Dereliction of duty:
Are UK alcohol taxes too low?

Dereliction of duty: Are UK alcohol taxes too low?

AN INSTITUTE OF ALCOHOL STUDIES REPORT
PUBLISHED MARCH 2016

WRITTEN AND PRODUCED BY AVEEK BHATTACHARYA

<u>About the Institute of Alcohol Studies</u>

Executive summary

There are three standard reasons why governments tax alcohol:
1. *Externality Correction*: to ensure that alcohol prices reflect the cost to third parties who are harmed by drinking
2. *Paternalism*: to reduce people's consumption for their own good
3. *Revenue Raising*: to fund the government

The UK Government estimates that externalities associated with alcohol cost England and Wales £21 billion every year

Alcohol duty in England and Wales currently generates only £9 billion, less than half of the value of these externalities

This suggests **higher alcohol taxes can be justified on the basis of the harm drinking causes to wider society alone, without considering the impact on the drinker themselves**

The lost enjoyment suffered by moderate consumers as a result of alcohol duty is relatively small – we estimate £1.2 billion (less than 2% of market value) to be the absolute possible ceiling of the impact. This is dwarfed by the benefits of duty, in terms of reducing crime, healthcare savings and improving economic output, which total a value of at least £4.4 billion

Under certain assumptions, tax revenue should not just equal, but exceed the cost of externalities:
- If externalities are disproportionately higher at higher levels of consumption i.e. if moving from the fourth to the fifth drink is substantially worse than moving from the first to the second
- If we think that avoiding harm to third parties should be given greater weight than the enjoyment of drinkers

There is a strong case for paternalistic taxes on alcohol, as it is highly plausible that many people drink excessively, and this overconsumption can be deterred by alcohol taxes – this adds a further reason for raising duty

Economists are divided as to whether alcohol taxes cause less distortion to the economy than other taxes and are therefore a particularly desirable way of raising government revenue

The interaction of alcohol taxes with other policies is complicated – stricter licensing and drink driving regulations, all else equal, mean that taxes should be lower

On balance, these arguments suggest to us that alcohol taxes in the UK are too low

We believe the Government should be committed to higher alcohol taxes as a result of its claim that alcohol externalities cost England and Wales £21 billion each year

1. Introduction

Alcohol taxes are amongst the oldest levied by the British Government, yet they remain a consistent source of controversy. Every year, around the Budget, the alcohol industry pleads that consumers are over-burdened with tax,[1] and public health groups respond that cuts would be irresponsible.[2] It sometimes seems as though neither side of the debate will ever be satisfied: those against tax would be arguing for it to be reduced even if it were halved, and those in favour would continue to demand rises even if it were doubled.

This is inevitable for as long as we are unsure what the ideal level of alcohol would be. This report goes back to first principles, and lays out what, in theory, should determine this level. It then uses these ideas to address whether current UK rates are too low or too high.

Though alcohol tax has been extensively explored by economists, economic theory rarely figures in policy debates, and when it does it is often misinterpreted.[3] This report presents the relevant academic ideas in a clear and accessible way to inform the debate. (To this end, technical terms are highlighted in **bold**, and defined in a glossary at the end of the report). However, the setting of alcohol tax is not just about economics. It also involves questions of value, such as when **paternalism** is acceptable and how costs and benefits to different people should be balanced.

This means that determining the optimal level of alcohol tax is not a purely technical exercise, producing a certain single number estimate. Instead, we lay out the relevant considerations, and develop a set of indicators that would suggest whether alcohol is over or under-taxed.

Though in practice different tax rates are applied to beer, wine, spirits and cider, this report considers all beverages together. This is partly for simplicity's sake, to avoid discussing four different taxes simultaneously. It is also because of the practical difficulty of isolating the negative effects associated with different drinks types.[4] However, the general approach laid out here could in principle be applied to specific drinks categories.

In our view, the balance of arguments suggests that alcohol taxes in the UK are too low. In particular, we believe the Government should almost certainly be committed to raising duty. It is generally agreed that alcohol taxes ought to reflect the costs drinkers impose upon others, yet the Government's revenue from alcohol duty falls considerably short of its own estimates of these costs. Moreover, there may be a case for raising alcohol taxes beyond this point because many consumers drink more than they rationally ought to, as a result of dependency, compulsive behaviour or because they are not fully informed. A third

---

[1] Rodionova, Z. (2016), Scotch whisky makers call for further cuts to 'onerous' 76% tax, *Independent* [online]. 27 January [Accessed 29 February 2016]. Available from: <http://tinyurl.com/zhl9kf9>; BBPA, *Beer Duty.* [online] [Accessed 29 February 2016]. Available from: <http://www.beerandpub.com/campaigns/beer-duty>; WSTA (2015), Supporting a Great British Industry: The Wine and Spirit Trade Association's Budget Submission; WSTA, "In the UK we pay £2.05 duty on a bottle of wine compared to 32p paid in SA #LessTax #MoreCricket". 5 June 2016. Tweet. Available from: <https://twitter.com/wstauk/status/684343745316270081>. [Accessed 16 February 2016].
[2] Alcohol Health Alliance (2015), Budget 2015: The Alcohol Health Alliance's position on taxation. Available from: <http://ahauk.org/wp-content/uploads/2015/03/AHA-Policy-Position-Alcohol-Duty.pdf>. [Accessed 5 February 2016]; Boseley, S. (2014), Campaigners urge George Osborne to stand firm on alcohol tax rises, *The Guardian* [online]. 18 February. [Accessed 29 February 2016]. Available from: <http://www.theguardian.com/society/2014/feb/18/campaigners-george-osborne-alcohol-tax>.
[3] See page 12-13 for some of the common misconceptions in the debate around pigouvian taxes.
[4] Although some research has attempted to make such distinctions e.g. Srivastava, P. & Zhao, X. (2010) What Do the Bingers Drink? Micro-Unit Evidence on Negative Externalities and Drinker Characteristics of Alcohol Consumption by Beverage Types, *Economic Papers* 29:2, pp229-50.

consideration is that some economists favour alcohol taxes as involving less **distortion** to the economy. We acknowledge that alcohol taxes may reduce enjoyable moderate consumption. However, we believe this effect is relatively small compared to the positive consequences of alcohol taxes. We therefore tentatively conclude that optimal alcohol taxes in the UK would be higher.

2. Three justifications for alcohol taxes

There are three standard reasons why governments tax alcohol:

1. *Externality Correction*: to ensure that alcohol prices reflect the cost to third parties who are harmed by drinking.
2. *Paternalism*: to reduce people's consumption for their own good.
3. *Revenue Raising*: to fund the government.

We shall use these labels throughout this report to refer to the different rationales. All three are discussed in this report, with particular focus on externality correction, as it is the least controversial, and most widely accepted.

Externality correction and paternalism are responses to **market failure**. Economists typically presume market transactions are mutually beneficial to all parties. Suppose a consumer orders a pint of beer for £3 from a pub. It is reasonable to infer that the pleasure they get from the drink outweighs the associated costs – not just the financial cost of £3, but also the risk of doing something embarrassing while drunk, of having a hangover the next morning, and the longer term dangers to their health. For their part, the publican makes a profit on the beer, as it almost certainly costs them less than £3 to sell. Everybody wins – the drinker enjoys their beer, the publican makes money, and so the economist is loath to intervene.

Market failures are deviations from this theoretical perfect market. For example, **externalities** occur when market transactions affect not just the buyer and seller, but also third parties. In the case of alcohol, drinking leads to violence, accidents, reduced economic productivity and problems for the healthcare system. These costs to others are not typically considered by the drinker in deciding to buy a drink, and so are not reflected in the market transaction.

The perfect market account assumes that consumers fully appreciate and appropriately respond to the costs and benefits of drinking. However, if they are misinformed, irrational or weak willed, this represents a further market failure and justifies **paternalism**.
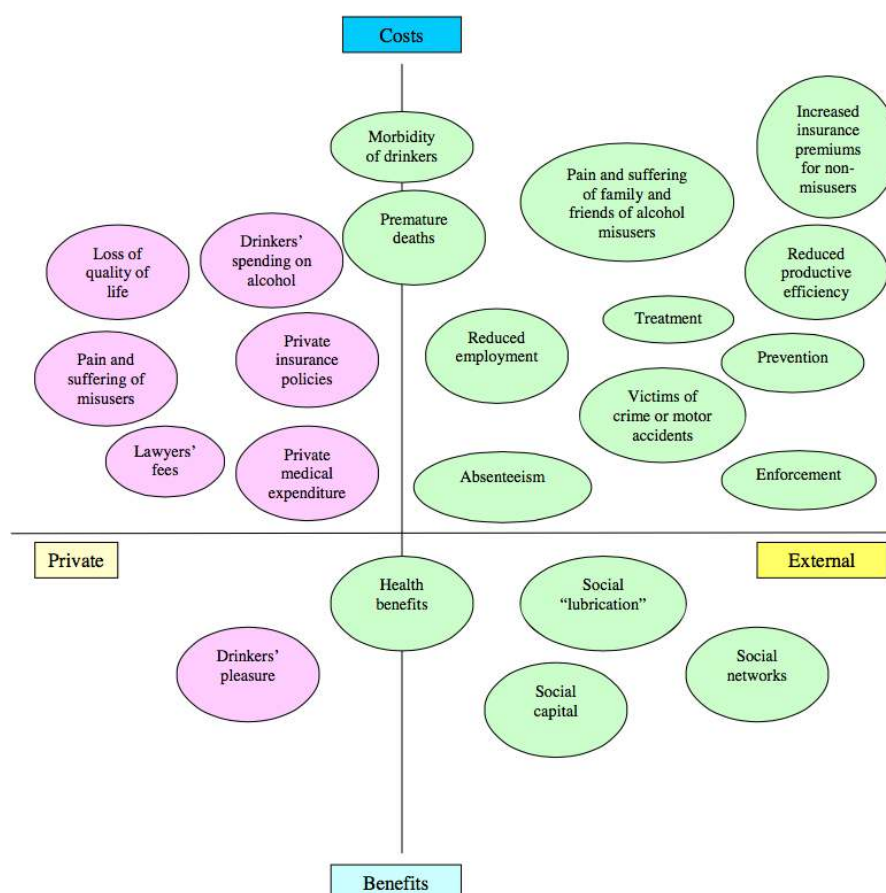
Market failures imply that the market outcome is not ideal, and can be remedied by taxes. But the mere existence of a market failure does not by itself justify taxes, or tell us what level of tax is appropriate. That is the question taken up in the following sections.

3. Taxing alcohol to correct externalities (pigouvian taxes)

3a. Pigouvian taxes in theory

The costs and benefits of alcohol can be categorised as private or external (**externalities**), depending on whether they are faced by the drinker or imposed on others. The diagram below provides a non-exhaustive overview of how different costs and benefits fit into this framework:

Figure 1: Categorisation of private and external costs and benefits

Source: Cabinet Office (2003), Alcohol Misuse: How much does it cost?, p11

The green bubbles represent **externalities**. Note that in principle these can be positive – a person's drinking could have benefits for other people, though in practice positive externalities are often ignored because they are speculative and difficult to value.
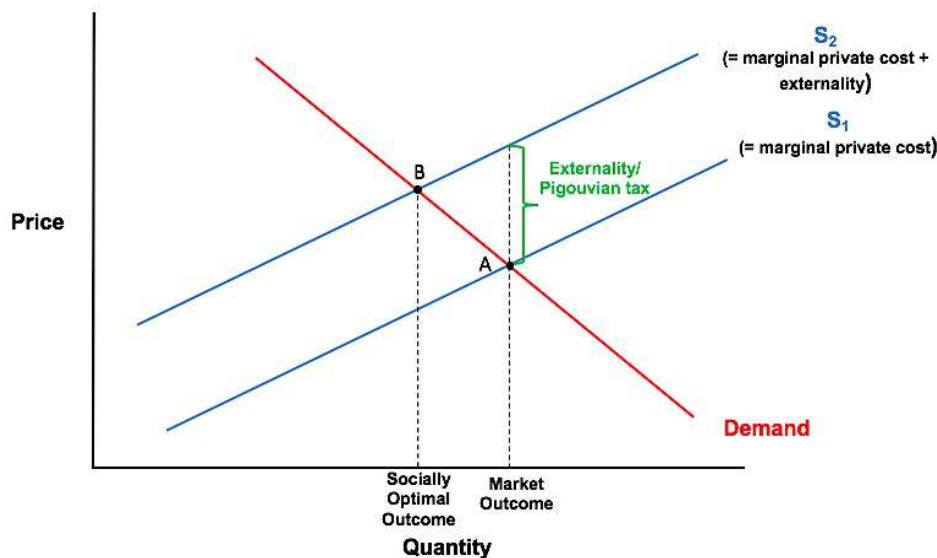
As described above, externalities represent a **market failure** because drinkers do not consider the impact of their drinking on others when deciding to buy a drink. The textbook response to this situation is to apply a **pigouvian tax** (occasionally spelt 'pigovian' – both variants mean the same thing), which seeks to 'internalise the externality': force the

consumer to consider these effects by ensuring that the price they pay fully reflects the associated externalities.

Using our example from earlier, suppose that the pre-tax price of a pint of beer is £3. Suppose further that the net **externalities**[1] associated with drinking a pint of beer are valued at £1 – on average, each pint of beer is associated with costs of that much to others (crime, healthcare, violence). In that case, a **pigouvian tax** of £1 ought to be imposed on every pint of beer, raising the price to £4.

Economists illustrate this process with supply and demand curves as in the chart below. S_1 reflects the quantity that sellers are willing to trade on the market for a given price. S_2 shows how this would change if a pigouvian tax were imposed, increasing the price at every level by the value of the externality. The new market equilibrium moves from A to B, the socially optimal level of consumption.

Figure 2: Mechanism of a pigouvian tax

It is difficult to exaggerate the extent of support for the principle of **pigouvian taxation** among mainstream economists from across the ideological spectrum. Proponents as diverse as Gary Becker and Paul Krugman are among several Nobel laureates to be members of the 'Pigou club' founded by Harvard Professor Gregory Mankiw (a former adviser to George W. Bush).[2] Even those on the political right who are usually sceptical of state intervention in markets accept that externalities justify taxes.[3] Yet this academic consensus has all too often failed to be reflected in the practice of policymakers.[4]

---

[1] Negative externalities minus positive externalities, if they exist
[2] Masur, J. S. & Posner, E.A. (2015) Towards a Pigouvian State, *University of Pennsylvania Law Review* 164:93, p96.
[3] Craven, B.M. et al (2013), Pigovian taxes and minimum pricing, *IEA Blog* [Blog]. Available from: <http://www.iea.org.uk/blog/pigovian-taxes-and-minimum-pricing>. [Accessed 7 January 2016]; Wilde, V. (2014), Why we should cut alcohol and tobacco taxes and why we can't, *Adam Smith Institute Blog* [Blog]. Available from: <http://www.adamsmith.org/blog/liberty-justice/why-we-should-cut-alcohol-and-tobacco-taxes-and-why-we-cant/>. [Accessed 7 January 2016].
[4] Masur & Posner (2015), op. cit.

3b. Are current UK alcohol taxes lower or higher than an optimal pigouvian tax?

So much for the theory. What does this imply for actual levels of alcohol tax in the UK? Recall that a **pigouvian tax** raises the price of a product by the full value of the **externalities** it causes. This implies that optimal tax revenue should equal total net externalities.

Putting a numerical value on the externalities associated with alcohol is extremely tricky.[5] Fortunately, the Government has an official estimate: a cost of £21 billion per year to England and Wales, a number it has reaffirmed on multiple occasions in parliament in recent months.[6] This figure is controversial, as any such estimate is likely to be.[7] For example, Christopher Snowdon of the libertarian Institute of Economic Affairs is sceptical of the magnitude of some of the economic and intangible crime costs included in this total.[8] However, contrary to his assertion that the number is intended to be at the "very top end of what is plausible",[9] the Government's original report admits that "The estimates given in this study are far from comprehensive – rather, due to the lack of data in certain areas, they are probably underestimates of the true costs associated with alcohol misuse".[10] Several costs are omitted from the Government's official reckoning, including costs to families and social networks[11], social care costs[12] and reduced efficiency in the workplace.[13] Moreover, at 1.2% of GDP,[14] the £21 billion is at the lower end of comparable estimates from other countries – indicating at the very least that it is not a wild overestimate.[15]

The Government's externality estimate is based on thorough research and thoughtful analysis. It is imperfect, but in the absence of a better alternative, we use it as the basis of our study. Even if the reader disagrees with this number, it is clear that it is endorsed by the Government, so the following can be read as an exploration of the implications of the facts as the Government sees them. In any case, in the analysis, the reader is free to plug in a different figure if they prefer.

Calculating tax revenue is easier. In the UK, two different taxes are levied on alcohol – alcohol duty and value added tax (VAT). However, only alcohol duty can be considered a **pigouvian tax**, as VAT is indiscriminately applied to alcohol at the same rate as most other goods, and so cannot be considered a targeted response to alcohol externalities.[16] In the

---

[5] See, for example, Godfrey C. (2004), The financial costs and benefits of alcohol: European Alcohol Policy Conference: Bridging the Gap. *The Globe*. Issues 1 & 2 pp7-14; Freebairn J. (2010), Special Taxation of Alcoholic Beverages to Correct Market Failures, *Economic Papers*, pp206-7.

[6] HL 27 October 2015, vol 766 WA2472; HL 22 October 2015, vol 766 WA2474.

[7] See Bhattacharya, A. (2015) Response to the IEA's Discussion Paper, 'Alcohol and the Public Purse'. London: Institute of Alcohol Studies. Available from: <http://www.ias.org.uk/uploads/pdf/IAS%20reports/rp17092015.pdf>. [Accessed 1st February 2016]; Bhattacharya, A. (Forthcoming), 'Which cost of alcohol? What should we compare it against?', *Addiction*.

[8] Snowdon, C. (2012) The Wages of Sin Taxes. London: Adam Smith Institute.

[9] Snowdon (2012), op. cit., p33.

[10] Leontaridi, R. (2003) Alcohol misuse: how much does it cost? London: United Kingdom Cabinet Office, p2.

[11] Home Office (2012) A Minimum Unit Price for Alcohol Impact Assessment. London: Home Office, p5.

[12] Bhattacharya (2015), op. cit., p5.

[13] Leontaridi (2003), op. cit., p36.

[14] UK GDP in 2015 was £1,789bn - £21bn is 1.2% of this. See ONS (2016), Time series: Gross Domestic Product (GDP) – CVM (25 February) [online]. Available from: <http://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/abmi>. [Accessed 1 March 2016].

[15] Rehm, J. et al (2009), Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders, *Lancet* 373, p8.

[16] The question of how to consider the VAT levied on alcohol duty is trickier. We exclude it, following Sijbren Cnossen who argues that the 'corrected' price after duty is appropriate one to apply VAT to. See Cnossen, S. (2005) Economics and Politics of Excise Taxation, in S. Cnossen (ed.) *Theory and Practice of Excise Taxation*. Oxford: Oxford University Press, p7.

most recent fiscal year, the Government raised £9.2 billion of alcohol duty in England and Wales.[17]

Figure 3: Comparison of externalities and duty revenue in England and Wales, 2014-15

This £9 billion clearly falls short of the Government's £21 billion **externality** estimate. This clearly suggests that alcohol duties ought to be raised, as prices paid by drinkers do not at present fully reflect the costs they impose on others. This does not necessarily imply duty rates should be more than doubled to £21 billion, since higher duty rates should reduce consumption, and, in turn, alcohol-related externalities. However, it does mean that current levels of duty are inadequate.

It might be helpful at this point to clarify a few misconceptions around **pigouvian taxes** that have characterised the debate on alcohol duty. First, pigouvian taxes are not about recovering costs to the taxpayer.[18] They are there to ensure the price drinkers face reflects the cost they impose on others, only some of which are costs to the taxpayer. Pigouvian taxes should reflect public healthcare costs, productivity costs to employers or injuries from drunken assault. Though only the first of these is borne by the taxpayer, all of them are externalities.

Second, intangible costs, such as the emotional distress of being a victim of crime, are externalities and as such perfectly valid considerations when setting a pigouvian tax.[19] Bearers of intangible costs are negatively affected by other people's drinking, yet their preferences are not reflected in the market transactions – the definition of an externality.

Third, while equalising tax revenue and externalities is not the objective of a **pigouvian tax**, it is a reasonable indicator of whether such a tax is appropriately applied.[20] If the **externality**

---

[17] According to HMRC's Alcohol Bulletin December 2015, alcohol duty raised £10.5 billion in 2014-15. 88% of this came from England and Wales (HMRC, A disaggregation of HMRC tax receipts between England, Wales, Scotland & Northern Ireland). This implies England and Wales account for £9.2 billion of alcohol duty.
[18] Snowdon, C. (2014), Fact checking the Alcohol Health Alliance, *IEA Blog* [Blog] Available from: <http://www.iea.org.uk/blog/fact-checking-the-alcohol-health-alliance>. [Accessed 29 February 2016].
[19] Ibid.
[20] Snowdon, C. (2015), The Institute of Alcohol Studies' Response to Alcohol and the Public Purse, *Velvet Glove, Iron Fist* [Blog]. Available from: <http://velvetgloveironfist.blogspot.co.uk/2015/09/the-institute-of-alcohol-studies.html>. [Accessed 29 February 2016].

associated with each pint of beer is £1 (as in our hypothetical example above), and there are 8 billion pints sold each year, then the total externality and the revenue raised by a pigouvian tax will both be £8 billion. If the tax succeeds in reducing consumption to 7 billion pints, then both externality and revenue will drop to £7 billion. Of course, this makes a crucial simplifying assumption – that the average externality is the same across every drink. The next section looks at the implications of relaxing this assumption.

3c. What if the marginal externalities associated with drinking are higher at higher levels of consumption?

So far we have assumed that there is a single value for the **externalities** associated with drinking: that consuming a unit of alcohol – any person, any alcohol, in any circumstances – carries the same risk of harming others. Clearly this is unlikely to be the case in reality. In an ideal world, we would charge a different rate of tax on every transaction – a lower rate to the sober pensioner than to drunken and aggressive youngsters on a night out, reflecting the greater likelihood of the latter group harming others. In practice, though, it is impossible to gather the necessary information and to administer such focused taxes.

Since perfectly targeted taxes are impractical, economists tend to agree that it is reasonable to apply a single average externality to all drinkers, and to ignore the differences between them.[21] The optimality of this approach has been formally demonstrated by Peter Diamond, the Nobel prize-winning economist.[22] This means that in general total externalities do offer a rough and ready indicator of how much revenue alcohol taxes should yield, supporting our earlier conclusion that UK alcohol duty is too low.

There is, however, an important exception to this rule of thumb. If the externalities of drinking vary, not between individuals, but between the number of drinks consumed *by a given individual*, then the value of optimal alcohol taxes will not just equal the total externalities – they may in fact exceed them.
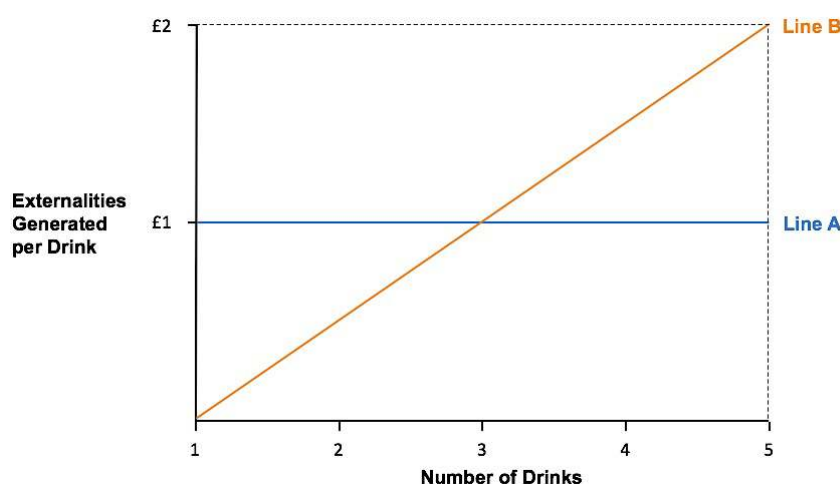
This is the case because a **pigouvian tax** tries to reflect the marginal external cost of a drink – that is, the cost associated with the *last* drink a person chooses to consume. The chart below demonstrates. It shows how the number of drinks already consumed affects the harm associated with each additional drink. Line A reflects the simplifying assumption we have been making – that each drink has the same associated externalities. The sixth pint of beer is no worse than the first. Line B shows an alternative possibility – that each extra drink makes it increasingly more likely that a person will drive drunk, get in a fight etc.

Suppose that the current equilibrium in the chart is five drinks – that is the amount that a person would choose to consume without a **pigouvian tax**. In the first instance, the tax seeks to influence the decision to take a fifth drink, so it should reflect the externalities associated only with the fifth drink. If line A is correct, this is £1; if line B is correct, it will be £2.

---

[21] Smith, S. (2005), Economic Issues in Alcohol Taxation, in S. Cnossen (ed.) *Theory and Practice of Excise Taxation*. Oxford: Oxford University Press, p72. See also Barker, F. (2002), Consumption Externalities and the Role of Government: The Case of Alcohol, *New Zealand Treasury Working Paper 02/25*, p5.
[22] Diamond, P. (1973), Consumption Externalities and Imperfect Corrective Pricing, *The Bell Journal of Economics and Management Science* 4:2, pp526-38.

Figure 4: Possible functional forms for externalities

Notice that at five drinks, the average **externality** (£1 per drink) and total externality (£5) are the same for both lines. Nevertheless, the optimal pigouvian tax will raise significantly more revenue under line B (£2 x 5 = £10), exceeding the total externality. This implies that if the marginal externality is higher than the average externality – basically, if the relationship between drinking and externalities does not look like line A – then alcohol duty should raise more than the total value of externalities.
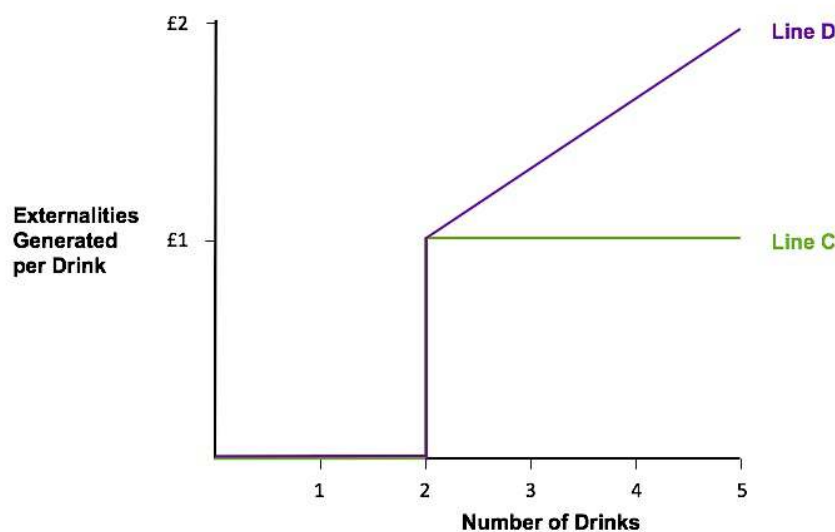
Unfortunately, there is little evidence on the specific form of the relationship between alcohol consumption and externalities, to guide us over whether line A or B is correct. We can, however, use common sense. Most of the externalities associated with alcohol, such as crime and acute health problems, are linked to intoxication and heavy consumption on single occasions ("binge drinking"). This means that they are unlikely to occur at very low levels of consumption.[23] This, in turn, suggests that there is a threshold below which drinking is unlikely to lead to externalities – a relationship something like C or perhaps D in figure 5.[24] Even in these cases, the values below the threshold pull the average externality down below the marginal externality, and so optimal duty will be greater than total externalities.

In summary, the likelihood that higher alcohol consumption is associated with higher marginal externalities is another reason to suspect that alcohol duties are too low.

---

[23] Not all externalities, however – non-acute health problems also cost public healthcare.
[24] This is, for example, how the Sheffield Alcohol Policy Model models the relationship between drinking and crime. See also Barker (2002), op. cit., p17.

Figure 5: Possible functional forms for externalities

3d. What about moderate drinkers who don't cause externalities?

Some readers may be concerned that we have skipped too quickly over the situation of 'socially harmless' drinkers, which we take to mean those who produce lower externalities than average.[25] As we acknowledged above, applying a general average **externality** to all drinkers, regardless of their personal habits, is a defensible rule of thumb, but it means that socially harmless drinkers will be taxed more than they ideally ought to be. Most economists accept that there is a balance to be struck between addressing externalities and deterring consumption that is harmless to others.[26] There are three factors to consider in striking this balance.
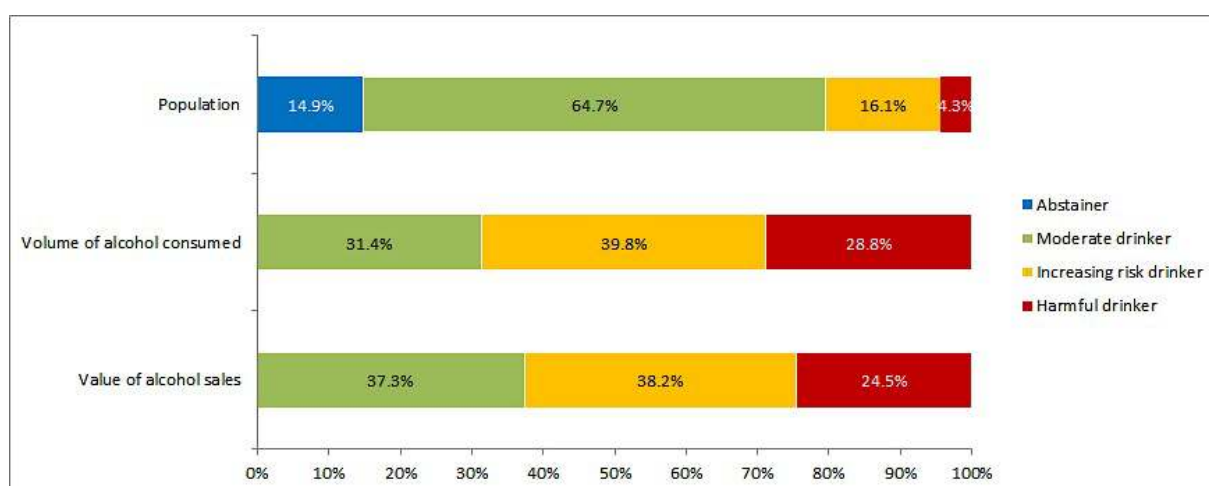
First, the proportion of total alcohol consumption consumed by socially harmless drinkers. In practice, it is extremely difficult to identify whose consumption is socially harmful, but we make the plausible assumption is that they are heavier drinkers. The most recent available data for England shows that 20% of the population drinks above the previous low risk guideline levels, and that this group accounts for the majority of alcohol consumption: 69%.[27] This indicates (though it does not prove) that only a minority of alcohol consumption is inappropriately taxed.

---

[25] In the discussion that follows the term 'moderate' is used as shorthand for 'non-externality generating' drinker.
[26] Freebairn (2010), op. cit., p211; Crawford, I. et al (2010), Value added tax and excises, in Mirrlees, J. et al (eds), *Dimensions of Tax Design: the Mirrlees Review*, pp275-406; Smith (2005), op. cit.; Barker (2002), op. cit., p5.
[27] University of Sheffield analysis, based on Health Survey for England 2013 data

Figure 6: Distribution of alcohol consumption in the England by riskiness of drinking

Note: Moderate drinker: 0-21 units/week for men; 0-14 for women. Increasing risk drinker: 21-50 units/week for men; 14-35 for women. Harmful drinker: 50+ units/week for men; 35+ for women
Source: University of Sheffield analysis, based on Health Survey for England 2013 data

Second, the responsiveness of different consumers to price. There is evidence that heavier drinkers are less likely to be discouraged by higher prices.[28] For example, the University of Sheffield has estimated that a 10% increase in price is associated with a 2% reduction in hazardous and harmful drinkers' consumption, but a 5% reduction in moderate drinkers' consumption.[29] This suggests that alcohol taxes have less effect on socially harmful consumers, and so counts in favour of lower taxes.

However, this greater responsiveness to price also bears upon the third consideration: the relative enjoyment that each group gets from drinking. The fact that lighter drinkers are more likely to be put off by price rises suggests that they like alcohol less to begin with. This could probably be inferred already from the fact that they choose to consume less alcohol. The point is that any account of the negative impact of alcohol taxes on socially harmless drinkers should account for their likely weaker taste for it. At the same time, we must be extremely careful with such inferences, since the stronger preference for alcohol shown by heavy drinkers may reflect irrationality or dependence (see below).

In the abstract, this is all rather confusing, with different considerations pulling in different directions. To make sense of it, we need to quantify how much worse off socially harmless drinkers are as a result of alcohol duty to compare it to the social benefits of reducing externalities. Such comparisons are tricky, but fortunately economists have techniques for making such valuations. Our analysis indicates that the absolute possible upper limit of the loss is relatively small.

Consider that there are two ways in which a drinker is affected by alcohol duty. The first is that they continue to buy alcohol, but have to pay more for it because of the tax (the green area marked 'Tax' in figure 7 below). However, this tax money does not simply disappear. It is used by the Government to invest in services, cut taxes or pay down debt to the benefit

---

[28] Meier, P. et al (2008), Modelling the Potential Impact of Pricing and Promotion Policies for Alcohol in England: Results from the Sheffield Alcohol Policy Model Version 2008 (1-1), p51; Sassi, F. et al (2013), The Role of Fiscal Policies in Health Promotion, *OCED Health Working Papers No.* 66, p10.
[29] Meier, P. et al (2008), op. cit., p52.

of citizens.[30] Consequently, many – perhaps most – of the people who pay alcohol taxes will be better off on balance.[31]

As with any fiscal policy, there will be winners and losers – but since a minority of the population accounts for the majority of alcohol consumption, most people will likely receive more in offsetting benefits than they pay in tax. However, in our view this is only problematic if the redistribution disproportionately hurts the poor, which UK alcohol duty does not.[32] The Institute of Fiscal Studies has found that a 5% alcohol price rise is "if anything, broadly progressive: the worst-off households lose around 0.1% of their budget on average compared to almost 0.2% for those further up the expenditure distribution".[33]

For these reasons, in line with the standard economic approach, we do not consider the higher prices faced by socially harmless drinkers as among the costs of alcohol duty. Instead, the costs we evaluate come from the second effect of alcohol duty on drinkers: discouraging them from buying alcohol (the purple triangle in figure 7).

If alcohol consumers are put off by the tax, they will redirect their spending to some other product, presumably that they value less. Suppose that a person would be willing to pay £3.50 for a beer, and £3 for a cola. With no tax, both beer and cola cost £3, so the person chooses to drink beer. Now imagine that alcohol duty of £1 per beer is imposed. At £4, the beer is now too expensive, so they will switch down to cola. The person is financially no worse off – they have paid £3 for a drink in both cases. But they are worse off in the sense that they have a drink they like less. Moreover, we can quantify this loss – 50p per drink. This 50p is referred to by economists as the **deadweight loss** – the amount of 'value' that is lost as a result of people switching to products they value less – and is represented by the purple triangle in figure 7.
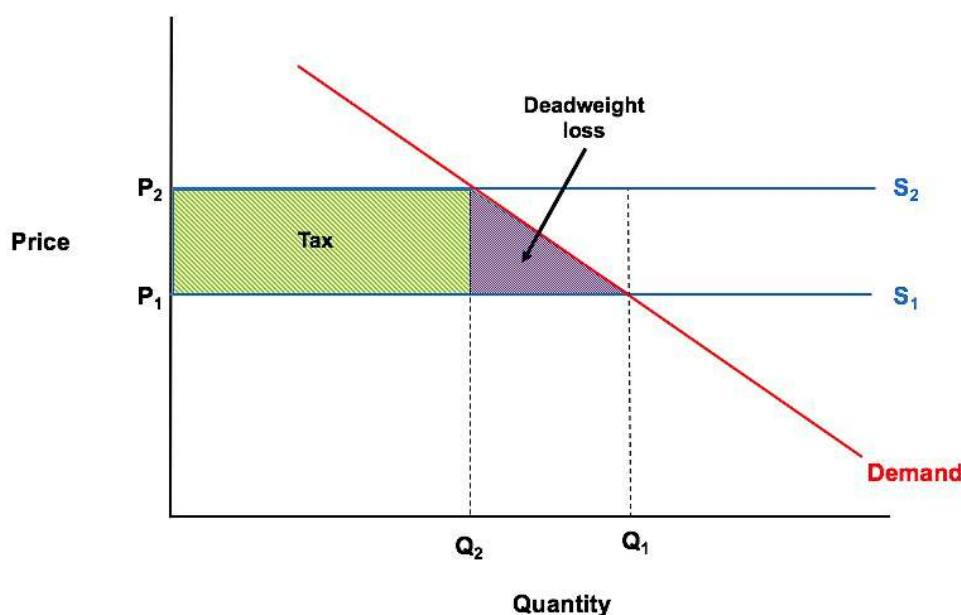
[30] Sassi et al (2013), op. cit., p21.

[31] See Cook, P. (2008), A Free Lunch, *Journal of Drug Policy Analysis* 1:1, pp1-4.

[32] The case that alcohol taxes are not regressive is even stronger if we go beyond their financial impact, as their health benefits are greater for poorer households. See Meier, P. et al (2016), Estimated Effects of Different Alcohol Taxation and Price Policies on Health Inequalities: A Mathematical Modelling Study, *PLOS Medicine*. doi: 10.1371/journal.pmed.1001963.

[33] Leicester, A. (2011) Alcohol pricing and taxation policies. *IFS Briefing Note BN124*, pp17-18. See also Smith (2005), op. cit. pp63-7. See also Levell, P. et al (2016), Excise duties, in Emmerson, C. et al (eds.), *The IFS Green Budget February 2016*, p208.

Figure 7: Deadweight Loss

Economists can calculate the **deadweight loss** associated with a tax by estimating the amount of consumption that is deterred as a result of taxes. For example, Byrnes et al have calculated that the deadweight loss as a result of alcohol taxes in Australia is $A 612 million – less than 2% of the total market value.[34]

Applying a simplified version of this model to the UK alcohol market, we estimate that at present alcohol duty results in deadweight loss can be no more than £1.2 billion – 2% of the total market value *(see technical appendix for details)*. The calculations behind this estimate are somewhat crude, but it provides an indication of the order of magnitude of the problem. This is dwarfed by the benefits of alcohol duty, which conservatively implies **externality** savings of over £4.4 billion.[35] By contrast, the £1.2 billion represents the absolute ceiling of the relevant cost of the policy – in actual fact, this is a significant overestimate for two reasons.

First, this number represents the total loss to all drinkers – it does not distinguish between those who generate externalities and those who do not. However, we should only be concerned about socially harmless. Remember that drinkers who generate externalities are *supposed* to face higher prices, and so incur some loss – that is the point of a **pigouvian tax**.

Second, this loss to socially harmless drinkers will be offset by some gain in enjoyment from consuming other products. Imagine, in the example above, that the person values a drink of cola at £3.25, rather than £3. In that case, in trading down from beer to cola, they go from a drink they value at £3.50 to one they value at £3.25 – a loss of 25p, rather than the full 50p loss. Our £1.2 billion looks only at the loss from not drinking alcohol, but we cannot estimate

---

[34] Byrnes, J. et al (2012), The Efficiency of a Volumetric Alcohol Tax in Australia, *Applied Health Economics and Health Policy* 10:1, pp37-49.
[35] The model implies removing duty on alcohol would increase alcohol consumption by 18%. Applying this increase to the £21 billion of externalities in England and Wales suggests that £3.8 billion of externalities have been saved. Adding Scotland and Northern Ireland will push this figure to £4.4 billion. This is conservative because it applies the average externality – if, as is likely, the marginal external cost increases with consumption this number will be higher still.

the countervailing gain. Thus the actual relevant **deadweight loss** is likely significantly lower than £1.2 billion.

A final important consideration is that this analysis assumes that a person's willingness to pay for a good is an accurate reflection of how much benefit they get from it. This is a problematic assumption given that many heavy alcohol consumers are dependent or misunderstand the risks involved. This is another reason why £1.2 billion is an overestimate of deadweight loss – some of this supposed loss is the result of irrational consumption.

3e. A non-utilitarian framework would imply higher pigouvian taxes still

There is an implicit value judgment in the discussion so far, typical of economic analysis, but nevertheless controversial. Economists tend to assume a broadly utilitarian framework, whereby all costs and benefits are counted equally, regardless of who bears them. However, this has the troubling implication that the enjoyment a person gets from drinking can be traded off one-for-one with the misery they cause to a person they assault.

The potential perversity of this approach is vividly highlighted by Uwe Reinhardt's 'punch in the nose' thought experiment:

> Suppose, for example, that I feel very aggressive today and therefore would like to punch you in the nose. An honest referee (an economist) asks me what I would be willing to pay for that privilege. Suppose the maximum I'd be willing to pay were $1,000. Next, the honest referee asks you how much you would have to be paid to receive that punch in the nose without hitting me back. Because you are strapped for cash, you might accept the punch for $600. The referee (our economist) is ecstatic, for (s)he perceives here the opportunity to enhance social welfare. Consequently, the deal is struck, you kindly present your precious nose, I punch, you bleed and hold out your hand in anticipation of my payment of $1,000. Alas, I walk away happily, along with my $1,000, which I refuse to surrender.[36]

Reinhardt's point is that economists focus on the overall costs and benefits of a policy, without looking specifically at how deserving the winners and losers are. With respect to **pigouvian taxes**, the key thing to remember is that these taxes do not directly compensate the sufferers of alcohol-related externalities. All that they seek to do is to ensure that drinkers in some way take their interests into account.

The upshot of this is that, at least implicitly setting a pigouvian tax involves trading off the benefits enjoyed by drinkers against the costs they impose on others. The standard economic approach says that £1 of benefit to the drinker is worth £1 of cost to others. Yet it is plausible to think that the interests of the drinker should count for less – for example, on account of the fact that sufferers of externalities are often 'innocent': the costs are imposed on them without their consent.

Different people may weigh these interests in different ways. However, note that the standard economic assumption is the most conservative possible in assuming that costs and benefits are weighed equally. For example, doubling the weight given to third parties' interests would imply the optimal **pigouvian tax** should be doubled. Thus a non-utilitarian moral framework could imply significantly higher alcohol taxes.

---

[36] Reinhardt, U. (1992) Reflections on the Meaning of Efficiency: Can Efficiency Be Separated from Equity? *Yale Law & Policy Review* 10, pp312-13.

4. Paternalistic taxes on alcohol

4a. Empirical arguments around paternalism

This report has focused on externality correction, because this is widely accepted across the political spectrum. However, **externalities** are not the only **market failure** associated with alcohol that may justify taxes. More controversially, many favour **paternalistic** taxes to reduce alcohol consumption. **Paternalism** is often used as a pejorative term. In this report, however, we use it neutrally to describe actions that seek to influence a person's behaviour for their own benefit.

Paternalism is controversial because it challenges the widespread assumption that each individual is the best judge of how to promote their own wellbeing. However, alcohol consumption is one of the areas where this assumption is weakest. To begin with, alcohol is an addictive and psychoactive substance – many people's consumption is a reflection of dependence or intoxication, rather than rational preference. A second consideration is that many drinkers are not fully informed and do not fully appreciate the risks involved in drinking. For example, only half of people are aware that alcohol causes cancer.[1] Even if they grasp these facts in the abstract, many people underestimate their own personal risk of developing alcohol-related health problems.[2] A third issue increasingly raised by economists is the idea of weakness of will, or, in the jargon, '**time inconsistency**'. This occurs when people hold contradictory preferences at different points in time. So, for example, a person may resolve to cut down their drinking when they see their doctor, read a leaflet or stand on their scales, but fail to carry this out when surrounded by the temptations of the pub.[3] More generally, there are myriad non-rational influences that shape decisions to drink – including habit, availability and social influence.

The mere fact that all alcohol consumption is not fully rational and informed is not in itself justification for **paternalism**. We need to be confident not just that people make mistakes in deciding how much to drink, but also that the government is well placed to identify those mistakes and help people take better actions.

Alcohol is a good candidate for meeting these conditions for two reasons. First, because there is a systematic tendency towards irrational overconsumption – most of the factors considered above encourage rather than discourage drinking. Secondly, because the negative consequences of excessive drinking are indisputable: it is reasonable for the government to assume its citizens do not want liver disease or cancer.

As with a **pigouvian tax**, there is a balance to be struck between reducing harmful consumption and inadvertently discouraging rational consumption. O'Donoghue and Rabin address this question, formally modelling the impact of a 'sin tax' in a society where a 'sinful good' is over-consumed.[4] As with a **pigouvian tax**, the higher cost on rational consumers

---

[1] Templeton, S-K. (2016), Alcohol risk for half of adults, *Sunday Times* (3 January). See also: Office for National Statistics (2010), Drinking: adults' behaviour and knowledge in 2009. Opinion Survey Report No. 42, p100.

[2] Leigh, B.C. (1987), Beliefs about the effects of alcohol on self and others, *Journal of Studies on Alcohol* 48:5, pp467-75. Hansen, W.B. et al (1991), Perceived personal immunity to the consequences of drinking alcohol: The relationship between behavior and perception, *Journal of Behavioral Medicine* 14:3, pp205-24; Dillard, A. et al (2009), The Dark Side of Optimism: Unrealistic Optimism About Problems With Alcohol Predicts Subsequent Negative Event Experiences, *Personality and Social Psychology Bulletin* 35:11, pp1540-50.

[3] Gruber, J. (2010), Commentary by Jonathan Gruber, in Mirrlees, J. et al (eds), *Dimensions of Tax Design: the Mirrlees Review*, pp407-22; O'Donoghue, T. & Rabin, M. (2006), Optimal sin taxes, *Journal of Public Economics* 90:10-11, pp1825-49.

[4] O'Donoghue & Rabin (2006), op. cit.

can be offset by other tax cuts and spending, and so the researchers conclude that "even relatively large taxes are unlikely to cause much harm to 100% self-controlled agents".[5] In other words, even if it is only a small proportion of society that consumes excessive alcohol, substantial taxes may still be justified.

4b. Normative arguments around paternalism

The arguments above address concerns that **paternalism** can be effective, showing how the government can have the relevant insight to successfully guide individual choices. However, these do not allay moral concerns over whether paternalism is legitimate in principle. One standard view (typically associated with Kantian philosophy) holds that paternalism involves a form of disrespect for the rational agency of individuals.[6] However, philosophers such as Sarah Conly, have argued that there is no disrespect involved in recognising people's limitations.[7] Discouraging alcohol consumption can also be seen as infringing the liberal principle that the state ought to be neutral between different value systems.[8] However, defenders of paternalism can respond that reducing drinking can be consistent with many individuals' own value systems – for example, if excessive drinking is based on misinformation.

These are complex philosophical questions, and ones that we cannot hope to resolve here. Our point is merely that there is a plausible case paternalistic alcohol taxes. Though many will dispute this case, for those who do believe that many individuals drink too much for their own good, this provides a further rationale for higher alcohol taxes, and perhaps another argument for why alcohol is under-taxed in the UK.

This report does not attempt to put a number on what an optimal paternalistic tax ought to be. Such a judgment depends on a host of factors, including the proportion of consumption that is irrational and the responsiveness of such consumption to taxes, which would be incredibly difficult to quantify and reach agreement on. Our goal here is merely to raise the issue for consideration.

---

[5] O'Donoghue & Rabin (2006), op. cit., p1841.

[6] Dworkin, G. (2014), Paternalism, in Zalta, E. (ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2014 Edition). Available from: <http://plato.stanford.edu/archives/sum2014/entries/paternalism/>. [Accessed 4 February 2016].

[7] Conly, S. (2012), Against Autonomy: Justifying Coercive Paternalism. Available from: <http://www.stern.nyu.edu/sites/default/files/assets/documents/con_037090.pdf>. [Accessed 4 February 2016]. See also: Glod, W. (2008), How Not to Argue Against Paternalism, *Reason Papers 30*, pp7-22.

[8] Wall, S. (2012), Perfectionism in Moral and Political Philosophy, in Zalta, E. (ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2012 Edition). Available from: <http://plato.stanford.edu/archives/win2012/entries/paternalism/>. [Accessed 4 February 2016].

5. Revenue raising taxes on alcohol

The third common justification for specific taxes on alcohol is revenue raising. Taxes are not only used to incentivise or discourage particular types of behaviour, but are often also intended as a source of funds for government spending. Economists argue that revenue raising taxes of this second sort ought to avoid **distortions** as far as possible. What this means is that if I prefer apples to oranges before taxes, the taxes should not influence me to choose oranges over apples – they should preserve my original preference as far as possible. A number of economists have argued that alcohol taxes should be favoured for raising revenue because they are particularly good at avoiding such **distortions**.

One principle commonly cited in this discussion is the **Ramsey rule**, which holds that the more price elastic a good is, the less tax ought to be levied on it.[1] In other words, taxes should be higher on goods where people are less put off by price increases, for the obvious reason that this makes it less likely that people will change the goods they buy. While alcohol is less price elastic than other goods, it is not clear the difference is large enough to support differential tax rates.[2]

The other idea that is regularly raised is **Corlett and Hague's** argument that taxes ought to be higher on products that are complements for leisure.[3] The issue arises because it is very difficult for taxes to maintain neutrality between work and leisure. Almost all taxes make leisure more appealing, and work less so. Taxes on income reduce the reward that people get for working. Taxes on consumption, like VAT, mean that people can buy less for their wages. By contrast, it is impossible to tax people's leisure time, at least directly. Corlett and Hague suggest the solution to this problem is to tax goods that people tend to buy for using in their leisure time. Basically, the idea is to make it more expensive to do the things that people do when they have time off, to encourage them to spend more time at work. To be clear, this is not driven by any fundamental notion that work is superior to leisure – it is simply trying to counterbalance the **distortions** in the tax system that make work less attractive. People, by and large, tend not to drink alcohol when they work. This is borne out by empirical research.[4] Thus the Corlett-Hague argument suggests that alcohol taxes can help reduce work disincentives in the tax system.

These arguments are plausible in theory, but many economists are sceptical about their practical relevance. For example, Stephen Smith notes that "The policy conclusion is frequently drawn that the case for differential commodity taxation is then rather weak, except in countries with poorly developed systems of income taxation and social assistance".[5] However, other economists have maintained that there is a strong case for **Corlett-Hague** taxes, while acknowledging that determining an appropriate level for these taxes is problematic.[6] Therefore the revenue raising benefits of alcohol taxes remain controversial.

---

[1] Cnossen (2005), op. cit., p3; Smith (2005), op. cit., pp60-1; Crawford et al (2010), op. cit., p320.
[2] Smith (2005), op. cit., p62.
[3] Cnossen (2005), op. cit., p3; Smith (2005), op. cit., p61; Leicester (2011), op. cit., pp15-6; Crawford et al (2010), op. cit., p286-91; West, S.E. & Parry, I.W.H (2009), Alcohol-Leisure Complementarity: Empirical Estimates and Implications for Tax Policy, *National Tax Journal* 62:4, pp611-33.
[4] West & Parry (2009), op. cit.
[5] Smith, S. (2005), op. cit., p61. See also Crawford et al (2010), pp290-1.
[6] West & Parry (2009), op. cit.

6. How do different arguments and policies interact?

This report has provided an overview of the three different types of justification for alcohol taxes – externality correction, paternalism and revenue raising – acknowledging that there are different levels of controversy and disagreement around each of them. It is worth pausing a moment to consider how they fit together. They cannot simply be added together. It would be incorrect, for instance, to suggest that because optimal **pigouvian taxes** are (say) £21 billion and optimal paternalistic taxes are (say) £10 billion, total alcohol taxes should therefore be £31 billion. In such a case, an optimal pigouvian tax might already deter all the consumption that an optimal paternalistic tax would, and so the optimal level might still be £21 billion, or it could be higher.

Working out how these different objectives interact to produce a single optimal tax is a tricky task. However, analysis from the US suggests that both revenue raising and **externality** correction contribute to the optimal level of tax, which is substantially higher than either one taken alone. Parry et al find that "the fiscal component of the optimal alcohol tax may be as large, or larger, than the externality-correcting component. Therefore, fiscal considerations can significantly strengthen the case for higher alcohol taxes".[1]

On the other hand, the interaction of taxes with other market interventions ought to be considered in setting tax rates. Take, for example, drink driving. Increasing the potential penalty associated with being caught drink driving adds an additional disincentive to drink besides taxes, and so mitigates the externality. Consequently, as drink driving penalties increase, the optimal pigouvian tax should fall accordingly. Similarly, stricter licensing regulations for premises selling alcohol make it less likely that people will drink irrationally, and so reduces the need for taxes to discourage drinking.

---

[1] Parry, I. et al (2009) Fiscal and Externality Rationales for Alcohol Taxes, *Resources for the Future Discussion Paper 06-51-REV.* Available from: <http://www.cddep.org/sites/default/files/parry.laxmin.west_.2006.fiscalandexternrationalsforalcrtax_6.pdf>. [Accessed 4 February 2016].
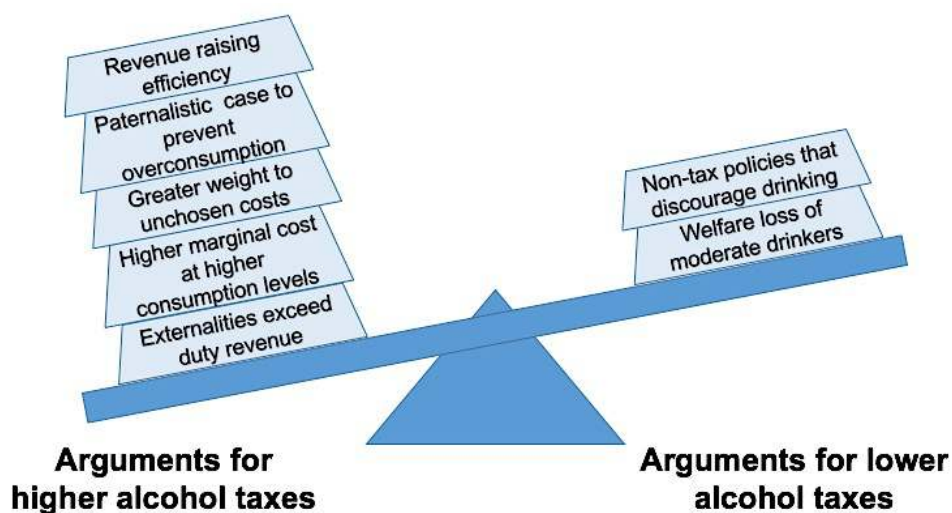
7. Conclusion

This report has three objectives. The first is to make the argument that alcohol taxes are too low in the UK. We believe that the points raised in this report make a compelling case for raising alcohol duty. However, we appreciate that there is significant uncertainty about the numbers and contentious philosophical questions at stake, so we recognise this conclusion is open to reasonable disagreement. The second objective is to argue that the UK Government ought to be committed to higher alcohol taxes. We are more confident in this conclusion. If – as the Government claims – alcohol is implicated in externalities of £21 billion in England and Wales, we find it hard to see how optimal alcohol duty could raise significantly less than £21 billion. It is currently less than half of that. The third objective of this report, if we have achieved nothing else, is to provide an overview of the various arguments at stake to help structure and inform future debates on the appropriate level of alcohol taxation.

Our view is that the setting of alcohol taxes should start from **externality** correction, as this is the least controversial and most easily quantified objective of alcohol taxation. While we acknowledge that the Government's estimate is imperfect, it clearly suggests that externalities (£21 billion in England and Wales) significantly exceed revenue from alcohol duty (£9 billion). This by itself is a strong argument that current levels of taxation are less than an ideal **pigouvian tax**.

Yet when we weigh up the other considerations, we find many more telling in favour of higher alcohol taxes than those which suggest taxes should be cut. First, there is the likelihood that marginal externalities exceed average externalities, which would increase the level of an optimal pigouvian tax. Second, there is the argument that the interests of the victims of externalities should count more than the interests of people who cause them. If this is correct, pigouvian taxes should be higher still. Third, there is a strong case for alcohol taxes on paternalistic grounds: there is good reason to think that a significant amount of alcohol is drunk irrationally by people who would benefit from drinking less, and that higher taxes would help bring this about. Fourth, there are at least some economists who believe that alcohol taxes are a particularly efficient way of raising government revenue, and should therefore be preferred to other taxes.

On the other hand, there are two countervailing considerations which weigh against tax rises. First, there is the **deadweight loss** to drinkers who do not create externalities, but are nonetheless discouraged from drinking. However, we estimate their loss of enjoyment is relatively small – much less than 2% of total market value (£1.2 billion), and is much smaller than the benefits of duty. Second, the impact of non-tax policy such as drink-drive penalties and licensing regulation in disincentivising socially harmful drinking. This is harder to evaluate as it is difficult to quantify.

Figure 8: Balance of arguments for and against higher alcohol taxes

Weighing these arguments together is tricky, as some of them cannot be easily quantified and some depend on controversial value judgments. However, we suggest that there are enough strong arguments in favour of higher taxes to tentatively conclude that alcohol taxes are too low in the UK.

Glossary

Corlett-Hague rule: The principle that taxes ought to be higher on goods associated with leisure, so as to reduce disincentives to work as a result of the tax system.

Deadweight Loss: A measure of the loss of value associated with a market intervention, such as a tax. For example, the extent to which moderate drinkers are worse off as a result of an imperfectly targeted tax (financially, and in terms of enjoyment).

Distortion: The extent of the impact of a market intervention in terms of the deviation from the allocation of goods and services that would occur if each person were left to follow their own preferences.

Externality: A cost or a benefit that affects a third party but is not considered by the buyer or seller in a market transaction. In the context of alcohol, major externalities include the financial and emotional burden of alcohol-related crime, the economic impact on employers and colleagues and healthcare and criminal justice costs to the taxpayer.

Market failure: A situation in which the market does not achieve the optimal social outcome. This can have a range of causes: if there are externalities, the market does not account for the impact on third parties; if consumers are irrational or not fully informed, they may consume too much or too little; if markets are not competitive, producers can restrict supply and artificially raise the price.

Paternalism: Actions which influence a person's choices in a way that is believed to benefit them.

Pigouvian tax: A tax that is levied with the specific goal of correcting for an **externality** by ensuring the price a consumer pays reflects the cost of their consumption on others.
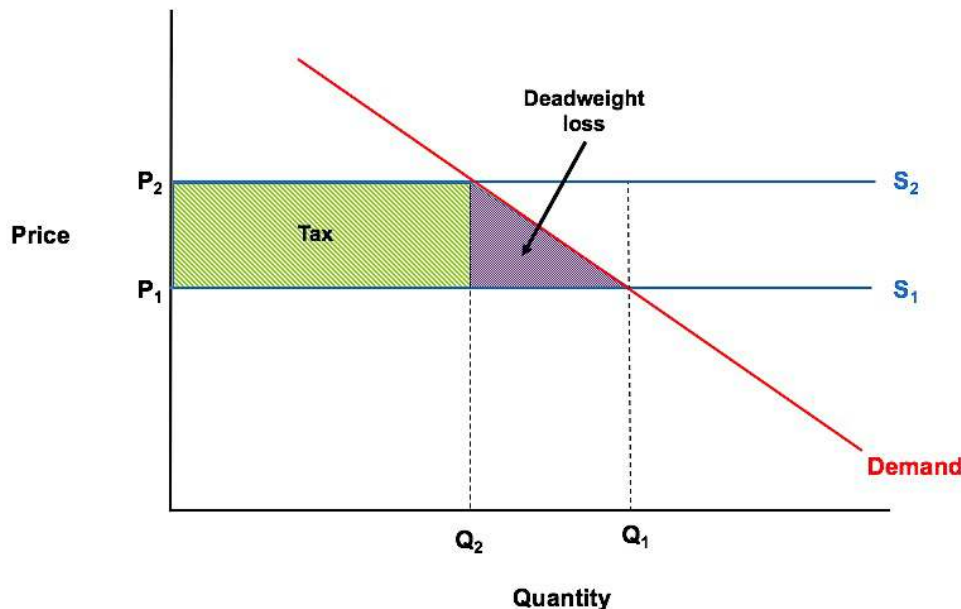
Ramsey rule: The principle that taxes ought to be higher on goods that price rises are less likely to put people off consuming, as this involves less **distortion**.

Time Inconsistency: A situation where people have contradictory preferences at different points in time – for example, if a person vows to give up drinking in the morning, but feels tempted by a drink in the evening.

Technical appendix

As mentioned in the text above, our consumer surplus model is a simplified version of the model used by Byrnes et al, in their modelling of Australian alcohol taxes.[1]

The model seeks to estimate the shaded purple area in the chart above – this represents the deadweight loss to drinkers as a result of the imposition of a tax, as prices rise from P_1 to P_2. Geometrically, we can see that this is given by the formula:

$$\text{Deadweight Loss} = \tfrac{1}{2}\,[(P_2 - P_1)*(Q_1 - Q_2)]$$

The parameters are calculated as follows:

- Q_2 (taxed demand) is the current volume of alcohol consumption in the UK. Per capita UK consumption in 2014 was 7.7 litres of pure alcohol,[2] while the UK population was 64.6 million.[3] Multiplying these together gives a total of **500 million litres**.
- P_2 (post-tax price) was calculated by dividing the total UK alcohol market value in 2014 (£46.7 billion)[4] by the market volume (500 litres, calculated above) to get **£93/litre.**
- P_1 (pre-tax price) was calculated by multiplying the post-tax price by the proportion of market value that is not associated with alcohol duty. Total alcohol duty in 2014 was £10.6 billion, but including VAT at 20%, this rises to £12.7 billion. We include the VAT levied on the alcohol duty but not the VAT on the pre-tax price as this replicates the effect of removing alcohol duty altogether. This £12.7 billion represents 27% of the

---

[1] Byrnes (2012), op. cit.
[2] Tettenborn, M. (ed.) (2015) *British Beer & Pub Association Statistical Handbook 2015*. London: British Beer & Pub Association, p.29.
[3] Office for National Statistics website, Theme: Population [Online]. Available from: <http://ons.gov.uk/ons/taxonomy/index.html?nscl=Population>. [Accessed 4 February 2016].
[4] Tettenborn (2015), op. cit., p.39.

total retail market value. Thus the pre-tax price is 73% of the post-tax price of £93/litre: **£68/litre.**

We assumed a price elasticity of -0.50, in line with the OECD's finding that "Four recent meta-analyses reported average elasticities for all alcoholic beverages in the region of -0.50".[5] This allowed us to calculate Q_1, notional untaxed demand – the market volume if excise duties were to be removed - using the 'midpoint method':[6]

- The formula for price elasticity (where elasticity is denoted by π) under a *tax rise* is

$$\pi = ([Q_2 - Q_1]/Q_1) / ([P_2 - P_1]/P_1)$$

  which rearranges to

$$Q_1 = Q_2 / (1 + \pi [\{P_2 - P_1\}/ P_1)$$

  Substituting in the values from above, we get: $Q_1 = 615$ million litres

- The formula for price elasticity (where elasticity is denoted by π) under a *tax cut* is

$$\pi = ([Q_1 - Q_2]/Q_2) / ([P_1 - P_2]/P_2)$$

  which rearranges to

$$Q_1 = ([\pi Q_2 \{P_1 - P_2\}] / P_2) + Q_2$$

  Substituting in the values from above, we get: $Q_1 = 568$ million litres

- Averaging these two values of Q_1, as per the midpoint method, we estimate that untaxed demand $Q_1 =$ **592 million litres**.

As per the formula above, the deadweight loss is given by:

$$\text{Deadweight Loss} = \tfrac{1}{2} [(P_2 - P_1)*(Q_1 - Q_2)]$$

Substituting in the values for P_1, P_2, Q_1 and Q_2 we can estimate that the **total lost consumer surplus is £1.2 billion**.

[5] Sassi et al, op. cit., p.10
[6] AmosWeb, Midpoint Elasticity Formula [online]. Available from:
<http://www.amosweb.com/cgi-bin/awb_nav.pl?s=wpd&c=dsp&k=midpoint+elasticity+formula>. [Accessed 4 March 2016].