


ARTICLES

Innovation, Regulation, and Excise Taxation

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Innovation and regulation may reduce the harm arising from the production and consumption of excisable goods, which may warrant lower excise rates. However, countries often rely on excise revenues and may face conflicting interests in supporting innovation through differential excise rates and regulation on reduced harm goods and collecting sufficient tax revenues. This paper summarises recent innovations and regulations of excisable goods, discusses their potential implications for the design of excise regimes, and calls for further debate on excise taxes in the face of recent innovations and regulations.

1. Introduction

Excise taxes play an essential role to improve the accuracy of information provided by the market by raising market prices to reflect social costs and benefits, rather than private costs and benefits. Where market prices accurately reflect (net) social costs, producers and consumers can make better informed decisions. Improved decisions may contribute towards improved market, economic and social outcomes. It is for this reason that towards efficient taxation, the rate of excise taxes should be based on the external and internal costs not reflected in the price of goods, where these costs are significant.¹²

Recent innovation and regulation aim to reduce the costs of products not reflected in price. Much innovation in and regulation of smoking and nicotine, alcohol, energy and vehicles, sugar, and other products aim to reduce the harm to individuals and the environment from their production and consumption. Where innovation and regulation reduce harm, the social costs not reflected in price should be less.

If innovation and regulation reduce social costs not reflected in price, an efficient excise regime should reflect these cost reductions by lower excise rates on innovated or greater regulated goods. Without such a regime, market prices

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¹ Since there are costs involved in administering and complying with taxes, taxing goods with small social costs not reflected in price may give rise to economic losses.

² In terms of neoclassical welfare economics, the existence of external costs or negative externalities gives rise to market failure and excise taxes can correct this market failure. In terms of this theory, consumers have all the necessary information and internalise this information correctly to make fully rational decisions; all internal costs are therefore reflected in consumer demand. Behavioural welfare economics, however, provide firm evidence that consumers do not have all the necessary information, rarely internalise information correctly, and do not make fully rational decisions. It is therefore likely that consumer demand does not accurately reflect internal costs and, therefore, prices do not reflect these costs. Again, an excise tax can correct for this failure. Other economic theories, such as post-Keynesian theory, do not rely on demand and supply curves to establish prices but cost-plus pricing; prices are set by producers. Also under this theory of price are excise taxes desirable since they avoid 'false prices' in the market and allocate costs to individuals that give rise to these costs, which aligns with general principles of justice. There are, therefore, different reasons for excise taxes within different economic theories.

will not communicate to producers and consumers that certain products are comparatively less harmful. Without this information, producers and consumers may continue making decisions that are more harmful to themselves, others and the environment — decisions that may not align with broader government objectives.

However, the revenue needs of many countries may give rise to hesitancy in reducing excise rates on reduced harm products. Excise taxes often pose less political opposition than other tax instruments, are comparatively easy to administer, and can provide substantial revenues — revenues that can aid in meeting government objectives. If a government's rationale for excise taxes is primarily to raise revenues, arguments surrounding the reduced costs not reflected in the price of certain products may not be relevant.

Further debate is therefore required regarding the rationale of excise taxes in the face of changing technologies and increased regulation of excisable products. Towards this debate, this paper summarises recent innovation in and regulation of products that are often subjected to excise taxes. It considers how these innovations and regulations affect social costs not reflected in price and presents the economic argument on how an efficient excise regime should reflect this impact.

2. Recent innovations in excisable goods

Due to increased scientific evidence, technological improvements, improved access to information, changes in social norms and changes in consumer preferences and other factors, there has been extensive innovation in excisable goods in recent years. This section surveys some of these innovations in smoking and nicotine, alcohol, energy and vehicles, sugar and other goods that may warrant an excise. It does not include telecommunication since these services provide external benefits, so an excise is not warranted from an economic viewpoint.³

2.1. Smoking and nicotine

The form in which nicotine is consumed has undergone significant innovation in recent years. The primary aim of this innovation is to reduce individual harm by limiting or eliminating other toxins when consuming nicotine through smoked or combusted tobacco.⁴ Cigarettes, for instance, contain approximately 600 ingredients that when burned create over 7,000 chemicals, of which many are toxic and 69 cause cancer.⁵ Innovative, non-combusted nicotine products have fewer and lower levels of toxins and includes electronic nicotine delivery systems (ENDS), heat-not-burn (HnB) systems and tobacco-free oral nicotine pouches (NPs).

³ Where substantial rents exist, a rent tax may be appropriate. Where such a tax cannot be administered, using the excise as a proxy may be warranted in certain contexts. For further discussion, see Matheson and Petit (2021).

⁴ The influence of new nicotine products on effective demand and harm at the societal level should not influence the efficient rate of the excise.

⁵ See <https://www.lung.org>.

By reducing the number of toxic chemicals consumed, or assisting to cease smoking,⁶ non-combusted nicotine products can reduce the internal and external costs of individual consumption. A systematic, independent review by Glasser et al. (2017) of the literature on ENDS finds that although evidence on population use and long-term health consequences is lacking, ENDS are increasing in use, particularly among current smokers, pose substantially less harm to smokers than cigarettes, and are being used to reduce or quit smoking. Another review of the evidence commissioned by Public Health England (2018) states that ‘based on current knowledge, stating that vaping is at least 95% less harmful than smoking remains a good way to communicate the large difference in relative risk unambiguously...’. The National Academies of Sciences, Engineering, and Medicine state that ‘Laboratory tests of e-cigarette ingredients, in vitro toxicological tests, and short-term human studies suggest that e-cigarettes are likely to be far less harmful than combustible tobacco cigarettes’ (National Academies of Sciences, Engineering, and Medicine, 2018, p. 1).

This reduced harm translates into ENDS having an estimated cancer potency as low as less than one per cent of smoking tobacco (Stephens, 2018). Recent independent research finds that using non-combustible nicotine products also present a lower risk of cardiovascular disease compared to cigarettes (Choi et al., 2021).

HnB tobacco products are also often found to be less harmful than cigarettes, although these products have been much less independently studied than ENDS. There is, however, some evidence that the harm of tobacco consumed by HnB may be less than that consumed by smoking a cigarette. An independent review by Simonavicius et al. (2019) finds that HnB products delivers up to 83 per cent of nicotine of cigarettes with at least 62 per cent less harmful toxicants. However, out of the 11 trials on HnB use by humans, only one was not affiliated with a tobacco manufacturer.⁷ Another review by Drovandi et al. (2020) also finds reduced biomarker exposures in HnB compared to cigarette and calls for further independent research. A recent review by Begić et al. (2023) identified 25 random controlled trials for inclusion and found that HnB products significantly reduce biomarkers of exposure and biological effects related to cardiovascular disease, compared to cigarettes. Stephens (2018), in a seemingly independent study, finds that most HnB products have less than 10 per cent the cancer potency of smoking tobacco and the relative risk per stick is about 20 per cent.

Since NPs are smokeless and tobacco-free, comprising a nicotine-containing cellulose matrix inside a fibre pouch, their toxicant profiles are comparable to nicotine replacement therapy (NRT) products, such as nicotine gum and lozenges, which are considered as the nicotine products with the lowest health

⁶ Adkison et al. (2013), for instance, finds that 85.1% of respondents used electronic nicotine delivery systems to help them quit smoking.

⁷ This review finds no difference between the results funded by the tobacco industry and independent studies.

risks (Azzopardi et al., 2021). NPs, however, offer users faster uptake of nicotine than NRTs and potentially improved flavouring, which may increase the likelihood of users considering NPs as a substitute to cigarettes. Substitution is further supported since the amount of nicotine uptake in NPs replicates the nicotine uptake from cigarettes (McEwan et al., 2022).

A challenge with the existing literature on ENDS and HnB products is that, as with other innovative products, there has been limited time to study their long-term harm. There are studies that estimate long-term consequences, such as Lee et al. (2022), that estimate a substantial reduction in death even under pessimistic assumptions if cigarettes were largely replaced by ENDS. However, without longitudinal studies the long-term effects of ENDS and HnB products remain uncertain.

2.2. Alcohol

Innovation in the alcohol beverage industry to reduce harm of consumption is challenging. Ethyl alcohol is generally the most harmful toxicant that an individual ingests when consuming an alcoholic beverage. This means that the most effective method for reducing harm of consumption is to reduce the alcoholic content of beverages. Therefore, innovation has primarily focused on providing low alcohol or alcohol-free alternatives with a similar taste to higher alcohol beverages. Other innovations include sugar-reduced alcoholic beverages, natural or organic wines and biodegradable packaging.⁸

Besides reducing the alcoholic content of a beverage, other potentially promising innovations are medicines that reduce alcohol uptake or improve the body's ability to metabolise alcohol and, thereby, lower blood alcohol content. Y. Liu et al. (2013), for instance, provides evidence that nanotechnology can reduce blood alcohol levels in mice. Limited evidence suggests that probiotic nutritional supplements may inhibit absorption of alcohol (Pfützner et al., 2022), which has contributed to the release of a supplement often used for this purpose.⁹ If these technologies can be developed to lower blood alcohol content in humans consistently, it may substantially reduce the internal and external costs of alcohol consumption.

2.3. Energy and vehicles

Innovations in energy have predominantly aimed to reduce the environmental impact of energy use by providing energy through alternative sources and improving efficiency of existing energy sources. Well-known examples of so-called green technologies include solar panels, wind energy, hydro energy, LED lighting and batteries. By reducing the greenhouse gas (GHG) emissions involved in energy production and consumption, these technologies reduce the external costs of energy use.

⁸ There have also been similar innovations to farming and foodstuffs for the inputs used in the industry.

⁹ See <https://www.myrkl.co.uk/>. It should be noted that the manufacturer does not claim that the supplement reduces alcohol absorption.

Recent technologies also show potential for further reductions in external costs. Carbon upcycling technologies have the potential to capture carbon in the atmosphere and convert this carbon into fuels or consumer products. When used to produce fuels, this technology might provide for carbon-neutral gasoline, which will significantly reduce the external costs of fuel use by combustion vehicles. Other alternative fuels such as biodiesel and hydrogen also have the potential to provide near carbon-neutral power to vehicles.

Improvements in the effectiveness of energy storage also show promise to lower external costs from home and vehicle energy consumption.¹⁰ Extensive research focuses on improving lithium batteries, but the use of alternative raw materials is also studied. Sodium-ion batteries, for instance, might be produced at much lower cost to lithium batteries, with decreased GHG emissions linked to mining and improved recyclability.¹¹ Li et al. (2022) also show how a molten salt battery can, through freeze-thaw thermal cycling, keep 90 per cent of its energy over two months.

With current technology, however, the external costs from using electric vehicles will be context-specific and largely depend on the carbon intensity of the power grid. A battery electric vehicle charged with electricity produced with fossil fuels will have a similar environmental impact to a combustion vehicle over its lifetime, including emissions because of vehicle production, fuel production and fuel consumption. In this context, a hybrid electric vehicle will contribute fewer total emissions than a battery electric vehicle. Where vehicles are charged with renewable energy, a battery electric vehicle can contribute less than 20 per cent of the total lifetime emissions of a combustion vehicle (Massachusetts Institute of Technology, 2019).

2.4. Sugar

Although many foodstuffs may give rise to social costs not reflected in price, existing excise regimes overwhelmingly focus on sucrose and especially sugar-sweetened beverages. Although the design and effectiveness of such an excise can be questioned, its existence motivates innovation to produce sucrose alternatives.

Existing alternatives include saccharin, aspartame, acesulfame-K, sucralose, allulose, xylitol, tagatose and erythritol. These alternatives provide a sweet taste, but their biochemical structure is such that our bodies do not have the enzyme to convert most or all of their molecules into digestible carbohydrates (carbohydrates that provide energy to the human body). They can act as a substitute for sucrose with a comparatively lower level of energy uptake.

¹⁰ This is as a result of lower GHG emissions in the production and disposal or recycling of batteries and reduced battery discharge when not in use.

¹¹ See <https://cen.acs.org>.

Whether these alternative sugars are less harmful than sucrose is an area of ongoing research. Since they provide fewer digestible carbohydrates, substituting sugar with an alternative may reduce total digestible carbohydrate intake of individuals. This may reduce the prevalence of diseases associated with excessive consumption of carbohydrates.¹²

However, certain alternative sugars have been associated with health risks. Saccharin, aspartame, acesulfame-K and sucralose, for instance, have been connected to metabolic changes that may contribute to obesity (Rother et al., 2018). Allulose can be used by certain potentially harmful bacteria as a substrate (Hauner et al., 2022). That these alternative sugars may cause harm that is unrelated to the excessive consumption of carbohydrates calls for further research to support an efficient excise regime.

Other sugar alternatives such as xylitol, tagatose and erythritol are, at the current state of knowledge, associated with health benefits. Besides providing fewer digestible carbohydrates to sucrose, xylitol stimulates the immune system, digestion, lipid and bone metabolism, and reduce certain infections (Benahmed et al., 2020). Tagatose has been extensively studied as a potential type 2 diabetes drug since it reduces blood glucose levels in the liver and has a positive effect on gut bacteria (Roy et al., 2018). Erythritol has been shown to have endothelial protective effects (Boesten et al., 2015).

Although the higher costs of production of sugar alternatives associated with health benefits to sucrose has been a barrier to adoption, biotechnology and its related production processes can reduce costs of production. Ongoing research is likely to give rise to production techniques that allow for competitively priced, healthy alternative sugars.

2.5. Other

Goods that warrant, but are less often subjected to excise taxes, are also undergoing innovation. Innovation in cement, which contributes about 8 per cent of global CO₂ emissions (Ellis et al., 2020), has produced reduced carbon alternatives that are made from industrial by-products like fly ash, aluminosilicates, silica and iron. Cement can also be produced by a mix of seawater and CO₂, or by using magnesium ions in seawater (Badjatya et al., 2022).¹³ By reducing production emissions through alternative ingredients or techniques, the environmental impact from cement can be significantly reduced.

Fertiliser and especially synthetic nitrogen fertilisers, which contribute about 2.5 per cent of global GHG emissions and about 20 per cent of total agricultural emissions (Menegat et al., 2021), are also a focus for climate technology. One approach, for instance, is to edit the genetics of nitrogen-producing bacteria to increase their nitrogen production and use these bacteria

¹² For a meta-analysis on the association between carbohydrate consumption and diseases see Seidelman et al. (2018) and Reynolds et al. (2019).

¹³ Also see <https://theconstructor.org>.

as fertiliser.¹⁴ Another approach is to produce ammonia, which is a base material for fertiliser, sustainably. Doing so without the use of high volumes of pre-treated water, however, remains a challenge (Ghavam et al., 2021).

New methods of genetically modifying plants also show promise to reduce the use of fertilisers, pesticides and fungicides. Minichromosome technology, for instance, provides the opportunity to enhance some aspects of a plant without altering its genes. This can allow for plants that are more nutritious and less reliant on chemicals, without the negative consequences of the current generation of genetically modified foods.

Technology is also changing how other foodstuffs are produced. Additive manufacturing, with the use of a 3D printer, allows for the production of foodstuffs with personalised nutritional values and can address malnutrition. Proteins can also be printed as meat alternatives or real meat with the use of stem cells. Further, with biomanufacturing, meat can be grown in a laboratory. These technologies have the potential to reduce the demand for livestock farming and the environmental impact of meat consumption.

Innovations in waste management are also assisting to establish a circular economy, which aims to ‘design out’ waste and pollution. Using AI and robotics to identify, sort, and recover recyclable waste at scale shows promise to increase the efficiency of recycling and the extent of relying on recycled inputs. Rather than burning waste, recent innovations allow for waste to be converted into fuels (S. Liu et al., 2021). Decreasing costs and increasing availability of biodegradable plastics and packaging are also reducing the need to recycle, by using these plastics and packaging as compost.

3. Regulation of excisable goods

Regulation of excisable goods will generally lower costs not included in price by internalising some of these costs,¹⁵ reducing consumer demand in the formal market of excisable goods, motivating innovation in reduced harm alternatives, and motivating substitution towards less regulated and, if appropriately designed, less harmful existing alternatives. The extent that regulation will lower social costs not reflected in price depends on the effectiveness of these regulations. Therefore, this section provides a brief survey of recent regulations and their known effectiveness within the markets of smoking and nicotine, alcohol, energy and vehicles, sugar and other excisable goods.

3.1. Smoking and nicotine

Smoking and nicotine tend to be highly regulated. Common regulations prohibit certain harmful ingredients, only allow individuals above a certain age to purchase nicotine products, limit advertising of nicotine products, set health warning requirements on packaging and advertisements, and place restrictions on where nicotine products can be consumed. Recent regulatory trends in

¹⁴ See <https://research.umn.edu>.

¹⁵ An example of this type of internalisation is a smoking room at an airport. The smoker incurs additional costs, be it time, discomfort, or second-hand smoke, to be able to smoke.

nicotine set permissible levels of tar and nicotine, require plain packaging, require explicit graphics as health warnings, and ban advertising. Perhaps the strongest regulation is in New Zealand, which aims to ban cigarette purchases over the lifetime of individuals of a certain age. These regulations are generally effective in reducing cigarette consumption and therefore lower social costs not reflected in price (DeCicca et al., 2022; Jha et al., 2006; Markowitz, 2008).

Reduced harm nicotine products, such as ENDS, have also been subject to stricter regulations.¹⁶ In particular, flavoured products have been restricted or banned, likely because of a perception that flavoured products increase youth uptake of smoking and ENDS increase cigarette smoking. Although early evidence supports this perception, more recent analysis, for instance, Pesko and Warman (2022) and Cotti et al. (2022), find that ENDS and cigarettes are economic substitutes, rather than complimentary goods. Where this finding holds, it implies that consuming ENDS does not result in the consumption of cigarettes, which is a common concern of regulators.

Restrictions or bans of ENDS can reduce youth consumption but may cause youth substituting towards more harmful nicotine products, such as cigarettes. Using a difference-in-difference analysis, Friedman (2021) finds that San Francisco's ban on flavoured nicotine products led to increased cigarette smoking among youth.¹⁷ Similarly, Dave et al. (2019), also using a difference-in-difference analysis, find that legal age sale laws applied to ENDS increased youth cigarette smoking. Survey evidence by Posner et al. (2022) also find that if ENDS flavours are banned, 39 per cent of respondents indicate they will substitute tobacco-flavoured ENDS and 33 per cent of respondents indicate they will substitute cigarettes. They further find that if all ENDS were banned, 39 per cent of respondents indicate they will substitute cigarettes. These findings suggest that care is required in designing regulations aimed at youth users of ENDS to avoid adverse implications and increasing social costs not reflected in price.

The lower harm from the second-hand exposure to ENDS and HnB compared to smoke from cigarettes may warrant differential regulation. Although limited independent evidence is available, it indicates that harm from second-hand exposure to ENDS is much lower than cigarettes. Czogala et al. (2014) found that ENDS exposes others to nicotine but not to other combustion toxicants. The amount of exposure to nicotine was found to be about 10 times lower than for cigarettes. Protano et al. (2016) found that exposure to submicron particles by others are four-times lower for ENDS and HnB compared to cigarettes.

Regulations to encourage substitution by adults from cigarettes to reduced harm nicotine products are less prevalent. Wu et al. (2022) study the impact of ENDS introduction on cigarette consumption in six regions and find that

¹⁶ Similar common regulations for cigarettes are generally applicable to ENDS and, although there is limited evidence, advertisement restrictions seem to be effective (Hansen et al., 2018; Mantey et al., 2018; Padon et al., 2018).

¹⁷ There are studies with a weaker design that find flavour restrictions reduce nicotine consumption (Kingsley et al., 2019; Pearlman et al., 2019).

stronger regulations that support substitution of cigarettes with ENDS are associated with a decrease in overall cigarette consumption. Since recent evidence suggests that ENDS and similar reduced harm nicotine products are substantially less harmful than cigarettes, such regulations may reduce the costs of smoking and nicotine and motivate further innovation.

3.2. Alcohol

Alcohol is also highly regulated. Common regulations set age restrictions, limit advertising, require on-package and advertisement health warnings, restrict the place and circumstances of consumption, including recent consumption, of alcohol and provide licensing laws to limit the sale of alcohol to certain businesses and times. Recent regulatory trends prohibit the sale of alcohol to intoxicated persons, regulate digital and cross-border alcohol marketing (World Health Organization [WHO], 2022), regulate density of alcohol suppliers, and implement a minimum price per unit of alcohol.

These regulations can be effective to reduce the social costs not reflected in the price of alcohol. A review of the evidence suggests that besides taxation and price regulations, regulations that limit marketing can reduce the probability that a person begins to drink, or reduce the amount of alcohol consumed. Prohibiting late-night on-premise sales of alcohol and measures to prevent driving under the influence can reduce harm due to alcohol consumption. Other regulations aimed at managing the place and circumstances of consumption are less effective and measures to manage the drinking environment (e.g. plastic cups) may cause a net economic loss (Burton et al., 2017; Chisholm et al., 2018).

An important area of regulation in developing countries in particular is the regulation surrounding home brewing, home distillation, undenatured ethanol, and higher alcohols (e.g. propanol, isobutanol and isoamyl). Non-commercial alcohol, which can involve home distillation of spirits and mixing of ethanol and other alcohols with beverages, substantially raises the social costs from alcohol consumption, not reflected in the price (International Center for Alcohol Policies, 2008; Mkuu et al., 2019).¹⁸

Although enforcement of regulations that limit or prohibit home brewing or distillation of alcohol may be challenging, regulations aimed at reducing the consumption of undenatured ethanol and higher alcohols may be successfully enforced.¹⁹ These alcohols are often imported or produced in the formal domestic economy. The cost of domestic ethanol production may be greater than the benefits (Hahn & Cecot, 2009). Regulations may require a licence

¹⁸ Although higher levels of lead are sometimes observed, it is generally not the case that home-made alcohol, without adding other alcohols, is more toxic than alcohol beverages made by industry (Rehm et al., 2014). However, not accurately controlling or being informed of the amount of ethanol in beverages, together with a much lower cost-to-ethanol ratio that eases excessive consumption, raises the cost of alcohol consumption.

¹⁹ There is no high-quality evidence on the success of these regulations.

to purchase undenatured ethanol and higher alcohols and require adding bittering agents to consumer products. Regulations that limit the amount of alcohol in medicines can also reduce the costs of alcohol consumption.

3.3. Energy and vehicles

The production, supply and use of energy tends to be highly regulated. Regulations generally regulate the structure of and competition in the market; mining rights and operating licences; the location of operations; the operation, use and maintenance of equipment and power systems; the performance and compliance of right holders and licensees; technical and safety standards; property and land rights; tariffs and charges; tradable emission permits; rights and protection to consumers; rural electrification and the imports and exports of electricity.

Some countries have implemented separate regulations relating to renewable energy. Besides the regulations discussed above, regulations may introduce an auction system for renewable sources, limit installation areas of renewable energy equipment, require the adoption of certain technologies, manage the feed-in of electricity into the grid, regulate the sale of energy between tenants, support research and development, provide fiscal incentives and establish feed-in tariffs and other remuneration schemes. Many of these regulations lower the social costs not reflected in the price of energy.

Different renewable energy regulations and policies also affect innovation in renewable technologies, which may indirectly lower social costs not reflected in price. Hille et al. (2020) find that research, development and demonstration programs are associated with the greatest innovation in renewable technologies in a sample of 194 countries and territories. Fiscal incentives such as public spending, capital subsidies and low-cost loans and the announcement of government renewable energy targets are also associated with increased innovation.²⁰ The impact of regulation on innovation may, however, vary with the level of economic development of a country (Du et al., 2021).

The production of motor vehicles is predominantly regulated to meet safety, environmental and theft-protection standards, which lower social costs not reflected in price. To meet these standards, there are specific regulations that vehicle components need to comply with, such as for doors, steering wheels, seats, seat belts, roof strength, breaks and so forth. Regulations also set speed, noise and other limits. Some countries further require the electric vehicle manufacturer to implement warning sounds when these vehicles travel at low speeds.

Vehicle market regulations are also increasingly implemented to meet environmental objectives. Some countries, such as Zimbabwe, Nepal and India, regulate or prohibit the importation, purchase or registration of vehicles older than a certain age. Regulations that limit the driving time of certain

²⁰ In a smaller sample, Nicolli and Vona (2016) find that reducing entry barriers has the greatest effect on innovation in renewable energy. Also see Johnstone et al. (2010).

vehicles are sometimes implemented.²¹ Developed countries and states, such as Norway, Germany, the United Kingdom and California have set target dates to ban combustion vehicles or zero-emission vehicle mandates that require manufacturers to produce a specific number of electric vehicles.²² Besides those limiting driving time, the effectiveness of these regulations has received little empirical attention and will depend on the enforcement capacity of a specific country.²³

Incentives may also assist in consumer substitution towards electric vehicles, which, depending on the country, can reduce the cost of vehicle use. These incentives include tax benefits, subsidies on purchase, on charging or to industry, free tolls and parking and travel and parking priorities. Reviewing the empirical literature, Song and Potoglou (2020) find that incentives that close the price between electric and combustion vehicles are most effective towards consumer substitution. However, the benefit of subsidy incentives tends to shift from consumers to producers in the short term and onto infrastructure improvement in the long term.

3.4. Sugar

Although regulating sugar production is challenging, especially in less-developed countries with informal farming, once sugar cane is processed and enters formal markets, regulation becomes more feasible. Common regulations follow command-and-control approaches to set hygiene, transport and other requirements to ensure food safety and quality. Recent regulatory trends focus on communicating and improving health outcomes from sugar consumption. These may involve ingredient labelling and warnings of nutritional content, advertising of foods high in sugar, and school food and tuck shop products. Public awareness campaigns are also increasingly common.

There is little high-quality evidence available on the effectiveness of these recent regulations. The evidence suggests that such regulations can be effective, but the effectiveness is context-specific (Barbour et al., 2022; Micha et al., 2018; Popkin & Hawkes, 2016). Where effective, these regulatory trends will reduce the costs of sugar consumption.

3.5. Other

Cement production is often regulated to meet environmental and health standards and, thereby, reduce its social costs not reflected in price. To manufacture cement, raw materials (e.g. limestone, clay and iron) are ground and heated in a rotary kiln, which is a large furnace fuelled by coal and coke, oil, gas and/or various waste materials. Besides emissions from the burning of these fuels, hazardous air pollutants are emitted in this process.²⁴ Regulations can

21 These regulations can be found in, among others, populous Latin American cities such as Mexico City, Buenos Aires and Sao Paulo.

22 Policies that require public procurement of electric vehicles are also applied.

23 Studies on limiting driving time indicate that these restrictions can be easily avoided (Guerra & Millard-Ball, 2017).

24 See <https://www.epa.gov>.

limit the fuel types used and/or set limits for the different emissions produced (e.g. mercury and nitrogen oxides).²⁵ Production restrictions can also limit production to certain times or areas, such as the off-peak production mechanism applied in China.²⁶ Empirical evidence on the effectiveness of these regulations could not be found.²⁷

Similar to cement, fertiliser production is regulated to meet environmental and health standards and reduce social costs not reflected in price. The importation, number of producers and suppliers, input materials, manufacturing procedures, output of certain chemicals or toxic contaminants, manure management and packaging and labelling can be regulated. In particular, inorganic fertilisers can contain potential toxic elements such as cadmium and uranium, which pose a risk to human, animal and plant health and warrant regulation.²⁸ Technical and enforcement challenges and a lack of knowledge on manure management have resulted in these regulations being ineffective in some countries (Liverpool—Tasie et al., 2010; Ndambi et al., 2019; Simiyu et al., 2013).

Common regulations to reduce the costs of agriculture follow command-and-control approaches to set quality and safety standards for inputs and outputs, protect lands, habitats or species, require the removal of invasive species and limit agricultural activities to certain areas. A more recent trend is agri-environmental instruments; regulation aimed at reducing the negative environmental impact of agriculture and schemes that do not rely on command and control, such as the International Organization for Standardization (ISO) 14001 series for environmental management systems. This is a scheme that compensates for costs incurred due to modifying production processes, or certification of outputs if certain processes were followed.

A key difference between command-and-control and other agri-environmental schemes is that, unlike command-and-control instruments, these schemes are voluntary. They provide incentives towards compliance by either direct payment when meeting certain contractual obligations, or potential increases in demand from consumers who prefer environmentally friendly products.

It is not clear whether command-and-control approaches should be preferred to agri-environmental schemes to reduce the negative impact of agriculture. There is a lack of empirical evidence. The findings of Sauer and Walsh (2011) and Sauer et al. (2012) suggest that for less formal farming, command-and-control instruments are more costly and less likely to influence producer behaviour. But the effectiveness of agri-environmental schemes seems

²⁵ Such regulations also influence the selection of raw materials used to manufacture cement since these contain different levels of air pollutants.

²⁶ Wang et al. (2021) find that this regulation has a negative effect on firm performance.

²⁷ Rahman et al. (2015) find that the adoption of alternative fuels in cement manufacturing has had a positive impact on the environment.

²⁸ See <https://nutrیمان.net>.

to depend on context, showing effectiveness in some countries and ineffectiveness in others (Tyllianakis & Martín—Ortega, 2021; Uthes & Matzdorf, 2013).

Waste management tends to be strongly regulated. Common regulations specify which waste management activities require a licence, how waste should be treated, where waste may be disposed of, and what type of waste may be disposed. Recent regulations have focused on e-waste management, often limiting trans-boundary e-waste movement and recycling requirements of e-waste (Ilankoon et al., 2018). Stronger regulation of single-use plastics is also common, with many countries prohibiting the use of plastic bags and straws or setting a minimum price for these items.

The regulation of waste management can be effective. Kuang et al. (2022) finds that regulating e-waste in China significantly reduced the exposure to pollutants associated with e-waste within a sample of 860 individuals.²⁹ In a systematic review, Adeyanju (2021) finds that regulations based on the thickness of plastic bags are not effective, but regulations that prohibit the use of plastic bags significantly reduce plastic bag consumption. In another review, Borg et al. (2022) find that regulation of plastic is effective, but a combination of approaches may be required to give rise to sustained behavioural change.

4. An efficient excise regime

Towards improved decisions by producers and consumers, market prices should be based on social costs. For excisable goods, this requires excise rates that accurately internalise social costs not reflected in price into market prices. Although the exact social costs not reflected in price will be different in every country and context, comparable social costs not reflected in price between traditional and innovative goods may be similar for most countries.

The interplay between excise taxes and regulation also requires consideration. For governments to meet their objectives, a difficult balance between supporting innovation through excise taxes and regulation, collecting sufficient tax revenues to meet government objectives, and meeting government objectives through the excise regime and regulation is required.

This section provides an economic argument on the design of an excise regime for smoking and nicotine, alcohol, energy and vehicles, sugar and other products in the face of recent innovations and regulations. The argument is already reflected in the excise regimes of some countries. However, in many countries, uncertainty remains around the appropriate design of an excise regime if adopting an economic approach.

²⁹ Bhaskar and Turaga (2018) find that e-waste regulation in India gave rise to a small increase in the appropriate recycling of e-waste.

4.1. Smoking and nicotine

Although there is strong toxicological evidence that ENDS are likely to be less harmful than cigarettes and the existing evidence supports the same for HnB products, the long-term effects of these products remain uncertain. Two approaches to excise and regulation policy have been adopted or recommended in the face of this uncertainty:

- Treat these products equivalent to cigarettes.³⁰ Because of the lack of evidence that these products are equally harmful to cigarettes over the short or long term, there is little evidence supporting a claim that the external and internal costs of these products are the same as for cigarettes, and the rationale for this approach does not closely follow that economic approach to excise taxes. Only if there is strong evidence that cigarettes are a complementary good to ENDS and HnB, will the internal and external costs of cigarettes be relevant to the treatment of ENDS and HnB products. However, as indicated above, the evidence of whether these products are complimentary or substitutions for cigarettes are mixed.
- Treat these products differently to cigarettes. Underlying this approach is a recognition that science is never fully developed, and science-based policy is always limited by unknowns and, therefore, based on available evidence. Because of the lack of evidence that ENDS and HnB have similar harm to cigarettes, it is not assumed that the internal and external costs of ENDS, HnB and cigarettes are the same. These products are viewed as separate products to cigarettes and an estimate, based on available evidence, of their internal and external costs are made, which includes considering if they have strong substitution or complementary goods, for which the evidence is mixed. The existing estimates of the costs of smoking and comparative harm between ENDS, HnB and cigarettes are useful evidence for this estimate. This approach closer represents the economic approach to excise taxes.

Relying on this economic approach and based on the available evidence that indicates the availability of less harmful substitutes for cigarettes, balancing excise revenues and regulation while motivating substitution away from cigarettes is important. Towards this balance, setting an efficient excise rate on cigarettes and combustible tobacco is the first requirement. In general, this

³⁰ This approach is not necessarily risk-adverse. It may result in fewer individuals, including youth, starting to consume ENDS or HnB products and potentially smoking cigarettes. However, individuals who would have consumed nicotine irrespective of these products are more likely to prefer cigarettes under this approach, which may be more harmful. Further, it heightens the risk that existing smokers will continue smoking cigarettes rather than substituting towards ENDS or HnB products, which may be less harmful.

should be a specific rate per gram of combustible tobacco, used to calculate the specific rate per unit for cigarettes.³¹³² This approach avoids substitution between cigarettes and combustible tobacco motivated by the excise regime.

The specific rate has benefits over an *ad valorem* rate. An *ad valorem* rate is susceptible to trade mis-pricing and under-valuation of ex-factory prices and will not convey accurate information to consumers since it taxes higher quality cigarettes at a higher effective rate than lower quality cigarettes, suggesting that lower quality cigarettes are less harmful. In general, *ad valorem* rates can only be preferred in the context of high inflation where indexation of the specific rate would not provide stable real revenues.

The specific rate should consider the extent that smoking is regulated, since these regulations have been effective in reducing smoking and, therefore, reducing social costs not reflected in price. The rate should be higher in less regulated environments and lowered as regulation is increased. However, the prevalence of smuggling and price of cigarettes and tobacco in neighbouring countries may limit the ability of a country to apply such a rate.

Having established a rate on combustible tobacco, differential taxation for reduced harm alternatives is may be warranted. Our current knowledge indicates that ENDS are about a twentieth as harmful as smoking tobacco such as cigarettes. Independent evidence on HnB products is more limited but indicate that these products may be about a fifth as harmful as cigarettes per stick, which, based on typical amounts of tobacco in a stick equals about half the harm per gram of tobacco.³³ If the same regulations apply to these products as smoking tobacco, excise rates that reflect comparable harm would be about 40 per cent of the specific rate per gram of tobacco per millilitre of ENDS liquid.³⁴ For HnB products, setting a rate per stick at about 20 per cent of the specific rate per cigarette may be appropriate.³⁵ Considering the comparative harm from waste of cigarette butts and disposable ENDS, where a plastic excise is not administered, may further refine these rates.

Differential regulation between cigarettes and less harmful substitutes may warrant revision of these rates. Such regulation may support substitution towards non-combusted nicotine products and, based on our current knowledge, accelerate the achievement of public health objectives. Since the

31 A cigarette generally includes about 0.8 grams of tobacco.

32 This rate should not change depending on where the tobacco is produced or the raw materials used, a practice often observed in African and Asian countries.

33 HnB generally contains less than half the amount of tobacco per stick of cigarettes. The harm differential therefore largely represents the difference in amount of tobacco consumed.

34 A cigarette contains about 0.8 grams of tobacco. A millilitre of ENDS liquid is about equivalent to 10 cigarettes in terms of number of puffs. The harm is estimated at about five per cent of a cigarette for the same number of puffs.

35 These rates do not consider the substitution effect from cigarettes to ENDS or HnB or the complementary effect of ENDS or HNB on cigarette consumption since the evidence on these effects is mixed. If there is substitution, a lower rate on non-combustible tobacco may be warranted since it provides a positive externality of reduced cigarette smoking. The opposite is the case if it is found that non-combustible tobacco is complementary to cigarettes.

harm from second-hand exposure to non-combusted nicotine is estimated to be less than cigarettes, differential regulation regarding public smoking may be warranted in certain circumstances.

Regulation should be careful to not motivate substitution towards cigarettes by current users of non-combusted nicotine products. The existence of such regulation may increase the total social costs not reflected in the price of smoking and nicotine. Since the evidence suggests that regulation that aims to reduce youth smoking of ENDS may have adverse effects, and that ENDS and cigarettes may be substitutes rather than complementary goods in certain cases, information campaigns may be preferred in certain contexts. Such an approach will also be aligned with the latest evidence, as summarised in McNeill et al. (2022).

4.2. Alcohol

Since alcohol has high-harm substitutes such as undenatured ethanol, home brewing and home distillation, balancing excise revenues, regulation, information campaigns and support for low-alcohol alternatives is important. To remove undenatured ethanol as a substitute, limiting the import and purchase of undenatured ethanol to license holders and requiring the addition of bittering agents by regulation may be preferred to excise taxation.

Since regulations aimed at limiting or eliminating home brewing and distillation may struggle with enforcement challenges, the price difference between informal and formal alcohol is a policy concern in many countries. Since limiting smuggling and supporting substitution to formal alcohol may raise tax revenues and reduce the consumption of high-risk alcohol, an excise rate below the optimal rate may be preferred where smuggling, home brewing and/or distillation is prevalent. Where these practices are not prevalent, the rate should reflect the social costs not included in the price of alcohol consumption.

Whether the rate is set at or below the optimal level, a specific rate per litre of 100 per cent alcohol is generally appropriate. Many countries set excise rates on alcohol based on beverage type, place of production, raw materials used and other factors. Countries that do not experience high inflation also use *ad valorem* rates. Since a percentage of pure alcohol gives rise to similar social costs not reflected in price, irrespective of beverage type, place of production and raw materials used, only a specific rate that disregards these variables will provide accurate information to consumers. The specific rate should, however, consider the extent of regulation of alcohol, especially where regulation limits marketing of alcohol, limits late night sales and prevents driving after alcohol consumption.

Such a specific rate will also, appropriately, tax reduced alcohol and alcohol-free beverages at rates that reflect their reduced harm for the same volume of beverage. Since an alcohol-free beverage does not contain alcohol, it should not be taxed under the alcohol excise. However, low and alcohol-free beverages often include sugar, and this component of the beverage may warrant an excise in certain contexts.

4.3. Energy and vehicles

To meet the Nationally Determined Contributions under the Paris Agreement, most countries will have to support innovation in energy and vehicles. Part of this support could be through differential excise rates on energy and vehicles and regulation that motivates substitution towards lower harm alternatives.

A first step is an excise that internalises the social costs not reflected in price of electricity by either taxing harmful inputs (e.g. coal, diesel and gas) with a specific rate based on their greenhouse gas emissions or, if inputs are not taxed or insufficiently taxed, electricity as output with a specific rate based on the emissions per kilowatt-hour.³⁶ Taxing inputs may be preferable towards a differentiated excise regime on electricity since changes in electricity generation will immediately change the total excise on electricity. Where electricity as output is taxed, the rate would have to be adjusted as the process and inputs of electricity generation changes.

A differential approach, as outlined above, will create an incentive to substitute for greener electricity. Regulation that supports green energy and feed-in by producers can also motivate substitution.

Besides electricity, motor fuels should be taxed at a specific rate per litre to internalise the environmental, pollution and noise costs of fuel combustion into fuel prices.³⁷ Fuel excises are often set to include other external costs, such as vehicle accidents, congestion, road damage and space consumption of vehicles. However, with the introduction of electric vehicles that do not consume fuel, it may be preferred to account for these externalities under the vehicle excise. If not, the excise on fuel may exceed the costs not reflected per litre of fuel consumption.³⁸

The excise taxes above on electricity and fuels are important for an efficient excise regime on vehicles. If the excise on electricity and fuel does not internalise social costs not reflected in price, these costs would have to be accounted for under the vehicle excise, giving rise to complexities differentiating between combustion and electric vehicles. However, where the excise on electricity and fuels internalises costs, the vehicle excise can represent other social costs not reflected in price, contributed by all vehicle types. These costs include vehicle accidents, congestion, road damage and space consumption.

³⁶ Another option is a separately administered carbon tax. The design of this tax is beyond the scope of this paper. Its introduction should, however, reduce the excise on electricity and fuels if these excises already include all social costs not reflected in price.

³⁷ Besides accurately reflecting costs not included in price, a specific rate also has the benefit of less fluctuation in the price of fuels compared to the *ad valorem* rate and, thereby, be a more stable source of revenues.

³⁸ This is the case since there are non-fuel consuming vehicles giving rise to social costs not reflected in price, such as road damage.

Since costs arising from vehicle accidents, congestion, road damage and space consumption are correlated with distance travelled, the excise regime on vehicles needs to take this into consideration.³⁹ A potential policy is to have a weighted specific rate per kilometre or mile travelled, with the weight being based on the weight of the vehicle, or another variable that is correlated with size and weight.⁴⁰ This approach would provide that all vehicles can be subjected to the same policy, and the excise paid periodically, perhaps during licence renewal. In addition, a separate excise may have to be levied at the purchase stage based on the age of a vehicle, with new vehicles not paying the excise.^{41,42}

The combined policy on electricity, fuel and vehicles will support the adoption of reduced harm energy and vehicles that are smaller, newer and rely on a less harmful source of fuel. Where electricity generation is less harmful than fuel combustion, the excise burden will be comparatively less on electric vehicles. Further, since the excise on vehicles does not raise the purchase price of new vehicles, substitution towards these vehicles is more likely.⁴³ Consumers may also prefer smaller vehicles to lower the periodical excise tax based on weight and distance travelled, which would reduce the costs of road damage, congestion and space consumption.⁴⁴

4.4. Sugar

An excise on sugar may not be needed or warranted in certain countries. Both low and high percentages of carbohydrate⁴⁵ consumption are associated with increased all-cause mortality (Seidemann et al., 2018). This suggests that sugar consumption is beneficial as a source of sustenance and harmful when excessively consumed. The excise on sugar, or carbohydrates more generally, will only be warranted in countries where excessive consumption thereof gives rise to substantial social costs not reflected in price, such as public health care costs.

If there are substantial social costs not reflected in price due to sugar consumption, an excise at a specific rate per gram of sugar may be appropriate. However, if those people with low incomes rely on sugar as sustenance, the tax may not be equitable and information campaigns and regulation may be preferred. Where the public health system is weak, the external cost of sugar

39 Such an approach may prove to be challenging in some developing countries, especially to limit evasion by adjusting odometers on older vehicles. However, the same countries generally do not have many electric vehicles and the traditional approach to fuel and vehicle excises can be applied.

40 This cannot be engine capacity since it is not relevant to electric vehicles.

41 Many existing regimes also consider the carbon emissions of a vehicle. However, with efficient excises on fuels this may not be required. The reason is that fuel consumption and carbon emissions, after controlling for vehicle age, weight, and distance travelled, tend to be closely correlated.

42 In regions where vehicle smuggling is common, regulation may be preferred to an excise on old vehicles.

43 Newer vehicles are less prone to breaking down and generally have improved safety features, which reduces the costs of road accidents.

44 Where governments wish to further motivate the adoption of electric vehicles, further regulation and incentives as outlined in Section 3 could assist.

45 Sucrose is a carbohydrate consisting of a glucose and fructose molecule.

consumption may be higher and warrant stronger regulation and taxation, preferably on all foodstuffs that contribute to nutrition-related diseases, if administratively feasible.

Since innovation can provide a sugar substitute to those people with low incomes and lower external costs, regulation, taxation and information campaigns to support innovation may be beneficial. Currently, there is insufficient scientific evidence to allow precise estimates of the comparative harm of sucrose and its various alternatives. Setting an excise rate on sugar alternatives is therefore challenging. It may be appropriate to, in the short term, rather rely on information campaigns and differential regulation, such as advertising, for sugar alternatives that are currently only associated with health benefits, such as xylitol, tagatose and erythritol.

4.5. Other

The toxins and emission from cement production is seldom taxed under an excise. Although a substitute may not yet be readily available, an excise on cement may be warranted towards environmental objectives, especially where regulations cannot be effectively enforced.⁴⁶ An excise on cement may also motivate innovation towards an alternative that is produced in a manner that is more environmentally friendly, as well as motivating substitution towards this cement once it enters the market.

Regulation may be preferred to taxation to avoid the potential toxic elements in inorganic fertiliser and its potential impact on human, animal and plant health. Since fertiliser contributes GHG emissions but is also essential to food security, subjecting it to an excise will depend on context. In countries without food security, the external benefits from fertiliser may exceed the external costs and therefore not warrant an excise. Where environmental objectives are a greater priority than food security, an excise on fertiliser may be warranted. Such an excise will also motivate innovation and improved manure management by farmers.⁴⁷

Although the agricultural sector is the largest contributor to GHG emissions in many countries, these emissions are seldom taxed.⁴⁸ This sector is also difficult to regulate in many countries. Where enforcement challenges are common, the existing evidence suggests that agri-environmental schemes might be preferred to command-and-control strategies. Where farming is informal, a preferred balance within this sector may be to have policies that support innovation, together with agri-environmental schemes.⁴⁹ Such an approach may assist formalisation of the sector and, thereby, raise revenues from other taxes.

⁴⁶ The rate of the excise may not be at an efficient level where there is a concern of substituting cement with wood. The rate should also consider the extent that fuels used to produce cement are already subjected to excise taxes.

⁴⁷ Information campaigns may also be important to improve manure management by farmers.

⁴⁸ In less-developed countries, enforcement challenges often prevent taxation. Further, taxing the agriculture sector tends to be politically challenging in many if not most countries.

⁴⁹ A fee-bate approach to taxing agriculture can be considered where there are larger businesses and available data.

To reflect the environmental costs of waste in prices, goods that contribute to these costs may warrant an excise and regulation. E-waste and plastics may require a combination of excise taxation, regulation and information campaigns to effectively reduce their environmental harm. The excise rate needs to reflect the strength of regulation with lower rates where regulation is stronger. Differential excise taxation between biodegradable and non-biodegradable plastics may also motivate substitution towards reduced harm plastics.

5. Conclusion

For market prices to provide accurate information to producers and consumers, applying different excise rates on goods based on their internal and external costs not reflected in price is important. Although this practice is already adopted to some extent in many countries, consistent application of the economic approach on all excisable products is seldom observed.

For many countries, the economic approach would require adopting a specific rate, increasing their excise rates on cigarettes, smoking tobacco and alcohol, redesigning the regime on electricity and its inputs, fuels and vehicles, administering lower rates on the reduced harm alternatives to excisable goods, and improving international cooperation to reduce illicit trade. The base of the excise regime may also have to be widened in certain contexts to include sugar, cement, single-use plastics and fertiliser, where sufficient administrative capacity exists.

Regulation and information campaigns that support innovation and substitution towards reduced harm excisable goods by consumers can lower social costs not reflected in price. This is especially the case for the regulation of reduced harm nicotine products to assist substitution from smoking tobacco, undenatured ethanol to avoid substitution, renewable energy to assist substitution, and fertilisers to avoid intoxication, which can have significant influence over the total external costs of smoking, alcohol, energy and vehicles and other excisable goods.

An excise regime, as outlined, would represent an economic rationale for excise taxes. It is, however, unlikely that excise regimes in practice will consistently implement lower rates as reduced harm innovations and stronger regulations are introduced. Further debate is therefore required on the rationale and future of excise taxes in the face of innovation and regulation that will continue to reduce social costs not reflected in price.

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