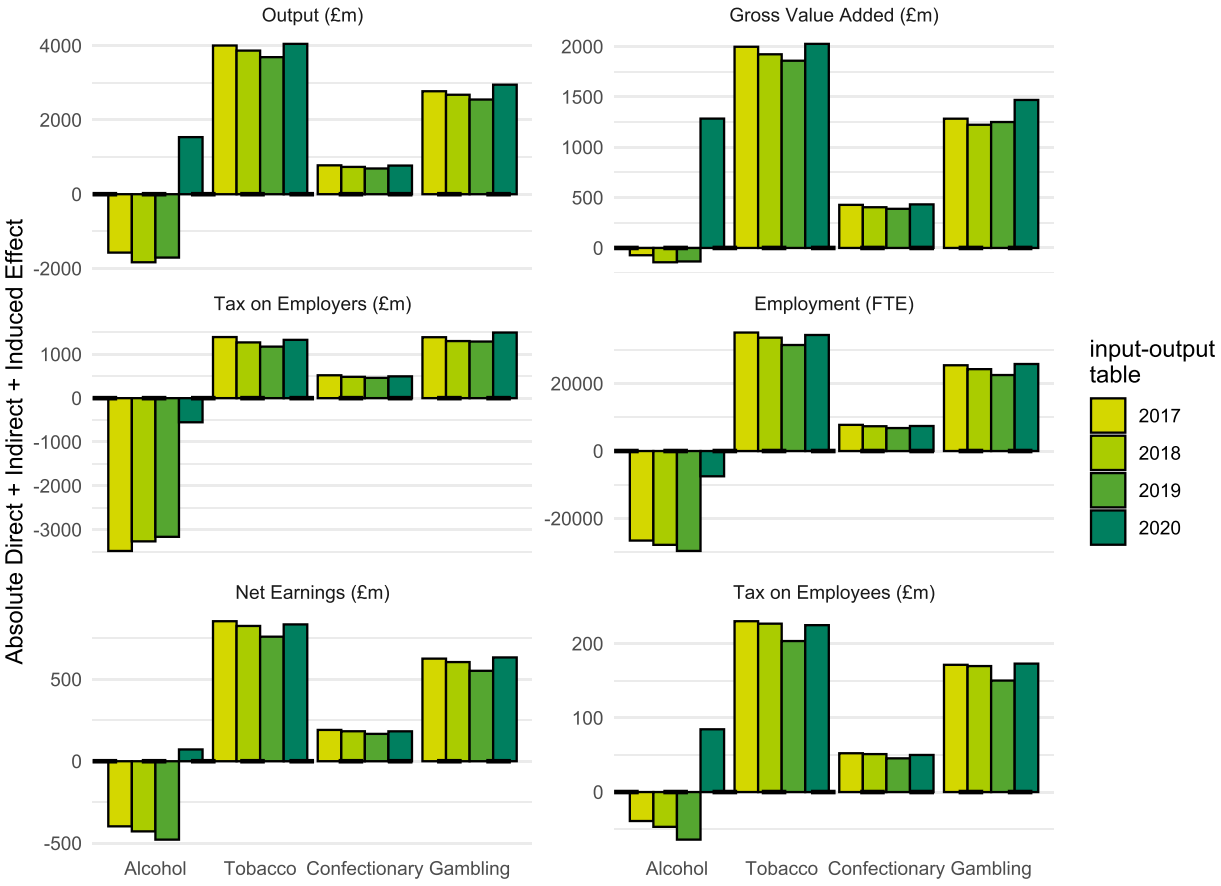

FIGURE 3 Sensitivity analysis: testing the robustness of results for the six economic outcomes when varying the year of input–output table.

receipt gains. There is evidence, for example, that alcohol tax increases can lead to increased employment through government spending of additional tax revenues [44], and these mechanisms can be modelled in the framework presented here. Government impact assessments and academic studies of public health policies, such as for recent UK alcohol and tobacco policies, typically lack inclusion of estimates of these wider economic outcomes [6, 45, 46], and consequently potentially underestimate the full benefits of these policies.

There are several limitations to this study. First, the modelling framework assumes fixed prices. This is a strong assumption, because large changes in demand for products would be expected to change the prices of those products. Changes in relative prices of inputs may lead to producers substituting between inputs, which would change the structure of the supply chain, affecting the composition of the input–output table. The fixed prices assumption implies that labour supply can expand to meet changes in demand with no effect on wage rates. As a result, the modelling presented can only plausibly be used to consider impacts in the short-term, when prices are less likely to change. Second, even if there are positive economic consequences of reducing demand for unhealthy commodities overall, there may still be localised negative consequences. If jobs supported by the production and sale of these commodities are lost, but the jobs that replace them are located elsewhere, either geographically or in terms of differing skill requirements, then workers in these sectors could be displaced. Finally, our results depend on the assumption that households redistribute spending to reflect current consumption patterns. This may not be the case in practice, and the types of individuals who would reduce their spending on the products modelled are likely not to be representative of the general population and, therefore, have different consumption preferences. Our deterministic sensitivity analyses address this source of uncertainty.

The results presented should be interpreted with the caveats that causality cannot be assumed and that the model is subject to several assumptions, but this does not detract from their usefulness at illustrating the potential economic impacts of public health regulation. In reality, large changes in demand are likely to encounter constraints in the supply capacity of the economy (e.g. the size of the labour force and rising prices). Results presented are likely to overestimate the impacts on output, GVA and employment. Furthermore, without standard errors on the estimates, which make up the input–output table, we were unable to address parameter uncertainty. We were, therefore, not able to use PSA to estimate CI to quantify the uncertainty.

Further research could address these limitations by incorporating both supply and demand-side components into a single framework to model full economic impacts of public health policies, which affect commercial determinants of health. Future research could also build on the methods presented here by using computable general

equilibrium modelling techniques, which allow for changing prices and labour productivity because of changes in individual health (e.g. through reduced absenteeism). These methods have been applied in the case of alcohol in Scotland [12], and could be applied to the commodities modelled here.

Although our findings relate to a UK-specific context, our conclusions and methodology generalise to other countries. In any setting, an appraisal of a policy that leads to reduced expenditure on unhealthy commodities, which does not also consider how those reduced expenditures might be reallocated by consumers into other forms of consumption, will potentially omit a large amount of offsetting positive economic impacts. Our methods are generalisable, with input–output tables routinely published by agencies such as the United States Bureau of Economic Analysis [47] and international organisations such as the Organisation for Economic Co-operation and Development [48]. These can be used to produce economic impact assessments for other settings using the open-source methods presented here.

In conclusion, our analysis finds that reducing demand for tobacco, confectionary, gambling and off-trade alcohol could lead to overall positive consequences for the economy, with only on-trade alcohol showing a strong economic importance. The CDOHIO model developed here can be used to incorporate inter-sectoral economic impact assessment into appraisals of new public health policies that aim to reduce the consumption of unhealthy commodities and, hence, enhance the evidence base for policymakers making public health policy decisions.

AUTHOR CONTRIBUTIONS

Damon Morris: Conceptualization (equal); data curation (lead); formal analysis (lead); investigation (equal); methodology (equal); software (equal); validation (equal); visualization (equal); writing—original draft (lead); writing—review and editing (equal). **Duncan Gillespie:** Conceptualization (equal); funding acquisition (equal); project administration (equal); supervision (equal); writing—review and editing (equal). **Megan James:** Data curation (equal); software (equal); validation (equal); visualization (equal); writing—review and editing (equal). **Penny Breeze:** Writing—review and editing (equal). **Alan Brennan:** Conceptualization (equal); funding acquisition (lead); project administration (equal); supervision (equal); writing—review and editing (equal).

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For the purpose of open access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission.

DECLARATION OF INTERESTS

None.

DATA AVAILABILITY STATEMENT

All data and code used in these analyses have been made open source. The main repository conducting the analysis is available on GitHub. The Commercial Determinants of Health Input–Output model software has also been made open source via GitHub as the cdohio R package. The employment and earnings data used in the model were derived from the Labour Force Survey, available at the UK Data Service.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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