



KAISA KOTAKORPI

Essays on Taxation and Regulation



ACADEMIC DISSERTATION

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Preface

This dissertation consists of an introductory chapter and four essays. The second essay is joint work with Dr. Markus Haavio (Bank of Finland and HECER). The first essay is forthcoming in *Economics Letters* and the fourth essay has been published in the *International Journal of Industrial Organization*. These two essays are reprinted here with the permission of Elsevier.

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Introduction and Summary

1 Introduction

This thesis consists of two parts: the first part comprises three essays that analyse different aspects of taxation of harmful goods in a situation where consumers have self-control problems. The second part, which consists of a single essay, examines the effect of access price regulation on investment and entry in telecommunications markets. The first part therefore explores a rationale for government intervention which has traditionally been controversial among economists, but has recently received more attention and also increasing acceptance within the profession: when we recognise that individuals can make errors in decision-making and may therefore fail to maximise their own welfare, there may be scope for government intervention that increases welfare. On the other hand, the second part analyses a more traditional rationale for government involvement in the economy, namely distortions caused by market power.

The rest of this introductory chapter proceeds as follows. In sections 2 and 3, we provide an introduction to the first and second parts of the thesis. Section 4 contains summaries of the essays.

2 Introduction to part 1: Taxation of harmful goods when consumers have self-control problems

2.1 Previous literature on taxation in the presence of self-control problems

The first part of this thesis analyses taxation of harmful goods when consumers have self-control problems. In the current subsection, we give a brief review of previous literature on this topic, and discuss how this thesis contributes to the literature.

We use the term "harmful goods" to refer to goods whose consumption yields current benefits, but causes utility costs (for example negative health effects) in the

future. By self-control problems we mean a situation where consumers make plans to behave in a certain way in the future, but end up revising their behaviour in a way that they regard to be undesirable *ex ante*. Preferences are therefore time-inconsistent. Self-control problems are typically associated with excessive consumption of harmful goods (see below for evidence and details of the models used), and there may therefore be a role for corrective taxation in this setting.

The literature on the optimal taxation of harmful goods in the presence of time-inconsistent preferences and self-control problems is recent and still rather scarce. Previous theoretical papers on the topic are O'Donoghue and Rabin (2003; 2006) and Gruber and Köszegi (2004). O'Donoghue and Rabin (2003) analyse the case of two goods and logarithmic utility, and consider how optimal linear commodity taxes (see Ramsey (1927)) are modified when one of the goods is harmful. They use the term "sin taxes" to refer to taxes on harmful goods, and we use this terminology throughout this thesis. O'Donoghue and Rabin (2006) examine the conditions under which the optimal sin tax is positive, and whether sin taxes can yield Pareto improvements (compared to a zero level of taxes). They further provide some comparative statics of the optimal sin tax when there are changes in the distribution of self-control problems or tastes. Gruber and Köszegi (2004) analyse a case where goods are not only harmful, but also addictive¹. Their key contribution is to modify the traditional measure of tax incidence to take into account the self-control benefits of taxes on addictive, harmful goods.

The thesis is also related on a more general level to papers that do not concentrate on the issue of harmful goods specifically, but deal with other issues in taxation in a context where consumers make mistakes. Blomquist and Micheletto (2006) provide a characterisation of the properties of an optimal redistributive mixed tax scheme in a general case where the government evaluates individual welfare using a different utility function than the one maximised by private agents. Pirttilä and Tenhunen (2007) derive rules for optimal income taxation and public provision of private goods in a framework where private agents' and the government's valuations for certain goods differ. Optimal taxes (and subsidies) in the presence of merit goods (that is, goods whose consumption the government wants to encourage) has also been analysed by Besley (1988), Racionero (2001) and Schroyen (2005). Krusell, Kuruscu and Smith (2000; 2002) discuss optimal government policy in a setting where consumers and the government share the same time-inconsistent preferences, and have no commitment

¹For addictive goods, consumption today not only causes harm tomorrow, but also increases the marginal benefit of future consumption. Throughout this thesis, we abstract from the implications of addictiveness of certain harmful goods, and concentrate instead on the consequences of harm caused by consumption.

power. Bernheim and Rangel (2005) and Kanbur, Pirttilä and Tuomala (2006) provide reviews of the nascent² literature on behavioural public economics³. For more general overviews of issues in behavioural economics, see Camerer, Loewenstein and Rabin (2004) and Rabin (2002).

We extend the literature on the taxation of harmful goods in the presence of self-control problems in three main ways. In the first essay, we leave the question of optimal sin taxes aside, and analyse the factors that affect their incidence. Gruber and Köszegi (2004) analyse a similar question in the context of addictive goods. By restricting attention to the simpler case of goods that are harmful but not addictive, we can consider more general utility functions than those considered by Gruber and Köszegi (2004). We derive an incidence measure for sin taxes, as well as a condition for the case where sin taxes improve individual welfare.

Secondly, we examine how sin taxes are determined in political equilibrium, and compare the equilibrium sin tax with the socially optimal level. The previous literature has focused on optimal taxes, and therefore our analysis of equilibrium sin taxes is an important extension to the literature. We also extend the previous literature by providing an explicit formula for the optimal sin tax in a second-best situation where consumers differ in their degree of self-control problems but a uniform sin tax is applied, and by comparing the optimal sin tax with the marginal distortion in consumption.

Thirdly, we extend the analysis of sin taxes to an international context. More specifically, we examine a country whose government attempts to use taxation to reduce the consumption of a harmful good, and analyse the extent to which cross-border shopping and tax competition undermine the feasibility of this type of taxation. We also analyse whether policy coordination in the form of minimum tax rates or tax harmonisation can improve welfare.

The practical implications of our findings can be summarised as follows. Firstly, considering tax incidence, we show that taxes on goods such as unhealthy food may be progressive. This is contrary to the common counter-argument against heavy VAT rates on necessities, which are usually regarded as regressive. The intuition for this result is that the self-control benefits of taxation depend importantly on the demand elasticity, and demand is typically more elastic for low income individuals. Therefore, when one

²Kanbur, Pirttilä and Tuomala (2006) make the point that even though the literature on behavioural public economics is new, it can be seen as a special case of non-welfarist welfare economics, where the outcomes of individual behaviour are evaluated using a preference function different from the one that generated the outcomes. See Seade (1980) for a seminal contribution to this strand of literature.

³See also McCaffery and Slemrod (2006).

considers for example lowering the VAT rate on food for redistributive reasons, it is important to note that in such exercises it is likely not to be optimal to treat all types of food equally.

Secondly, we show that when consumers differ in their degree of self-control problems, equilibrium tax rates on harmful goods are likely to be too low from a social point of view. The intuition is that taxation has a large benefit for consumers with a severe self-control problem, and only a small negative impact on consumers with no self-control problems (whose consumption of highly harmful substances is low even in the absence of taxation - taxes therefore only impose a small distortion for these individuals). Individuals do not take this asymmetry into account in their voting decisions, and equilibrium taxation therefore cannot achieve the socially optimal outcome. There may thus be a case for quantity restrictions on some highly harmful substances.

Thirdly, turning to the implications of international tax competition, we show that such competition should not lead governments to disregard paternalistic objectives of taxation completely: taxation can still be used to lower harmful consumption. The intuition is that even if higher taxes at home lead consumers to buy harmful goods such as alcohol abroad, the increase in cross-border shopping is *smaller* than the corresponding reduction in domestic consumption. Regarding policy coordination, we show that countries should aim at implementing minimum tax rates on harmful goods, rather than at harmonising tax rates at some intermediate level between the original tax rates. This is because the problems associated with tax competition (both from the point of view of reducing harm from consumption and raising revenue) are caused by tax rates being too low, not by tax rate differentials *per se*.

In the following subsections we discuss evidence on self-control problems and on hyperbolic discounting, which is the specific model of self-control problems used in this thesis. We then briefly discuss alternative economic models of self-control problems. Finally, we turn to a more general discussion of the economic debate on paternalism: that is, we discuss the circumstances under which the government may be justified in using economic policy to help boundedly rational individuals make better choices.

2.2 Self-control problems and hyperbolic discounting

The definition of self-control problems given in the previous subsection makes it clear that such problems are associated with a time-inconsistency in preferences. Under the traditional model of intertemporal choice used in economics, namely Samuelson's (1937) discounted utility model, such inconsistencies cannot arise. In this model, an

individual's intertemporal utility function is given by

$$U_t = (u_t, \dots, u_T) = u_t + \sum_{s=t+1}^T \delta^{s-t} u_s, \quad (1)$$

where $\delta \in (0, 1)$ and u_t is the periodic utility function. Discounting is exponential: consumption between any two periods is discounted by a constant factor of δ .

Frederick, Loewenstein and O'Donoghue (2002) provide a review of findings that contradict the traditional discounted utility model. In particular, there is plenty of evidence, primarily from experiments, that discount rates are decreasing over time (see for example Thaler (1981)). There is also extensive experimental evidence of preference reversals associated with time-inconsistent preferences (see for example Ainslie (1992)).

The phenomenon that discount rates fall over time has been referred to as "hyperbolic discounting" in the literature. In their review of the evidence on time discounting, Frederick, Loewenstein and O'Donoghue (2002, 360) claim that hyperbolic discounting is the best documented anomaly associated with the traditional discounted utility model. It was recognised already by Strotz (1955-6), that when discounting is not exponential as in the traditional model, this leads to time-inconsistent preferences, since the discount rate between two periods depends on the time when the consumption stream is evaluated.

The currently most widely adopted formalisation of hyperbolic discounting is the one introduced by Laibson (1997). In his model, the intertemporal utility function is given by

$$U_t = (u_t, \dots, u_T) = u_t + \beta \sum_{s=t+1}^T \delta^{s-t} u_s, \quad (2)$$

where $\beta \in (0, 1)$. This functional form captures the crucial feature of hyperbolic discounting, namely that the discount rate is decreasing over time: given (2), discounting is heavier between today and tomorrow ($\beta\delta$), than between any two periods that are both in the future (δ)⁴. The parameter β therefore measures the individual's tendency to pursue immediate gratification, or the "immediacy effect", emphasised for example by Prelec and Loewenstein (1991).

When discounting is hyperbolic, there is a present bias in preferences, and future costs and benefits are discounted too heavily from the point of view of maximising life-

⁴As noted by Laibson (1997), the discount function implied by (2) is not exactly hyperbolic. Hence the term "quasi-hyperbolic" discounting is often used when referring to Laibson's model. Krusell, Kuruscu and Smith (2000; 2002) point out that the mathematically correct term would be quasi-geometric. Phelps and Pollak (1968) used this functional form to model intergenerational time preferences.

time utility. Because of such excessive discounting, individuals consume too much of goods with immediate benefits and delayed costs, and too little of goods with immediate costs and delayed benefits⁵, even from the point of view of maximising their own welfare. We concentrate on the former types of goods, and in particular on the prominent example of goods with negative health effects, such as alcohol, tobacco and unhealthy food. Akerlof (1991) provides an insightful discussion of over-consumption of harmful goods as a form of procrastination, that is, the tendency to delay unpleasant tasks⁶.

In addition to the experimental evidence on hyperbolic discounting, mentioned above, there is empirical evidence from consumption, savings and borrowing data, that supports the (β, δ) -model over the exponential discounted utility model (see for example Angeletos *et al.* (2001) and Laibson, Repetto and Tobacman (2005)). For example, the benchmark estimates in Laibson, Repetto and Tobacman (2005) imply a short-term annualised discount rate that is approximately 10-times as high as the long-term annualised discount rate, and the restriction to a constant discount rate is rejected in all the specifications they use.

Turning to evidence specifically related to the consumption of harmful goods, Cutler, Glaeser and Shapiro (2003) discuss obesity and dieting as evidence of self-control problems in the consumption of (unhealthy) food. Gruber and Köszegi (2001) discuss evidence showing that preferences with respect to smoking are time-inconsistent. Firstly, a large proportion of smokers express the desire to quit, but fail to do so. Secondly, voluntary use of commitment devices that make smoking a more costly alternative, is evidence of individuals trying to mitigate the unwanted consequences of self-control problems. There is also plenty of similar evidence relating to alcohol consumption - see for example the discussion and references in Bernheim and Rangel (2005, 39).

Further, Gruber and Mullainathan (2005) use survey data on subjective well-being to show that smokers in Canada and the United States have been made better off by higher cigarette taxation. Such an effect cannot occur if individuals have standard, time-consistent preferences. These results therefore provide further evidence that smokers suffer from self-control problems.

Before turning to a more general discussion of possible government involvement in an economy where individuals use hyperbolic discounting, two important issues need to

⁵These two types of goods have been called *leisure goods* and *investment goods* by DellaVigna and Malmendier (2004), respectively.

⁶For other analyses of procrastination, see for example O'Donoghue and Rabin (1999; 2001). See Ariely and Wertenbroch (2002) for experimental evidence on procrastination and the associated demand for deadlines.

be discussed. Firstly, it is important to comment on the question of whether hyperbolic individuals behave rationally. Secondly, since hyperbolic individuals make inconsistent decisions, we need to consider what the appropriate welfare criterion is in this context.

There is some disagreement in the literature about the first question. Frederick, Loewenstein and O'Donoghue (2002, 365) argue that it is doubtful whether any of the discounted utility anomalies that they examine should be regarded as mistakes. Similarly, Krusell, Kuruscu and Smith (2002) view sophisticated, hyperbolic consumers as being fully rational, as they are aware of their self-control problem and attempt to minimise its effects⁷. On the other hand, in their discussion of behavioural public finance, McCaffery and Slemrod (2006) define rationality as individuals acting consistently on the basis of a well-defined utility function⁸. It is clear, however, that hyperbolic consumers fail to behave in a consistent manner.

Further, and perhaps more importantly, individuals with hyperbolic discounting fail to maximise their own life-time utility - this point is vividly illustrated for example by the example of procrastinating agents given in Akerlof (1991)⁹. Also the evidence on unrealised attempts to quit using a harmful substance and on the use of costly commitment devices, cited above, shows that hyperbolic individuals themselves consider their behaviour as erroneous. We would therefore like to argue for the interpretation that the consumption decisions of hyperbolic consumers can be considered to be irrational, and adopt this terminology in this thesis. Similar terminology is used for example by O'Donoghue and Rabin (2006).

Let us next turn to the important and related question of how to choose the appropriate welfare criterion in a situation where individuals make inconsistent decisions, as in the case of hyperbolic discounting. The standard choice in the literature has been to take the consumers' long-run preferences ($\beta = 1$) as those relevant for welfare evaluation. If hyperbolic discounting can be viewed as an error in decision-making, as we argue above, then the justification for this choice is in our view clear. Such a justifica-

⁷The distinction between naives and sophisticates, that is time-inconsistent individuals who either are or are not aware of their self-control problem, dates back to Strotz (1955-6) and Pollak (1968). O'Donoghue and Rabin (2001) introduce a model of partial naivete, where individuals are aware of their self-control problem but underestimate its magnitude.

⁸As pointed out by McCaffery and Slemrod (2006), a similar definition of rationality can be found for example in Becker (1962), who claimed that economists had more or less reached a consensus on such a definition.

⁹The individual considered by Akerlof (1991) does not anticipate having a self-control problem in the future. Sophistication can alleviate the implications of self-control problems, but not always so: for example Camerer and Loewenstein (2004, 24) argue that sophistication can in some cases *excacerbate* yielding to temptation. In the models that we use, the consumption decisions of naives and sophisticates coincide (in the absence of commitment).

tion has been used for example by O’Donoghue and Rabin (2003; 2006). This issue has been discussed in more detail by Gruber and Köszegi (2004), who argue for the use of the long-run perspective as the appropriate welfare criterion on the following grounds. Firstly, the agent’s long-run preferences are the welfare measure that would be used by a sophisticated individual if he were to vote for a tax change to be implemented from the next period onwards¹⁰. Secondly, if we think about the individual as a sequence of distinct selves whose preferences are in conflict, the long-run preferences are the ones that apply to all the selves except for the present one¹¹. In a similar vein, Bernheim and Rangel (2005, 9) argue that since the consumer judges trade-offs between period t and $t + 1$ by exactly the same criteria in all periods but one, the influence of any one self must decline to zero as the number of selves becomes large.

2.3 Other models of self-control problems

Before turning to a broader discussion about the justification of government involvement when individuals use hyperbolic discounting, we would like to briefly discuss two alternative models of self-control problems that have been used in the economics literature. Prominent alternative models of self-control problems are the model of cue-triggered decision processes by Bernheim and Rangel (2004) and the temptation utility model of Gul and Pesendorfer (2001).¹² Below, we discuss these alternative models and their implications for public policy, and contrast these with the lessons drawn from the hyperbolic discounting model.

Bernheim and Rangel (2004) model consumers as being in one of two states, either the cold or the hot state. When in the cold state, individuals behave as rational, utility-maximising agents and make optimal decisions. In the hot state, however, individual decision processes are not functioning properly¹³: individuals simply follow an urge to consume, and their consumption decisions are not determined by any type of optimising behaviour. The individual switches between the two states according to a random process. However, the likelihood of entering the hot state is increased if the individual

¹⁰Indeed, this result plays a key role in our comparison of optimal and equilibrium taxes in the second essay of this thesis: even though the welfare criteria used by the social planner and the consumer-voter coincide, the socially optimal and equilibrium tax rates are generally unequal when consumers are heterogenous.

¹¹Such a multiple selves terminology is often used in the literature (see for example Schelling (1984)). The future harm from consumption not fully taken into account in decision-making can then be seen as a within-person externality, or "internality" (see for example Herrnstein *et al.* (1993)).

¹²See Loewenstein (1996) and Laibson (2001) for models related to the Bernheim and Rangel model. For further discussion on the Gul and Pesendorfer model see Gul and Pesendorfer (2004).

¹³Hence the theory has also been called a decision-process malfunction theory of consumption.

encounters an appropriate cue from the surrounding environment. The likelihood of encountering a cue, on the other hand, increases in past consumption of the good in question. While in the cold state, individuals try to avoid such cues.

Gul and Pesendorfer (2001), on the other hand, follow a very different approach, where they model self-control by extending the traditional preference domain considered in the theory of consumer choice: they assume that individual utility is not only affected by an outcome actually chosen, but also by disutility experienced when a most tempting option is not chosen. The disutility arises as individuals need to exercise costly self-control in order to choose something other than the most tempting alternative. Their model, therefore, is non-standard in that preferences are defined over both final allocations and choice sets: removing an alternative that is not chosen from an individual's choice set can improve welfare, as the individual then avoids the disutility associated with temptation. In this model, however, there are no mistakes, and behaviour is always time-consistent. Gul and Pesendorfer (2007) extend this analysis to the case where the good associated with temptation is addictive.

The policy implications of the Bernheim and Rangel (2004) model as well as the Gul and Pesendorfer (2001; 2007) model are rather different from the model with hyperbolic discounting: in neither of these models can taxation be used to alleviate the negative consequences of self-control problems. In the case of Bernheim and Rangel, this is because over-consumption is a result of visceral factors not subject to any economic logic, and is therefore not affected by taxation. In the case of Gul and Pesendorfer, on the other hand, the problem of over-consumption in fact does not occur: individuals do not make mistakes and hence there is no scope for corrective taxation.¹⁴

We have chosen to model consumption decisions on harmful goods by using the hyperbolic discounting model for the following reasons. Firstly and most importantly, as was explained in the previous section, the evidence on hyperbolic discounting is extensive. If we believe in the evidence that individuals often discount the future excessively, over-consumption of harmful goods follows as a direct implication of individual time preferences.

Secondly, as we mentioned above, in the model of Bernheim and Rangel (2004) or Gul and Pesendorfer (2001; 2007), there is no role for corrective taxation. An important feature of Bernheim and Rangel's (2004) argument is that taxation only affects individuals in the cold state (that is, when individuals make rational decisions), and

¹⁴The only reason for corrective taxation in the Gul and Pesendorfer (2001) model would be the traditional case of negative consumption externalities. In the context of Bernheim and Rangel (2004), taxation can be used to correct externalities to the extent that they are caused by consumption in the cold state. If externalities are solely caused by compulsive consumption, taxation is again powerless.

can therefore only be distortive. However, regarding alcohol consumption, for instance, 70% of Europeans are classified as moderate or low-risk drinkers, but moderate drinking is defined as up to twice the level of consumption that is regarded as not interfering with a healthy lifestyle (Cnossen 2006, 12). Such "moderate" drinking is in our view unlikely to be the result of the kind of compulsive, cue-triggered behaviour depicted by Bernheim and Rangel (2004). Further, there is recent empirical evidence that abusive drinking is very price elastic (Farrell, Manning and Finch 2003). The empirical evidence of Gruber and Mullainathan (2005) also suggests that smokers can be made better off by higher taxes.

Turning to the model of Gul and Pesendorfer (2001; 2007), O'Donoghue and Rabin (2006) note that the conclusion that taxes cannot improve welfare depends crucially on the assumption that temptation disutility should be given full normative weight. If it is given anything less than full weight, the model will feature over-consumption, and taxation will improve welfare. Further, as Gruber and Köszegi (2004) point out, Gul and Pesendorfer assume that temptation is equally strong for all possible prices (as long as the consumer can afford to buy the good). Temptation can therefore only be reduced by somehow completely removing the good from the individual's choice set (for example through an outright ban). If this assumption was relaxed, positive taxes would again improve welfare.

To be fair, there is also evidence, for example of cue-triggered recidivism, that supports the Bernheim and Rangel (2004) model as a model of consumption of certain addictive substances - see the evidence cited in their paper. We therefore believe that rather than being substitutes, the different models can complement each other: they can highlight different aspects of consumer behaviour regarding harmful goods, and the best model depends on the good in question. For the types of goods that we consider - unhealthy food, cigarettes and alcohol - we believe that the kind of complete short-circuiting of rational decision-making modelled by Bernheim and Rangel (2004) is probably not the main feature characterising consumption decisions, and the hyperbolic discounting model may be more appropriate. For a treatment that attempts to build a unified framework that encompasses aspects of all the three models discussed, see Loewenstein and O'Donoghue (2005).

2.4 The concept of paternalism

It has been argued that time-inconsistency has negative welfare effects only if consumers are naive (DellaVigna and Malmendier 2004), that is, if they are not aware of

their self-control problem. However, this finding rests on the assumption that private markets can provide effective self-control devices for sophisticated time-inconsistent individuals. As has been argued by Köszegi (2005), however, market solutions to self-control problems are unlikely to be effective: even though both consumers and firms would have the incentive, *ex ante*, to sign contracts that implement the optimal level of consumption, in a competitive market consumers cannot be prevented from purchasing from other firms *ex post*. In a competitive market, therefore, consumption of harmful goods is as if only a spot market was available (that is, suboptimally high).

There may thus be scope for government intervention to help individuals overcome the harm caused by self-control problems. Such interventions are an example of paternalism, as the aim is to help individuals to make choices that make them better off. Traditionally, most economists have been very sceptical about paternalism, and many still remain so despite the evidence from behavioural economics and psychology that individuals do make choices that are not in their best interests¹⁵. In this section, we review arguments put forward by economists both for and against paternalistic policies.

Thaler and Sunstein (2003) provide a strong defence of paternalism¹⁶, claiming that there are no viable alternatives: they emphasise that public actors are in many cases forced to make decisions that affect some other people, and in such cases the paternalistic objective of choosing options that make affected individuals better off is the only reasonable mandate.

Thaler and Sunstein (2003) further stress that paternalism does not need to involve any form of coercion. They conduct much of their discussion in the context of choosing default options - an example of an inevitable choice to be made - for example in the case of savings programmes. O'Donoghue and Rabin (2006) take a similar idea a step further, arguing that sin taxes are no more a limit on choices than are any more traditional forms of taxation.

However, one must admit that unlike choosing default options, sin taxes *do* restrict choices through limiting individual budget sets. This is beneficial in so far as some options that would be chosen by boundedly rational individuals against their own self-interest are thereby ruled out. Nevertheless, it is likely that not all individuals are equally irrational and do not suffer from self-control problems to the same extent. The focus in recent discussion of paternalism in the economics literature has therefore been on how to design policies that help those who are irrational, while avoiding unnecessary

¹⁵This is not only true of anomalies related to time discounting, but there is ample evidence of mistakes regarding other types of decision-making as well - see for example Kahneman and Tversky (2000).

¹⁶See also Sunstein and Thaler (2003) for a longer discussion.

restrictions on the behaviour of rational individuals¹⁷. This requirement for paternalistic policies has been stressed for example by Camerer *et al.* (2003) and O’Donoghue and Rabin (1999).

Against this background it is clear why O’Donoghue and Rabin (2006) emphasise the question whether positive sin taxes can achieve Pareto improvements over zero sin taxes. However, they also stress that instead of solely focussing on minimal interventions, economists should study optimal paternalism. The essays in this thesis are an example of such an approach: we derive a formula for the second-best optimal sin tax in a situation where individuals differ in their degree of self-control problems. In doing so, we highlight the trade-off between benefits to highly irrational individuals, and costs to close to rational individuals, and find the optimal balance between the two. We show that sin taxes indeed have the desirable property that the benefits on highly irrational individuals are likely to outweigh the costs on rational individuals, and show how this should be reflected in optimal tax rates.¹⁸ Our analysis of sin taxes in an international context has a similar flavour: in that context, sin taxes induce another distortion, namely an increase in inefficient cross-border shopping, and we show how this additional distortion should be taken into account in optimal policy.

Needless to say, many economists remain sceptical about paternalism. For example, Glaeser (2006) makes the argument that when making decisions that affect private individuals, the individuals themselves have stronger incentives to make good decisions than government officials. Therefore, when we acknowledge that bounded rationality concerns government officials as well as private individuals, the presence of bounded rationality makes paternalism *less* attractive. However, contrary to Glaeser’s assumption, O’Donoghue and Rabin (2001) show that there are circumstances under which increasing stakes can in fact make errors in decision making (in their context greater procrastination) more likely. Further, in their review of 74 experiments analysing the effect of financial incentives on performance, Camerer and Hogarth (1999) show that increasing performance-based incentives typically does not improve rationality.

Much of the discussion on sin taxes and other paternalistic policies rests on the assumption that government policies can provide better commitment devices than pri-

¹⁷Diamond (1973) conducts a similar analysis in the context of externalities - how to design optimal taxes on externality generating goods, when individuals give rise to different levels of the externality, but a uniform tax has to be applied.

¹⁸Choi *et al.* (2003) discuss the distinct but related problem of choosing the optimal paternalistic policy when individuals suffer from the same degree of irrationality, but have different tastes - also in this case a uniform paternalistic policy will involve distortions for some individuals. However, this problem is no stronger in this case than when choosing traditional economic policies when agents are heterogeneous.

vate markets. Krusell, Kuruscu and Smith (2000; 2002) examine the welfare effect of government interventions when public officials have the same, time-inconsistent preferences as private individuals, and the government further lacks the ability to commit to policies. In such a context it is not surprising that government policies cannot improve welfare; to the contrary, Krusell, Kuruscu and Smith (2000; 2002) show that government intervention can in this case make sophisticated, time-inconsistent individuals worse off. Very roughly, the intuition is that an individual gets the full benefits of better commitment, whereas a government agent who has the perspective of the entire economy, perceives diseconomies of scale in commitment¹⁹.

The truth of the matter is bound to lie somewhere between the two polar cases: it is unlikely that government agents are fully rational or have full commitment power. However, in our view there is a strong case to be made for our assumption that governments have better commitment-ability than private individuals, as the preference reversals associated with self-control problems take place over very short time spans. For example, in their analysis of cigarette taxation, Gruber and Köszegi (2004) take the relevant period length to be one month. If one thinks of an individual attempting to quit smoking, casual observations suggest that preference reversals are likely to occur even more frequently than this, and hence the relevant period length when analysing the power of commitment devices may be even shorter. Whereas consumption decisions in private markets can be made almost instantaneously, implementing changes to tax laws take much longer (in modern democracies more likely years than months), and therefore it seems clear that such government policies can provide a more effective commitment device than private markets.

Relatedly, many economists may worry that if individuals do not know what is best for them²⁰, how can government agents know any better? Interestingly, Sheshinski (2003) has shown that even when individuals know more about themselves than it is possible for governments to know, it may be socially optimal to limit and sometimes even to eliminate choice if individuals are boundedly rational. See also Mirrlees (1987) for similar results.

Finally, some economists for example in the public choice tradition will object to paternalism on the grounds that it opens up new possibilities for the abuse of political and bureaucratic power: if consumer choices are no more viewed as sovereign for example in the realm of harmful goods, will this open up the possibility of politicians

¹⁹For details of this intuitive argument in the case of savings, see Krusell, Kuruscu and Smith (2002, 44-5).

²⁰Note, however, that in the case of self-control problems, this is not the case; individuals do know what the best course of action would be, but simply fail to act accordingly.

and bureaucrats imposing their preferences on private individuals in other domains of life? Relatedly, Glaeser (2006) argues that in cases where it is in the interests of firms to exploit human errors, it is easier for them to persuade a bureaucrat than a large number of consumers. In response to criticisms of this type, Sunstein and Thaler (2003) turn to their argument that paternalism is inevitable, stating that "We happily grant that planners are human, and thus are both boundedly rational and subject to the influence of objectionable pressures. Nevertheless, as we have stressed, these human planners are sometimes forced to make choices, and it is surely better to have them trying to improve people's welfare rather than the opposite." (Sunstein and Thaler, 2003, 1200). On the other hand, *if* a paternalistic mandate entails fewer constraints on the actions of bureaucrats, this may be harmful if bureaucrats are simply not interested in taking actions that are in line with the paternalistic ideal. Bernheim and Rangel (2005, 15), however, argue that it is possible to insist on high standards of proof, based on scientific evidence, whenever divergent positive and normative models are applied in designing public policy.

3 Introduction to part 2: Access price regulation, investment and entry in telecommunications

3.1 Background

The second part of this thesis analyses a more traditional rationale for government intervention in the economy, namely distortions caused by market power. More specifically, we analyse the issue of introducing competition into the market for local telecommunications services, when the telecommunications network remains a monopoly.

Introducing competition into local telecommunications has been an important goal of industrial policy in many European countries since the 1980s. Despite liberalisation, the market share of the incumbent telecommunications operator was at the end of the 1990s above 80% in all European countries and in most of them well above 90%. The question of determining the correct price at which one telecommunications operator can use the infrastructure of another, that is the access price, is a central issue in the attempt to make the liberalised telecommunications markets truly competitive. The principles of network access pricing in a static context have indeed been the subject of extensive research, which has been surveyed in Laffont and Tirole (2000) and Armstrong (2002). However, the important question of how access price regulation affects

firms' incentives for investment has so far received much less attention in the literature.

We contribute to the literature on access price regulation by considering an incumbent network operator's incentives to make investments that improve the quality of its network, when it has to sell access to rival service providers. The paper closest to ours is the paper by Foros (2004), who examines an access provider's incentives to upgrade its network to broadband when it also acts as an internet service provider and faces a single competitor in the retail market. Our study differs from Foros's paper in two main respects: we assume a different form of competition in the market for telecommunications services, and a different type of product differentiation between the incumbent and the rivals. Also our results differ in important ways: Foros (2004) emphasises that in the presence of access price regulation, the incumbent can use overinvestment (relative to the monopoly level) to deter entry when the incumbent's ability to offer value added services is much higher than that of the rival. However, we show that the incumbent underinvests (relative to the socially optimal level) and when the rivals are relatively efficient in turning the investment into value added services, suboptimal investments can lead to foreclosure.

3.2 Access pricing and investment incentives

There are a number of other previous studies on the effects of access price regulation on firms' incentives to invest in network infrastructure. These papers can be broadly divided into three complementary strands, according to assumptions made about the characteristics of the infrastructure – whether it is an existing monopoly, whether it has monopoly characteristics but involves a new service that requires completely new infrastructure to be built, or whether it is provided by competing firms.

Firstly, some authors have assumed, like we do in the present study, that the infrastructure under consideration is already in place and it is operated by a monopoly. The assumption of a monopoly network can be justified by the current situation in many countries. Further, in a recent study by Faulhaber and Hogendorn (2000), it was found that the provision of access to broadband telecommunications networks is likely to remain a naturally monopolistic activity at least in less densely populated areas. This assumption is particularly relevant when we consider for example certain common broadband solutions (such as DSL) that have been implemented through upgrading the existing local telecommunications network, which is in many countries operated by a monopolist (or several local monopolies). A central issue in this setting and the main question analysed also in our study, is to consider the incumbent's incentives to up-

grade the existing network. Buehler, Scmutzler and Benz (2004) examine the effects of several different institutional settings on a network owner's investment incentives, but they do not consider the case of an integrated network owner competing with an independent downstream rival. Sidak and Spulber (1997) emphasise the significance of the regulator's commitment problem in a dynamic setting. The issue of commitment is central also in our study. Pindyck (2004), Jorde, Sidak and Teece (2000) and Hausman and Sidak (1999) analyse the effects of the access pricing rule currently used in the US, namely total element long-run incremental cost (TELRIC) pricing, on the incumbent's investment incentives. These papers also consider the effect of access price regulation on the investment incentives of potential entrants, who face the decision of whether to build their own network or lease network elements from the incumbent. An important conclusion in this regard is that even though access price regulation at TELRIC rates guarantees access to the incumbent's infrastructure at favourable terms and therefore encourages entry, it also lowers entrants' incentives to invest in a competing network and therefore biases entrants toward renting the existing infrastructure and away from building their own network. (Pindyck 2004, 11).

For the sake of simplicity, we will not consider entrants' investment incentives in this study. However, it should be noted that to the extent that access price regulation has a negative effect also on rival firms' incentives to invest in infrastructure, this strengthens our conclusions: access price regulation may lead to an underinvestment problem that may have undesirable consequences for the long run development of the industry.

Secondly, it is important to consider firms' incentives to invest in new types of services that may have natural monopoly characteristics, but are not necessarily related to the existing telecommunications network (e.g. certain new broadband technologies have this feature). Such a situation has been considered by Gans (2001), who analyses a model where different firms compete to become the access provider for new types of network services. He shows that in the presence of this kind of a race, a socially optimal level of investment can in fact be reached. Implementing the social optimum would, however, require using a non-linear access price. In the present study we assume that linear access prices are used, which is the current practice in the telecommunications sector in many countries.

Thirdly, when network services are provided by a number of operators in a given geographical area, the investment incentives of competing network operators should be analysed. Such a situation is relevant for example in Britain, where cable TV companies have in many areas become effective competitors of the incumbent local

telecommunications networks. The case of competing networks has been studied by Valletti and Cambini (2005), who extend the model of network interconnection developed by Laffont, Rey and Tirole (1998) and Armstrong (1998) to consider network operators' incentives to invest in facilities with different levels of quality. They show that when network operators compete for directly connected customers, low access prices encourage investment. The reason is the following: when access prices are high, operators are more reluctant to take actions that increase the volume of calls made by their customers and therefore lead to a rise in access payments that have to be made when calls terminate on the rivals' network. This conclusion is in contrast to the result in the present study, where low access prices reduce a network monopolist's incentives to invest in its infrastructure.

3.3 Technology spillovers and investment incentives

An important issue in our study is to examine the effect of investment spillovers on the incentives to undertake network investments. Numerous authors have considered the question of how investment spillovers affect private incentives to perform R&D. These studies date back to Arrow (1962) and the issue has later been examined among others by Spence (1984), D'Aspremont and Jacquemin (1988) and Kamien, Muller and Zang (1992). Investment incentives in an oligopoly with vertical product differentiation have been examined by Motta (1992) and Rosenkranz (1995).

However, the case studied in our essay differs from the models discussed above due to the vertical relationship between the incumbent and its rivals, that is, the fact that the incumbent acts as a supplier of an intermediate good to its rivals: even if the incumbent's and the rival firms' final services are substitutes, higher demand for the rivals' services will not necessarily be detrimental to the incumbent, as it will also cause an increase in the rivals' demand for access. Spillovers are in the present context therefore not necessarily detrimental to investment incentives and the precise effect of access provision on the investment level depends, of course, crucially on the access pricing regime.

3.4 Foreclosure

We also examine the conditions under which the incumbent chooses an access price or an investment level that causes the rivals to exit the market and our study is therefore related to the literature on foreclosure. A recent contribution in this field is Rey and Tirole (2003), which considers a bottleneck owner's incentives for foreclosure in the

absence of regulation. Other articles particularly relevant from the point of view of our study include Weisman (1995; 1998; 2001), Reiffen (1998) and Beard, Kaserman and Mayo (2001), which examine incentives to reduce the quality of the input sold to downstream rivals when there is price competition downstream.

A major difference between our model and these analyses is that in the papers cited above, discrimination takes the form of activities that raise rivals' marginal costs. The bottleneck owner then has two possible instruments of discrimination, excessive access pricing and input quality degradation, that both affect the rival in the same way (increase marginal cost) but the former has a direct positive effect on the incumbent's profit while the latter may be costly for the incumbent (as for example in Weisman (1995)). Therefore it is not surprising that the incentives for quality degradation are shown to be especially strong under stringent access price regulation (see for example Beard, Kaserman and Mayo (2001)). Reiffen, Schumann and Ward (2000) further find some empirical evidence of discrimination against independent rival operators by regulated, vertically integrated local exchange carriers in the US cellular industry. In our model, investment affects the incumbent as well as the rivals, and therefore cannot be used as an instrument of discrimination that could be targeted at the rivals only. Baake, Kamecke and Normann (2004) also analyse the relationship between foreclosure and underinvestment, even though their focus is rather different from ours. They show that if vertical integration and therefore foreclosure of rival downstream firms is not possible, underinvestment in capital can be used as an alternative tool to restrict output.

4 Summary of the essays

4.1 Essay 1: The incidence of sin taxes

In the first essay of this thesis, we analyse the incidence of taxes on goods whose current consumption causes utility costs (for example negative health effects) in the future. When consumers have time-inconsistent preferences, they consume too much of such goods. Therefore, in addition to the monetary cost of taxation, taxes on harmful goods affect individual utility due to the corrective nature of the tax when preferences are time-inconsistent. In order to take this positive effect into account, traditional incidence measures need to be modified. Gruber and Köszegi (2004) have suggested the use of such a utility based incidence measure in the case of taxes on addictive goods such as cigarettes. Because of the complexity of the problem analyzed in their paper,

Gruber and Köszegi (2004) are restricted to consider a particular form of the periodic utility function (quadratic utility). By concentrating on the simpler case of goods that are harmful but not addictive, we can consider more general utility functions. We are also able to derive an explicit condition for the case where sin taxes improve an individual's welfare.

Contrary to traditional incidence analysis, the burden of sin taxes does not necessarily fall most heavily on individuals with the highest level of consumption: when consumption is high, the tax does imply a higher monetary cost, but also a higher utility benefit from self-control. It may even be the case that those with the highest level of consumption are hurt least by (or benefit the most from) the tax. Further, we show that the welfare effect of sin taxes depends importantly on the elasticity of demand, as well as on the extent of self-control problems and the marginal harm caused by consumption. To the extent that individuals with low income have more elastic demand than individuals with higher income, it is possible that taxes on goods such as unhealthy food are progressive, in the sense that their overall utility cost (benefit) is lowest (highest) for poor individuals. This is contrary to the common counter-argument against heavy VAT rates on necessities, which are usually regarded as regressive.

4.2 Essay 2: The political economy of sin taxes

The purpose of the second essay, which is joint work with Markus Haavio, is two-fold. Firstly, we contribute to the discussion on optimal sin taxes by deriving an explicit rule for the optimal tax in a second-best setting where individuals differ in their degree of self-control problems. Secondly, we examine how sin taxes are determined in political equilibrium, a question that has to our knowledge not yet been analysed in the literature.

Many economists have been concerned that sin taxes as well as other paternalistic policies that are aimed at helping irrational individuals are often detrimental for the welfare of rational individuals. This has resulted in an emphasis on the search for policies that help irrational individuals while having only a small or no impact on those who are rational²¹. However, there has recently been an interest in moving beyond studying minimal interventions, to studying optimal paternalism. Our analysis is particularly closely related in this respect to O'Donoghue and Rabin (2006).

When individuals differ in their degree of self-control problems but a uniform sin tax is applied, we are necessarily in a second-best situation. We analyse the trade-off

²¹See for example Camerer *et al.* (2003), Thaler and Sunstein (2003), as well as O'Donoghue and Rabin (2006) and the references therein.

between benefits to irrational individuals and costs to rational individuals further, and find the optimal balance between the two considerations: we provide an explicit formula for the second-best optimal sin tax and show that it exceeds the mean distortion in consumption. The reason is right at the heart of the recent discussion on paternalism: we show that under mild assumptions, sin taxes have a relatively small (negative) effect on the utility of (close to) rational individuals, who consume relatively little of the good. On the other hand, irrational consumers with a very high level of consumption gain a lot from sin taxes.

We then turn to analyse the majority voting equilibrium when individuals differ in their degree of self-control problems. As a benchmark, we consider the case where tax revenue is distributed back to consumers in such a way that the redistributive effects of taxation are eliminated. In this setting individuals prefer the level of taxes that completely eliminates the distortion in their own consumption, and the political equilibrium is the tax rate that corresponds to the median level of self-control problems. We show that equilibrium taxes are in most cases below the socially optimal level. The reason is that the asymmetric effect of sin taxes at different ends of the distribution of self-control problems is not taken into account by the median voter. However, in this setting where sin taxes have no redistributive effects, there is one particular case where the equilibrium and the social optimum coincide: this is when consumption is so harmful that the optimal level of consumption is zero even in the absence of taxation. In this case, it is in the interests of both the consumers and the social planner to eliminate all consumption.

We then proceed to analyse the case where the redistributive effects of sin taxes are taken into account. This case is the one that is more relevant from a practical point of view, and also highlights some interesting new issues. On the one hand, an individual without self-control problems will prefer a low tax, as high taxation would cause an unnecessary distortion in consumption from his point of view. On the other hand, however, sin taxes will redistribute income from irrational large-scale consumers to rational consumers, a reason for consumers with no self-control problems to vote for a high tax.

Despite these counteracting motives that affect an individual's preferred tax rate, we show that a majority voting equilibrium exists in our model also in this case, and corresponds to the tax rate preferred by the individual with the median level of self-control problems. Importantly, we show that when redistributive effects of sin taxes are taken into account, the equilibrium tax rate is below the socially optimal level *regardless* of the level of harm from consumption. The redistributive motive for taxation therefore

implies that equilibrium taxes are below the social optimum even when consumption is extremely harmful: the median voter does not consume the good in equilibrium, and simply wants to maximise redistribution from irrational individuals towards himself. On the other hand, the social planner wants to completely eliminate consumption.

One of the aims of our analysis is to contribute to the policy discussion on the taxation of harmful goods. The view that emerges from previous empirical literature seems to be that for example excise duties on cigarettes are in most countries very high compared to the external costs of smoking (see for example Cnossen and Smart (2005)). However, our analysis provides a theoretical argument that suggests that such taxes may nevertheless be too low from a social point of view.

The analysis also suggests a reason for why it may be optimal to impose quantity restrictions on the consumption of certain highly harmful substances (such as illicit drugs), rather than using price instruments alone: if we were to rely solely on tax policy to regulate the consumption of such substances, the optimal outcome may not be reached.

4.3 Essay 3: Paternalism and tax competition

The third essay analyses the feasibility of implementing paternalistic taxation in the presence of cross-border shopping and commodity tax competition. As is well known from previous literature, commodity tax competition between neighbouring countries can have the negative effect of eroding a country's tax base, when consumers take advantage of the opportunity of making cheaper purchases abroad. When governments wish to pursue paternalistic policies, tax competition causes a further externality which has thus far not been analysed in the literature: the possibility of cross-border shopping may undermine a government's attempts to control harmful consumption by relatively high taxation at home.

We first consider a country whose government wishes to use taxation to reduce the consumption of a harmful good when consumers have an option to purchase the good more cheaply abroad. In this analysis we take the foreign price as exogenous. We show that the paternalistic component of the tax is reduced due to the possibility of cross-border shopping, but it does not disappear altogether. The intuition is that cross-border shopping causes taxes to be a less effective means for controlling harmful consumption, but not completely so: due to transportation costs, the increase in purchases made abroad caused by a domestic tax increase is smaller than the corresponding reduction in domestic purchases. Hence taxation can still be used to lower

total consumption, albeit to a lesser extent than in the absence of cross-border shopping.

In addition to analysing how cross-border shopping affects the optimal tax on a harmful good when foreign prices can be taken as exogenous, we examine the implications of tax competition and international policy coordination. Building on the model of Haufler (1996), we characterise the equilibrium with tax competition, and examine whether policy coordination can be beneficial in this setting.

We show that the welfare effects of tax harmonisation would be negative on the low-tax country and ambiguous on the high-tax country. However, the prospects for welfare gains from a minimum tax rate requirement seem more promising. We show that in a model with quadratic transport costs²², the paternalistic country would benefit from a small increase in the other country's tax rate. The low-tax country would also benefit, if the harm function from consumption is not too convex.

Further, we find that a stronger paternalistic objective makes it more likely that the policy of a minimum tax rate requirement is Pareto improving: firstly, the paternalistic country is then more likely to benefit from the reduction in consumption caused by a higher foreign tax rate; and secondly, the paternalistic country is then more likely to respond to the minimum tax rate requirement by increasing its tax rate in turn, which is beneficial for the low-tax country as it alleviates the negative externality caused by tax competition.

Our analysis therefore indicates that even countries with very different attitudes towards paternalism can benefit from policy coordination. The divergent views about alcohol taxation held for example by different member states of the EU should therefore not be an obstacle to policy coordination aimed at eliminating harmful tax competition.

4.4 Essay 4: Access price regulation, investment and entry in telecommunications

We analyse the effect of access price regulation on a network provider's incentives to invest in its infrastructure. These infrastructure investments are assumed to increase customers' willingness to pay for final telecommunications services. We consider a vertically integrated incumbent who provides network access to rival operators in the retail sector. The network is assumed to have natural monopoly characteristics and it is therefore an essential input in the production of telecommunications services.

We examine the incumbent's investment decision both when there is no regulation

²²This is a standard assumption in previous literature on cross-border shopping.

and when the access price is regulated. We assume that the access charge is the only instrument available for the regulator. Further, we assume that the regulator is unable to make a credible commitment to a particular access pricing regime prior to the incumbent's investment decision, as the investment that we consider is irreversible and has an effect over a long period of time.

We model the rival firms in the retail sector as a competitive fringe. The assumption of price taking rivals in the retail market seems justifiable, as we assume that fixed costs in the retail market are negligible. The competitive fringe model has been used extensively also in the literature on optimal access pricing in a static context (see for example Armstrong (2002, Section 2)). Further, we assume that there is vertical differentiation between the incumbent and the fringe. Vertical differentiation can arise for example due to switching costs that customers incur when they choose to subscribe to one of the fringe firms instead of the incumbent, or due to any other type of incumbency advantage or goodwill. This assumption together with the assumption that rivals are small makes the model suitable for analysing the effect of the incumbent's investment decision on entry.

The main issues of interest that arise in our study are two-fold. Firstly, we examine the effect of spillovers to rivals' demand on the incumbent's incentives for investment. Secondly, we draw conclusions on cases in which the incumbent takes actions to foreclose the rivals from the market. In particular, we are interested in the interaction between these two issues: on the one hand, the presence of rivals has an effect on investment incentives, and on the other hand, the incumbent's investment decision has consequences for the viability of competition.

We find that even though rivals benefit from the incumbent's investment efforts, this is not in itself detrimental for investment incentives: when the incumbent is free to choose the access charge, the level of investment is increasing in the degree of spillovers to rivals' demand. However, access price regulation has a negative effect on investment incentives: the level of investment is in our model always lower with access price regulation than without it. Further, when the access price is regulated, spillovers that benefit rivals have an unambiguously negative effect on investment incentives. If the rivals are more efficient in utilising the investment than is the incumbent, this disincentive effect is so strong that no investment will take place.

We also show that the incumbent's optimal investment level is below the social optimum, regardless of whether access charges are regulated or not. We emphasise three reasons for why this underinvestment problem deserves attention from regulators. Firstly, like any other market distortion, insufficient investments imply losses to social

welfare. Secondly, when spillovers are high and the rivals would therefore benefit considerably from the investment, the underinvestment problem will also have adverse effects on the viability of competition. In some cases the investment level can be so low that the rivals are foreclosed from the market completely. Thirdly, in the case of access price regulation, the underinvestment problem is most likely to lead to the exclusion of competitors precisely when they would bring the highest benefits for consumers.

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Essay 1.

The Incidence of Sin Taxes*

Kaisa Kotakorpi

Abstract

We show that the burden of sin taxes does not necessarily fall most heavily on individuals with the highest level of consumption and derive a condition for cases where sin taxes improve individual welfare. We further argue that taxes on goods such as unhealthy food can be progressive when consumers have time-inconsistent preferences.

Keywords: tax incidence, self-control

JEL: H22, H30, I18

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1 Introduction

We analyze the incidence of taxes on goods whose current consumption causes utility costs (for example negative health effects) in the future. When consumers have time-inconsistent preferences, they consume too much of such goods. Using “sin taxes” to correct distortions in the consumption of harmful goods has also been considered in O’Donoghue and Rabin (2003; 2006).

In addition to the monetary cost of taxation, sin taxes affect individual utility due to the corrective nature of the tax when preferences are time-inconsistent. In order to take this positive effect into account, traditional incidence measures need to be modified. Gruber and Köszegi (2004) have suggested the use of such a utility based incidence measure in the case of taxes on addictive goods such as cigarettes¹. Because of the complexity of the problem analyzed in their paper, Gruber and Köszegi (2004) are restricted to consider a particular form of the periodic utility function (quadratic utility). By restricting attention to the simpler case of goods that are harmful but not addictive, we can consider more general utility functions. We are also able to derive an explicit condition for the case where sin taxes improve an individual’s welfare.

Contrary to traditional incidence analysis, the burden of sin taxes does not necessarily fall most heavily on individuals with the highest level of consumption: when consumption is high, the tax does imply a higher monetary cost, but also a higher utility benefit from self-control. It may even be the case that those with the highest level of consumption are hurt least by (or benefit the most from) the tax. Further, we show that the welfare effect of sin taxes depends importantly on the elasticity of demand, as well as on the extent of self-control problems and the marginal harm caused by consumption. To the extent that individuals with low income have more elastic demand than individuals with higher income, it is possible that taxes on goods such as unhealthy food are progressive, in the sense that their overall utility cost (benefit) is lowest (highest) for poor individuals. This is contrary to the common counter-argument against heavy VAT rates on necessities, which are usually regarded as regressive.

¹For addictive goods, consumption today not only causes harm tomorrow, but also increases the marginal benefit of future consumption.

2 Quasi-hyperbolic discounting and over-consumption of harmful goods

We consider a model where consumers use quasi-hyperbolic discounting (Laibson 1997), using a set-up that is similar to O'Donoghue and Rabin (2003, 2006). Lifetime utility of an individual is given by

$$U_t = (u_t, \dots, u_T) = u_t + \beta \sum_{s=t+1}^T \delta^{s-t} u_s, \quad (1)$$

where $\beta, \delta \in (0, 1)$ and u_t is the periodic utility function. Individuals derive utility from a composite good (z), which can be interpreted as leisure, and another good (x) which is harmful in the sense that it yields positive utility in the short-run, but has some negative effects in the long-run. Specifically, we assume that periodic utility is given by

$$u_t(x_t, x_{t-1}, z_t) = v(x_t) - h(x_{t-1}) + \alpha z_t \quad (2)$$

where α is the marginal utility of income. The function v is increasing and concave. The harm function h is increasing and it can in principle be either concave or convex, as long as $v'' - h'' < 0$. In our view the most likely case is the one where $h'' \geq 0$.

We assume that there is no borrowing or lending. In each period, consumers then maximize $u_t = v(x_t) - \beta\delta h(x_t) + \alpha z_t$ subject to a per-period budget constraint $qx_t + z_t \leq 1$, where we have normalized the wage and the consumers' fixed time endowment to 1, and q denotes the consumer price of good x . The demand for good x therefore satisfies² $v'(x^*) - \beta\delta h'(x^*) - \alpha q = 0$.

On the other hand, the levels of consumption that would maximize lifetime utility are those that maximize $\bar{u}_t = v(x_t) - \delta h(x_t) + \alpha z_t$. The optimal level of consumption therefore satisfies $v'(\bar{x}^*) - \delta h'(\bar{x}^*) - \alpha q = 0$: because of quasi-hyperbolic discounting ($\beta < 1$), the equilibrium level of consumption of the harmful good (x^*) is higher than the level that would maximize long-run welfare of the individual himself (\bar{x}^*).

3 Incidence of sin taxes

As market-based mechanisms for correcting the distortion caused by time-inconsistent preferences are likely to be ineffective (see Köszegi (2005)), the government can con-

²We have dropped the time index t , since with our specification consumption is constant across periods.

sider imposing a tax on the consumption of the harmful good. To the extent that laws on commodity taxation cannot be changed each period, this will provide an effective commitment-device for consumers. Optimal sin taxes have been analyzed in O'Donoghue and Rabin (2003, 2006).

We do not analyze the question of optimal sin taxes here, but simply examine the factors affecting their incidence. As in Gruber and Köszegi (2004), we measure incidence by the overall impact of the tax on individual utility. We assume that the tax comes into effect starting from the period after the decision to impose the tax is made. Therefore, each consumer evaluates the effect of the tax according to his long-run utility function (but taking into account that consumption decisions will be taken to maximize utility each period and will therefore be distorted, as above). The effect of a price (or tax) increase on a consumer's welfare (measured per period) is therefore given by

$$\frac{d\bar{u}(x^*)}{dq} = \frac{\partial \bar{u}(x^*)}{\partial q} + \frac{\partial \bar{u}(x^*)}{\partial x^*} \frac{\partial x^*}{\partial q}. \quad (3)$$

For time-consistent consumers, $x^* = \bar{x}^*$ and the effect of the tax on utility is given by Roy's identity, $\frac{d\bar{u}(\bar{x}^*)}{dq} = \frac{\partial \bar{u}(x^*)}{\partial q} = -\alpha x^*$. However, to obtain a correct incidence measure for the case where $x^* > \bar{x}^*$, we need to consider the second term, $\frac{\partial \bar{u}(x^*)}{\partial x^*} \frac{\partial x^*}{\partial q}$. This term is zero for time-consistent consumers but positive for time-inconsistent consumers, reflecting the fact that the price increase helps such consumers to overcome a distortion in consumption.

In order to analyze tax incidence in more detail, we note that the derivative in (3) is given by

$$\frac{d\bar{u}(x^*)}{dq} = -\alpha x^* + (v'(x^*) - \delta h'(x^*) - \alpha q) \frac{\partial x^*}{\partial q}. \quad (4)$$

Denoting the elasticity of demand for the harmful good by $\varepsilon = \frac{\partial x^*}{\partial q} \frac{q}{x^*}$, the welfare effect of a tax increase can be written as

$$\frac{d\bar{u}(x^*)}{dq} = -\alpha x^* \left[1 - |\varepsilon| \frac{(1 - \beta) \delta h'(x^*)}{\alpha q} \right]. \quad (5)$$

Our main results follow from equation (5), which shows that the traditional incidence measure is in our context multiplied by the term $1 - |\varepsilon| \frac{(1 - \beta) \delta h'(x^*)}{\alpha q}$. Therefore, if there are no self-control problems ($\beta = 1$) we obtain the traditional incidence measure. On the other hand, when $\beta < 1$, the tax has both monetary costs ($-\alpha x^*$) and self-control benefits ($x^* |\varepsilon| \frac{(1 - \beta) \delta h'(x^*)}{q}$).

In traditional incidence analysis, the burden of taxation always falls most heavily on individuals with the highest level of consumption. A key point to note here, however, is that not only the monetary costs, but also the self-control benefits of taxation are in many cases monotonically increasing in the quantity consumed. This is always the case for example when the harm function is the same for all individuals³, $h''(x^*) \geq 0$ and the elasticity of demand is constant or increasing in x .

Further, if self-control benefits increase more rapidly than the monetary costs, the burden of taxation falls *least* heavily on those with the highest level of consumption. This is more likely to happen if self-control problems are extensive (β is low), consumption causes a lot of harm (h' is high), demand is highly elastic or when future utility is discounted relatively little (δ is high). In these cases, there is more to be gained from better self-control.

For some parameter values, it is possible that the gain from enhanced self-control exceeds the monetary loss from the tax⁴. This is in stark contrast to traditional incidence analysis, where tax incidence is always negative. Rearranging (5) and using the individual's first order condition, a price increase leads to an increase in a consumer's welfare if

$$|\varepsilon| > \frac{v'(x^*) - \beta\delta h'(x^*)}{(1 - \beta)\delta h'(x^*)} \quad (6)$$

As discussed above, sin taxes can improve welfare only if demand for the harmful good is elastic enough (that is, if (6) is satisfied) - only when demand is responsive enough to price changes will taxation be an effective self-control device. We can consider two simple special cases. When harm is proportional to initial enjoyment from consumption, that is if $h(x) = \gamma v(x)$, where $\gamma \in (0, 1)$, (6) simplifies to $|\varepsilon| > \frac{1 - \beta\delta\gamma}{(1 - \beta)\delta\gamma}$. The right hand side of this inequality is greater than 1 and therefore $|\varepsilon| > 1$ is a necessary (though not always a sufficient) condition for the tax to be welfare-improving in this special case. However, in the more realistic case where harm is proportional to consumption rather than initial enjoyment ($h(x) = \gamma x$), condition (6) becomes $|\varepsilon| > \frac{v'(x^*) - \beta\delta\gamma}{(1 - \beta)\delta\gamma}$. $|\varepsilon| > 1$ is then no longer necessary for the tax to be beneficial for welfare.

The above analysis has interesting implications for the discussion on whether taxes on goods such as unhealthy food are regressive. By regressivity, we mean that the overall utility cost (benefit) of a tax, as measured by equation (3), is higher (lower) for

³Differences in consumption levels between individuals are then caused by factors such as differences in the function $v(x)$ or in β , and not by differences in the harm function. This seems to be a plausible approximation when we take $h(x)$ to be negative health effects caused by consumption.

⁴See Gruber and Mullainathan (2005) for empirical evidence that higher cigarette taxation can make smokers happier.

the poor than for the rich. We showed above that in the context of sin taxes, it is no longer necessarily the case that individuals with the highest level of consumption bear most of the tax burden. Therefore, in the present context, the traditional argument that high taxes on necessities must be regressive because they occupy a higher proportion of the budget of the poor simply has no bite.

Further, to the extent that demand is more elastic for the poor, the burden of sin taxes falls *less* heavily on the poor than on the rich.⁵ It can further be noted that the observation that food is a necessity and therefore has a low income elasticity, in no way precludes the possibility that the price elasticity may be high enough for (6) to be satisfied. In particular, if we concentrate on the example of unhealthy food, this has a natural and a very close substitute - namely healthy food - and therefore demand can be expected to be rather elastic, and such substitution will only reinforce the beneficial effects of the tax⁶. Further, the fact that the poor spend a larger share of their budget on food only tends to make the price elasticity higher for them, as implied by the Slutsky equation. Individuals with a low income may therefore be hurt less by - or benefit more from - sin taxes than the rich.

4 Conclusion

We have examined how traditional incidence measures have to be adapted in the case of sin taxes. In particular, we have emphasized that sin taxes do not necessarily fall most heavily on individuals with the highest level of consumption, since such individuals have the most to gain from the corrective nature of the tax.

Further, we have shown that the welfare effects of sin taxes depend importantly on the elasticity of demand for the harmful good. We can therefore conclude that to the extent that individuals with low income have more elastic demand than individuals with higher income, it is possible that sin taxes are in fact progressive. It is interesting to contrast this finding with a remark made by James Mirrlees, who has stated that "it is not inevitable that taxes distort the economy, but if they are fair, then they almost

⁵If β and/or δ vary across population groups, this has an effect on incidence. In their analysis of cigarette taxation, Gruber and Köszegi (2004) argue that the effect on incidence of varying δ is relatively small, whereas there is no evidence on how β varies in the population. The exact magnitude of the different effects in our context is a matter for empirical study, and is beyond the scope of this note.

⁶This is in contrast to the example of cigarettes, where substitution is at least in part likely to be towards untaxed bads such as drugs, which serves to partially undermine the positive health effects of taxation.

certainly do" (Mirrlees 2000, 2). If we make the usual interpretation that taxation that hurts low income individuals the most is "unfair", sin taxes are in fact a case of taxes that can be *both* fair and reduce distortions.

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Essay 2.

The Political Economy of Sin Taxes*

Markus Haavio Kaisa Kotakorpi

Abstract

We analyse the determination of taxes on harmful goods when consumers have self-control problems. We show that under mild conditions, the socially optimal tax rate exceeds the average distortion caused by self-control problems. Further, we show that in most cases the tax rate chosen in political equilibrium is below the socially optimal level.

Keywords: excise taxation, voting, self-control

JEL: H21, H30, D72

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1 Introduction

We analyse the determination of taxes on goods whose current consumption causes utility costs (for example negative health effects) in the future. When consumers have time-inconsistent preferences, they consume too much of such goods. Using “sin taxes” to correct distortions in the consumption of harmful goods when consumers have self-control problems has also been considered in O’Donoghue and Rabin (2003; 2006).

Market-based mechanisms for correcting the distortion caused by self-control problems are likely to be ineffective (see Köszegi (2005)), and consumers might thus value sin taxes as a commitment device. In addition to the monetary cost of taxation, sin taxes affect individual utility due to the corrective nature of the tax when preferences are time-inconsistent. If this positive effect outweighs the monetary cost, sin taxes can improve individual welfare - see Gruber and Köszegi (2004) and Kotakorpi (2006) for theoretical analyses and Gruber and Mullainathan (2005) for empirical evidence.

The purpose of the current paper is two-fold. Firstly, we contribute to the discussion on optimal sin taxes by deriving an explicit rule for the optimal tax in a second-best setting where individuals differ in their degree of self-control problems. Secondly, we examine how sin taxes are determined in political equilibrium, a question that has to our knowledge not yet been analysed in the literature.

Many economists have been concerned that sin taxes as well as other paternalistic policies that are aimed at helping irrational individuals¹ are often detrimental for the welfare of rational individuals.² This has resulted in an emphasis on the search for policies that help irrational individuals while having only a small or no impact on those who are rational.³ However, there has recently been an interest in moving beyond studying minimal interventions, to studying optimal paternalistic policies. Our analysis is particularly closely related in this respect to O’Donoghue and Rabin (2006).⁴

¹Throughout the paper, we refer to individuals with a self-control problem as irrational, as they behave in an inconsistent manner and make consumption decisions that fail to maximise their own life-time utility. Similar terminology has been used for example by O’Donoghue and Rabin (2006).

²Beyond this concern, some economists remain sceptical about paternalism for more general reasons - see for example Glaeser (2006) for a critical view. For example, the possibility of government failure may reduce the effectiveness and desirability of paternalistic policies. Despite the importance of this consideration, we abstract from this issue in the current paper. On the other hand, we show that in our model consumers would themselves vote for paternalistic policies: such policies can therefore be the outcome of a democratic decision making process, which has interesting implications for the justification of paternalism.

³See for example Camerer *et al* (2003), Thaler and Sunstein (2003) and O’Donoghue and Rabin (1999).

⁴O’Donoghue and Rabin (2006) examine the conditions under which the optimal sin tax is positive, and whether sin taxes can yield Pareto improvements (compared to zero taxes). They further provide comparative statics of the optimal sin tax when there are changes in the distribution of self-control

When individuals differ in their degree of self-control problems but a uniform sin tax is applied, we are necessarily in a second-best situation. We analyse the trade-off between benefits to irrational individuals and costs to rational individuals further, and find the optimal balance between them: we provide an explicit formula for the second-best optimal sin tax and show that it exceeds the mean distortion in consumption. The reason is right at the heart of the recent discussion on paternalism: for reasonable assumptions about the form of the demand function, sin taxes have a relatively small (negative) effect on the utility of (close to) rational individuals, who consume relatively little of the good. On the other hand, irrational consumers with a very high level of consumption gain a lot from sin taxes.

We then turn to analyse the majority voting equilibrium when individuals differ in their degree of self-control problems. We assume that individuals are fully aware of their self-control problem, and vote on the sin tax to be implemented from the next period onwards. Taxation can then provide a commitment device that helps individuals move their consumption closer to its optimal level.

As a benchmark, we consider the case where tax revenue is distributed back to consumers in such a way that the redistributive effects of taxation are eliminated. In this setting individuals prefer the level of taxes that completely eliminates the distortion in their own consumption, and the political equilibrium is the tax rate that corresponds to the median level of self-control problems. We show that equilibrium taxes are in most cases below the socially optimal level. The reason is that the asymmetric effect of sin taxes at different ends of the distribution of self-control problems is not taken into account by the median voter. However, in this setting where sin taxes have no redistributive effects, there is one particular case where the equilibrium and the social optimum coincide: this is when consumption is so harmful that the optimal level of consumption is zero even in the absence of taxation. In this case, it is in the interests of both the consumers and the social planner to eliminate all consumption.

We then proceed to analyse the case where the redistributive effects of sin taxes are taken into account. This case is the one that is more relevant from a practical point of view, and also highlights some interesting new issues. On the one hand, an individual without self-control problems will prefer a low tax, as high taxation would cause an unnecessary distortion in consumption from his point of view. On the other hand, however, sin taxes will redistribute income from irrational large-scale consumers to rational consumers, a reason for consumers with no self-control problems to vote for a high tax.

problems and tastes.

Despite these counteracting motives that affect an individual's preferred tax rate, we show that a majority voting equilibrium exists in our model also in this case, and corresponds to the tax rate preferred by the individual with the median level of self-control problems. Importantly, we show that when redistributive effects of sin taxes are taken into account, the equilibrium tax rate is below the socially optimal level *regardless* of the level of harm from consumption. The redistributive motive for taxation implies that equilibrium taxes are below the social optimum even when consumption is extremely harmful: the median voter does not consume the good in equilibrium, and simply wants to maximise redistribution from irrational individuals towards himself. On the other hand, the social planner wants to completely eliminate consumption. It is worth emphasising that our results regarding extremely harmful consumption goods are very robust to different functional form assumptions and do not depend on the distribution of self-control problems.

One of the aims of our analysis is to contribute to the policy discussion on the taxation of harmful goods. In European countries, tobacco products are taxed much more heavily than alcohol: the excise duty on the most popular brand of tobacco was on average approximately 60 % of the total retail price in the EU-15 member states in 2003 (Cnossen and Smart 2005), whereas the corresponding figure was 19 % for beer, 14 % for wine and 39 % for spirits (WHO 2004).⁵ It might appear that cigarette taxes are too high from a social point of view, particularly as cigarette taxes in most countries seem to exceed the external costs of smoking (Cnossen and Smart 2005)⁶. However, considering not only negative externalities, but also harm experienced but not taken into account by the consumer himself, optimal taxes should indeed exceed the level that would be appropriate if only externalities were taken into account. As our analysis shows, the redistributive motive for taxation implies that equilibrium taxes on highly harmful goods such as cigarettes may be too low from a social point of view.⁷

In addition to the previous literature on taxation when consumers have self-control problems, our analysis has some similarities with the analysis of commodity taxation in the presence of externalities: negative health effects (in the case of consumers

⁵The figures for alcoholic drinks were calculated using data for 9 countries only, as the figures for the rest of the EU-15 were not reported (see WHO 2004, 54). The average total tax collections in the EU-15 member states were approximately 100 euros per adult in the case of alcohol, and around 280 euros per capita in the case of tobacco (see for example Cnossen (2006a) and (2006b)).

⁶In the case of alcohol, on the other hand, taxes appear to be lower than the level that would be mandated even by externality considerations alone (Cnossen 2006a)

⁷The relatively low prevalence of smoking suggests that cigarettes fit our category of highly harmful substances (where most people abstain from consumption): smoking prevalence is around 20-30% in most EU countries, whereas only around 15% of adult Europeans abstain from alcohol consumption (Anderson and Baumberg 2006, European Commission 2004).

with self-control problems) as well as negative externalities are both harmful effects not taken into account by consumers, and governments might wish to alleviate these effects through taxation. Diamond (1973) has analysed optimal taxation of externality-generating goods when individuals give rise to different (marginal) externalities.⁸ In the case of externalities, however, there is no natural assumption to make about how the magnitude of the marginal externality should be correlated with individual demand. In our context, on the other hand, a high marginal internality is naturally associated with high consumption, since consumers with a more severe self-control problem have a higher level of consumption, *ceteris paribus*. This correlation is the mechanism that drives many of the key results in this paper.

The rest of the paper proceeds as follows. We introduce the model in Section 2 and derive the second-best optimal sin tax in Section 3. The political equilibrium is analysed in Section 4, where we first study the benchmark case where sin taxes have no redistributive effects, and then extend the analysis to account also for the redistributive effects of sin taxes. Section 5 shows that our main conclusions extend to the case where sin taxes are also used for revenue raising purposes. Section 6 concludes.

2 The model

We consider a model where consumers have a quasi-hyperbolic discount function (Laibson 1997), using a set-up that is similar to O'Donoghue and Rabin (2003; 2006). Lifetime utility of an individual is given by

$$U_t = (u_t, \dots, u_T) = u_t + \beta_i \sum_{s=t+1}^T \delta^{s-t} u_s, \quad (1)$$

where $\beta_i, \delta \in (0, 1)$ and u_t is the periodic utility function. Individuals are therefore assumed to be identical in all other respects, but they differ in their degree of quasi-hyperbolic discounting. We assume that the quasi-hyperbolic discount factor β has a distribution function $F(\beta)$ with mean $E(\beta)$ and median β_{med} . Throughout the paper we consider the general case where β has the support $[\beta_L, \beta_H]$, with $0 \leq \beta_L < \beta_H \leq 1$. Quasi-hyperbolic discounting implies that preferences are time-inconsistent: discounting is heavier between today and tomorrow, than any two periods that are both in the future.

⁸See Eerola and Huhtala (2007) for a recent contribution to the literature on the political economy aspects of environmental policy.

We assume that individuals derive utility from a composite good (z), which is taken as the numeraire, and another good (x) which is harmful in the sense that it yields positive utility in the short-run, but has some negative effects in the long-run. Specifically, we assume that periodic utility is given by

$$u_t(x_t, x_{t-1}, z_t) = v(x_t) - h(x_{t-1}) + z_t, \quad (2)$$

where $v' > 0$, $v'' < 0$ and the harm function⁹ is characterised by $h' > 0$ and $h'' \geq 0$.

We assume that there is no borrowing or lending. In each period, consumers then choose x to maximize¹⁰ $u(x) = v(x) - \beta_i \delta h(x) + z$ subject to a per-period budget constraint $qx + z \leq B + S$. We assume that product markets are competitive and normalise the producer price to 1, and $q = 1 + \tau$ denotes the consumer price of good x . B is the consumer's income (taken to be exogenous) and S is a possible lump-sum subsidy received by the consumer from the government. Taxes and subsidies will be modelled in more detail in later sections. Given the above specification, the demand for good x satisfies

$$v'(x^*) - \beta_i \delta h'(x^*) = q. \quad (3)$$

However, the time-inconsistency in preferences implies that the consumer would like to change his behaviour in the future: from the next period onwards, the consumer would like to choose consumption levels that maximise¹¹ $u^o(x) = v(x) - \delta h(x) + z$. We take this long-run perspective as the one relevant for welfare evaluation - this has become a standard choice in the literature on sin taxes (see for example Gruber and Köszegi (2004), O'Donoghue and Rabin (2003; 2006)). There are clear reasons that justify this choice of welfare criterion: Firstly, we assume that taxes are implemented from the period after the policy decision is made. Therefore, consumers themselves agree that $u^o(x)$ is the relevant utility function, and voting decisions will be made based on maximising this function. We thus use the same criterion consistently when

⁹As in O'Donoghue and Rabin (2006), we assume that the marginal benefits and marginal costs of consumption are independent of past consumption levels. In such a setting, it is not essential that the harm is modelled as occurring only in the period following consumption - h can be thought of as the discounted sum of harm occurring in all future periods. See Gruber and Köszegi (2004) for an analysis where past consumption affects current marginal utility.

¹⁰We have dropped the time index t , since with our specification consumption is constant across periods.

¹¹See equation (1) and think of a consumer in period t , making consumption decisions for period $t + 1$ onwards.

deriving both the optimum and the equilibrium level of taxes. Further, $u^o(x)$ is the utility function that applies to all periods except for the present one. Since we consider an infinite number of periods, the weight of any single period should be negligible as long as periods are sufficiently short¹². This latter consideration applies irrespective of the timing of the model.

The optimal level of consumption therefore satisfies $v'(x^o) - \delta h'(x^o) = q$: because of quasi-hyperbolic discounting ($\beta < 1$), the equilibrium level of consumption of the harmful good (x^*) is higher than the optimal level (x^o).

3 The second-best optimal sin tax

We argued above that long-run utility is the appropriate welfare criterion in our model. The social welfare function is then given by $W(q) \equiv \int_{\beta_l}^{\beta_H} G(V(q; \beta)) f(\beta) d\beta$, where $V(q; \beta)$ is the long-run indirect utility function. We assume that the function $G(\cdot)$ is utilitarian, and the social welfare function therefore becomes

$$\begin{aligned} W(q) &= \int_{\beta_l}^{\beta_H} V(q; \beta) f(\beta) d\beta = E_\beta [V(q; \beta)] \\ &= E_\beta [v(x^*(q; \beta)) - \delta h(x^*(q; \beta)) - qx^*(q; \beta) + S(q, \beta)] + B, \end{aligned}$$

where x^* satisfies (3) and is therefore distorted whenever $\beta < 1$, as argued above. Taking into account the government's budget constraint $\tau E_\beta [x^*(q; \beta)] = E_\beta [S(q, \beta)]$, the social welfare function can be written as

$$W(q) = E_\beta [V(q; \beta)] = E_\beta [v(x^*(q; \beta)) - \delta h(x^*(q; \beta)) - x^*(q; \beta)] + B.$$

Given the distortion in consumption caused by quasi-hyperbolic discounting, the government may consider imposing a sin tax on harmful goods as a corrective measure. The social planner's first-order condition is

$$\begin{aligned} E_\beta \left[\frac{\partial V(q; \beta)}{\partial q} \right] &= E_\beta \left[[v'(x^*(q; \beta)) - \delta h'(x^*(q; \beta)) - 1] \frac{\partial x^*(q; \beta)}{\partial q} \right] \\ &= E_\beta \left[[\tau - (1 - \beta) \delta h'(x^*(q; \beta))] \frac{dx^*(q; \beta)}{dq} \right] = 0, \end{aligned} \tag{4}$$

where the last step was obtained by using (3).

As we consider a case where a uniform tax is applied, choosing the optimal tax involves a trade-off between helping consumers with a severe self-control problem, whilst causing a distortion for those who are rational. From (4), the second-best optimal tax

¹²See also Bernheim and Rangel (2007, 4) for a discussion on this point.

is given by

$$\tau^o = \delta E_\beta [(1 - \beta)h'(x^*(q; \beta))] + \frac{\delta Cov_\beta \left[(1 - \beta)h'(x^*(q; \beta)), \frac{\partial x^*(q; \beta)}{\partial q} \right]}{E_\beta \left[\frac{\partial x^*(q; \beta)}{\partial q} \right]}. \quad (5)$$

It should be noted that the socially optimal tax rate is independent of the way in which tax revenue is distributed back to consumers, that is, of the form of the function $S(\tau, \beta)$. Therefore, in both of the cases considered below - that is, regardless of whether sin taxes have redistributive effects or not - the socially optimal tax rate is given by (5).

In order to get clearer results in the current and the next section, we make the following assumption about the functional forms of $v(x)$ and $h(x)$:

Assumption 1 (i) $v'''(x) \geq 0$ and (ii) $-2 \leq \frac{h'''(x)h'(x)}{[h''(x)]^2} \leq 1$.

Assumption 1 is satisfied for commonly used functional forms, for example when v is of the CRRA or CARA-variety¹³ or quadratic, and when the harm function is linear¹⁴, quadratic, exponential or $h(x) = x^s$ where $s \geq 4/3$.

We can now proceed to analyse the socially optimal tax rate in (5). The first term, $\delta E[(1 - \beta)h'(x^*)]$, is the average distortion caused by self-control problems in the economy. It can be shown that the second term in (5) is positive given Assumption 1. We can therefore state the following proposition:

Proposition 1 *The socially optimal sin tax is higher than the average distortion caused by self-control problems, that is, $\tau^o > \delta E_\beta [(1 - \beta)h'(x^*(q; \beta))]$.*

Proof. See the appendix. ■

It is shown in the appendix that a sufficient condition for Proposition 1 is that $\frac{\partial^2 x^*(q; \beta)}{\partial q \partial \beta} > 0$, which holds given Assumption 1. The condition $\frac{\partial^2 x^*(q; \beta)}{\partial q \partial \beta} > 0$ has a very intuitive explanation: it implies that taxation has a larger impact on irrational consumers with a very high level of consumption ($\beta \approx 0$) than on rational consumers with a moderate level of consumption ($\beta \approx 1$). The benefit of a high sin tax for consumers with a severe self-control problem thus exceeds the (negative) impact on

¹³Kimball (1990) provides an economic interpretation of the condition $v''' > 0$, albeit from a context that is rather different from ours: $v''' > 0$ is associated with the concept of prudence, and implies that precautionary savings of risk averse individuals increase with increased uncertainty.

¹⁴Note that when the harm function is linear, part (i) of Assumption 1 has to hold as a strict inequality.

the utility of (close to) rational individuals, and the socially optimal sin tax therefore exceeds the average distortion.

4 Political equilibrium

From the point of view of the consumer, the problem is that he would like to consume less in the future, but repeatedly fails to do so due to self-control problems. We assume throughout the analysis that consumers are sophisticated - that is, they are completely aware of their self-control problem¹⁵. However, market-based mechanisms for correcting the distortion caused by time-inconsistent preferences are likely to be ineffective (see Köszegi (2005)): even though both consumers and firms would have the incentive, *ex ante*, to sign contracts that implement the optimal level of consumption, in a competitive market consumers cannot be prevented from purchasing from other firms *ex post*. Consumption of harmful goods is therefore as if only a spot market was available (that is, suboptimally high). To the extent that laws on commodity taxation cannot be changed each period, sophisticated consumers might thus value sin taxes as a way of committing to a lower level of consumption in the future.

In this section we analyse the level of taxes that will emerge in a political equilibrium and compare the equilibrium tax rate with the social optimum. In each case considered below, we assume that consumers vote over a sin tax to be implemented in all subsequent periods, starting from the period following the vote¹⁶. As the utility from all subsequent periods is discounted exponentially, the individual's policy preference function is given by his indirect long-run utility function, $V(q; \beta_i) = v(x^*(q; \beta_i)) - \delta h(x^*(q; \beta_i)) + z$: the individual's preferred tax rate will be the one that maximises his long-run utility, taking into account the fact that actual consumption decisions will be distorted in the absence of a sin tax.

¹⁵The concepts of sophistication and naivete (complete unawareness of ones' self-control problem), were discussed already by Strotz (1955-6) and Pollak (1968) and have been recently analysed in numerous papers - see for example O'Donoghue and Rabin (1999) for an analysis of the implications of both sophistication and naivete, and O'Donoghue and Rabin (2001) for a model that introduces a formalisation of the intermediate case of partial naivete. Since there are no intertemporal linkages in the marginal benefits and costs of consumption in our model, consumption decisions (in the absence of commitment) would be the same for naifs and sophisticates. However, voting decisions depend on whether the individual is aware of his self-control problem: (partially) naive individuals would vote for a lower tax than sophisticated individuals.

¹⁶If consumers were to vote on taxes only for *this* period, all consumers would vote for zero taxes; and if they were to vote on taxes to be implemented forever but *including* the current period, they would vote for a lower level of taxes than implied by the analysis below (the socially optimal level of taxes would also be lower; see Gruber and Köszegi (2004, 1967)) .

Finally, we assume that the outcome of the vote is determined by direct majority rule¹⁷.

4.1 Benchmark: sin taxes have no redistributive effects

Even though the social optimum is unaffected by the way in which tax revenue is distributed back to consumers, consumers clearly will not be indifferent about the subsidies that they receive. The shape of the function $S(\tau, \beta)$ thus has an effect on the political equilibrium. Consider first the case where the tax has no redistributive effects¹⁸, namely $S(\tau, \beta) = \tau x^*(q; \beta)$.¹⁹ The long-run indirect utility function of individual i and therefore the policy preference function of individual i is then given by

$$\begin{aligned} V(q; \beta_i) &= v(x^*(q; \beta_i)) - \delta h(x^*(q; \beta_i)) - (1 + \tau)x^*(q; \beta_i) + \tau x^*(q; \beta_i) + B \\ &= v(x^*(q; \beta_i)) - \delta h(x^*(q; \beta_i)) - x^*(q; \beta_i) + B. \end{aligned} \quad (6)$$

where x^* again satisfies (3).

4.1.1 The case of moderately harmful consumption

In the case where sin taxes have no redistributive effects, the comparison between the equilibrium and the social optimum turns out to depend on the extent of harm from consumption. Let us first analyse the political equilibrium in the case where current consumption causes harm in the future, but the optimal (rational) level of consumption is nevertheless positive at zero taxes, that is $v'(0) - \delta h'(0) - 1 > 0$. Using similar steps as in the previous section, the first-order condition is given by

$$\frac{\partial V(q; \beta)}{\partial q} = [\tau - (1 - \beta)\delta h'(x^*(q; \beta))] \frac{\partial x^*(q; \beta)}{\partial q} \quad (7)$$

and each individual's preferred tax rate is given by

¹⁷The same results hold if there is a representative democracy with two-party electoral competition, the parties can fully commit to a tax policy and care only about their chances of being elected (and do not have preferences over the level of taxes themselves) - this would be a simple case of Downsian electoral competition (Downs (1957); see also Persson and Tabellini (2000)).

¹⁸In the present setting, it would also be possible to set individual-specific taxes. However, this case would not be very interesting, as there would then be no interpersonal trade-offs to be settled. The case of individual-specific transfers is also rather unrealistic, but it is useful for illustrating some of the key mechanisms in this paper, and serves as a benchmark for the more realistic case where sin taxes have redistributive effects.

¹⁹It is important to note that $S(\tau, \beta)$ is a lump-sum payment, and the consumer cannot change the subsidy by deviating from x^* .

$$\tau^*(\beta) = (1 - \beta) \delta h'(x^*(q; \beta)). \quad (8)$$

The policy preference function (6) is single-peaked²⁰, and a majority voting equilibrium therefore exists and the tax rate preferred by the voter with the median most preferred level of taxes is chosen in equilibrium. Further, policy preferences are clearly monotonic in β : in the absence of redistribution, each individual prefers the tax rate that fully corrects the distortion in consumption. Since the distortion term $(1 - \beta) \delta h'(x^*(q; \beta))$ is decreasing in β , the individually preferred tax rate is monotonically increasing in the level of self-control problems. Given this monotonicity, the tax rate chosen in a majority voting equilibrium is given by

$$\tau^* = (1 - \beta_{med}) \delta h'(x^*(q; \beta_{med})). \quad (9)$$

We are now in a position to compare the tax rate chosen in political equilibrium, τ^* , to the socially optimal tax rate τ^o . Let us first examine a simple case, where the harm function is linear, namely $h(x) = gx$. In this case $\tau^* = \delta g(1 - \beta_{med})$. On the other hand, equation (5) implies that $\tau^o = \delta g(1 - E[\beta] + \kappa)$, where $\kappa \equiv Cov\left[(1 - \beta), \frac{\partial x^*(q; \beta)}{\partial q}\right] / E_\beta\left[\frac{\partial x^*(q; \beta)}{\partial q}\right] > 0$. Then clearly $\tau^* < \tau^o$, as long as $E[\beta] < \beta_{med} + \kappa$. That is, the equilibrium tax rate is lower than the socially optimal rate, as long as there are enough relatively rational individuals (when the distribution of β is not too much skewed to the right). In the appendix, we show that this result holds also for more general harm functions.

Proposition 2 *Assume that sin taxes have no redistributive effects and the optimal level of consumption at zero taxes is positive. If the distribution of β is not too much skewed to the right, the socially optimal tax rate is higher than the tax rate chosen in a majority voting equilibrium.*

Proof. See the appendix. ■

The reader may worry that since the tax formulae in (5) and (9) are given only in implicit form, the result in Proposition 2 might only be related to tax *rules*, and not to actual tax *levels*. Limitations of this type are very common in the optimal taxation literature (see for example Gaube (2005)). However, using a Taylor-approximation of (7), we have further shown in the appendix that $\frac{dW(q)}{dq} - \frac{\partial V(q; \beta_{med})}{\partial q} \geq 0$ for all q , and

²⁰ $\frac{d^2 V(q; \beta_i)}{dq^2} = [v''(x^*) - \delta \gamma h''(x^*)] \left(\frac{dx^*}{dq}\right)^2 - [v'(x^*) - \delta \gamma h'(x^*) - 1] \frac{d^2 x^*}{dq^2} < 0$.

therefore the result that $\tau^o > \tau^*$ is robust to this objection.²¹ This conclusion holds as long as the approximation used in the proof can be considered to be valid. Given that we are in the current subsection concerned with goods that are moderately harmful (and tax rates should therefore not be very high), the approximation is likely to be fairly innocuous.

The case of a symmetric distribution of β is worth emphasising - in this case, intuition might suggest that the equilibrium and the socially optimal tax rates should coincide, but we have shown that the result $\tau^o > \tau^*$ nevertheless holds: there is a kind of bias in voting behaviour that tends to make the equilibrium tax rate too low.

In order to further clarify the intuition behind the result stated in Proposition 2, let us examine a specific example where there are three individuals with $\beta_1 = 0$, $\beta_2 = \frac{1}{2}$ and $\beta_3 = 1$. Then $\beta_{med} = E[\beta] = \frac{1}{2}$. The tax rate chosen in political equilibrium, τ^* now equals the tax rate preferred by individual 2. The tax rate τ^* is socially optimal if and only if

$$\frac{dW(q^*)}{dq} \equiv \frac{\partial V(q^*; \beta_1)}{\partial q} + \frac{\partial V(q^*; \beta_2)}{\partial q} + \frac{\partial V(q^*; \beta_3)}{\partial q} = 0$$

Because $\frac{\partial V(q^*; \beta_2)}{\partial q} = 0$, this condition can be written as

$$\frac{\partial V(q^*; \beta_1)}{\partial q} = -\frac{\partial V(q^*; \beta_3)}{\partial q} \quad (10)$$

Typically, the condition (10) does not hold in equilibrium. As an example, assume that $v(x) = \frac{\varepsilon}{\varepsilon-1} x^{\frac{\varepsilon-1}{\varepsilon}}$ and $h(x) = gx$ and the demand function is therefore $x^*(q; \beta) = (q + \beta\delta)^{-\varepsilon}$. With these functional forms, the tax rate chosen in political equilibrium is given by

$$\frac{\partial V(q^*; \beta_2)}{\partial q} = 0 \Leftrightarrow \tau^* = (1 - \beta_2) \delta g = \frac{1}{2} \delta g.$$

²¹To show that $\frac{dW(q)}{dq} - \frac{\partial V(q; \beta_{med})}{\partial q} > 0$ implies $q^o > q^*$, denote $\Delta(q) \equiv \frac{dW(q)}{dq} - \frac{\partial V(q; \beta_{med})}{\partial q} > 0$ and $\tilde{\Delta} \equiv W(1) - V(1, \beta_{med})$. Now $W(q) = V(q, \beta_{med}) + \int_1^q \Delta(\hat{q}) d\hat{q} + \tilde{\Delta}$. The price level chosen in the political equilibrium is $q^* = \arg \max_q V(q, \beta_{med})$. Next we show that the socially optimal price level $q^o = \arg \max W(q) > q^*$. (i) Assume by contrast that $q^o = \tilde{q} < q^*$. Now $W(\tilde{q}) = W(q^*) - [V(q^*, \beta_{med}) - V(\tilde{q}, \beta_{med})] - \int_{\tilde{q}}^{q^*} \Delta(\hat{q}) d\hat{q} < W(q^*)$. Thus \tilde{q} cannot be optimal, a contradiction. (ii) $W'(q^*) = \frac{\partial V(q^*; \beta_{med})}{\partial q} + \Delta(q^*) > 0$, where the inequality follows since $\frac{\partial V(q^*; \beta_{med})}{\partial q} = 0$ and $\Delta(q^*) > 0$. Thus we can conclude that $q^o > q^*$. Notice that this proof applies even if $W(q)$ and $V(q)$ are multi-peaked.

We then have that

$$\begin{aligned}\frac{\partial V(q^*; \beta_1)}{\partial q} &= [\tau^* - (1 - \beta_1) \delta g] \frac{\partial x^*(q^*, \beta_1)}{\partial q} = \frac{1}{2} \delta g \varepsilon \left(1 + \frac{1}{2} \delta\right)^{-(\varepsilon+1)} > 0 \\ \frac{\partial V(q^*; \beta_3)}{\partial q} &= [\tau^* - (1 - \beta_3) \delta g] \frac{\partial x^*(q^*, \beta_3)}{\partial q} = -\frac{1}{2} \delta g \varepsilon \left(1 + \frac{3}{2} \delta\right)^{-(\varepsilon+1)} < 0\end{aligned}$$

For individual 1 with a very severe self-control problem, the best outcome would be to have $\tau_1^* = \delta g$; the preferred outcome of the fully rational individual 3 would be to have no taxes, $\tau_3^* = 0$. In other words, the equilibrium tax rate is too low from the point of view of consumer 1 and too high from the point of view of consumer 3. Further, the absolute value of the difference between the equilibrium tax rate and each individual's preferred tax rate is the same for both individuals 1 and 3:²²

$$|\tau^* - \tau_i^*| = |\tau^* - (1 - \beta_i) \delta g| = \frac{1}{2} \delta g \varepsilon, \quad i = 1, 3.$$

Nevertheless, we have that

$$\frac{\partial x^*(q^*, \beta_1)}{\partial q} = \left(1 + \frac{1}{2} \delta g\right)^{-(\varepsilon+1)} > \left(1 + \frac{3}{2} \delta g\right)^{-(\varepsilon+1)} = \frac{\partial x^*(q^*, \beta_3)}{\partial q}.$$

In other words, a change in the tax rate affects the consumption decision of individual 1 more than it affects the consumption choice of individual 3. The result is very intuitive: the rational individual has a low level of consumption, and therefore increasing the sin tax cannot have a very large effect on his consumption level (in absolute terms). On the other hand, the individual with a severe self-control problem has a high level of consumption, and a tax increase has a larger effect on his level of consumption. Therefore we have that

$$\frac{\partial V(q^*; \beta_1)}{\partial q} > -\frac{\partial V(q^*; \beta_3)}{\partial q}$$

and thus

$$\frac{dW(q^*)}{dq} > 0.$$

This example confirms our intuition that if we take the political equilibrium as a starting point and increase the tax rate slightly, the self-control benefit gained by the individual with a severe self-control problem is higher than the loss experienced by close to rational individuals. However, the median voter does not take this asymmetric effect

²²This equality is caused by the linearity of $h(x)$.

into account. Therefore even if the distribution of self-control problems is symmetric, the equilibrium tax rate is below the socially optimal level.

4.1.2 The case of very harmful consumption

Consider next the case where consumption of commodity x is so harmful that the optimal (rational) level of consumption is zero even at zero taxes, that is, $v'(0) - \delta h'(0) - 1 \leq 0$. It is then immediately clear that, in the social optimum, no one should consume x . The (minimum) tax rate (τ^o) needed to implement the social optimum is such that even the least rational consumer abstains, and it is given by

$$\tau^o = v'(0) - \beta_L \delta h'(0) - 1. \quad (11)$$

It is easy to see that the socially optimal sin tax is in this case also a majority voting equilibrium for any distribution of β and for all functional forms $v(x)$ and $h(x)$:

Proposition 3 *Assume that sin taxes have no redistributive effects and the optimal level of consumption at zero taxes is zero. The socially optimal tax is then a majority voting equilibrium.*

Proof. Individuals with $\beta_i = \beta_L$ strictly prefer τ^o to any other tax rate. All individuals with $\beta_i > \beta_L$ strictly prefer τ^o to any tax rate below $\hat{\tau} = v'(0) - \beta_i \delta h'(0) - 1$ and are indifferent between τ^o and any tax rate $\tau \subseteq [\hat{\tau}, \tau^o]$. ■

That is, when it is optimal to abstain from the consumption of good x even in the absence of any taxation, all consumers prefer a tax policy that will help them to achieve a zero level of consumption. The socially optimal tax achieves this outcome and will therefore be a majority voting equilibrium. However, we show in section 4.2.2 that this result changes when we take into account the redistributive effects of sin taxes.

4.2 Accounting for the redistributive effects of sin taxes

Let us next analyse the more realistic case where the social planner does not have information on individual consumption levels, so that the subsidy paid to each consumer cannot be conditioned on individual consumption. We therefore assume from now on that all consumers receive a lump-sum transfer of equal size, and this subsidy is given by $S(q; \beta) = S(q) = \tau E_\beta [x(q; \beta)]$. The consumers' policy preference function is then given by

$$\tilde{V}(q; \beta_i) = v(x^*(q; \beta_i)) - \delta h(x^*(q; \beta_i)) - qx^* + \tau E_\beta [x^*(q; \beta)] + B.$$

4.2.1 The case of moderately harmful consumption

Consider again first the case where current consumption causes harm in the future, but the optimal (rational) level of consumption is nevertheless positive at zero taxes, that is, $v'(0) - \delta h'(0) - 1 > 0$. The first-order condition that determines voting behaviour of individual i is now given by

$$\begin{aligned} \frac{\partial \tilde{V}(q; \beta_i)}{\partial q} = & -(1 - \beta_i) \delta h'(x^*(q; \beta_i)) \frac{\partial x^*(q; \beta_i)}{\partial q} \\ & - x^*(q; \beta_i) + E_\beta [x^*(q; \beta)] + \tau E_\beta \left[\frac{\partial x^*(q; \beta)}{\partial q} \right]. \end{aligned} \quad (12)$$

In the case where taxation had no redistributive effects it was easy to see that the individual's preferred tax rate was monotonic in the level of self-control problems and a majority voting equilibrium was therefore guaranteed to exist. However, as noted in the introduction, in the case where sin taxes have redistributive effects there are two forces at play: on the one hand, a person with a high level of self-control problems will prefer a high tax in order to alleviate the distortion in his consumption decision. The corrective effect of taxation is identical to the case where sin taxes have no redistributive effects, and is given by the first term in (12). On the other hand, however, a high tax will also imply a transfer of income towards individuals with a relatively low level of consumption: this redistributive effect of taxation is captured by the remaining terms in (12). Because of these two opposite effects, policy preferences may not be well-behaved, and the existence of a majority voting equilibrium is therefore not self-evident in this case.

A median voter equilibrium exists if policy preferences satisfy the Gans-Smart single crossing property (Gans and Smart 1996). Gans and Smart show that when underlying preferences are defined over a two-dimensional real choice variable but attention can be restricted to a one-dimensional choice due to production or budget constraints (in our case due to the consumer's budget constraint), then single-crossing in the Spence-Mirrlees sense implies single-crossing in the Gans-Smart sense.

We therefore use the Spence-Mirrlees single-crossing condition to analyse the existence of a median voter equilibrium. The voters' preferences satisfy the Spence-Mirrlees condition if voters' marginal rates of substitution between z and q , $-\frac{\tilde{V}_q}{\tilde{V}_z}$, are globally monotonic in β . In our simple case of quasilinear preferences ($\tilde{V}_z = 1$), the condition reduces to $\frac{\partial \tilde{V}(q; \beta_i)}{\partial q}$ being monotonic in β .

In the appendix, we prove that $\frac{\partial \tilde{V}(q; \beta_i)}{\partial q \partial \beta} \leq 0$, and we can therefore state the following

proposition:

Proposition 4 *Assume that revenue from sin taxes is distributed equally among consumers. A majority voting equilibrium exists and the equilibrium sin tax is given by the tax rate preferred by the consumer with the median level of self-control problems.*

Proof. See the appendix. ■

The result $\frac{\partial \tilde{V}(q; \beta_i)}{\partial q \partial \beta} \leq 0$ implies that an individual's most preferred tax rate is again monotonically increasing in the level of self-control problems. To gain some intuition on why this holds also when the redistributive effects of sin taxes are taken into account, using equations (16) and (23) (see the appendix), the corrective term in (12) can be written as

$$-(1 - \beta_i) \delta h'(x^*(q; \beta_i)) \frac{\partial x^*(q; \beta_i)}{\partial q} = x^*(q; \beta_i) - x^*(q; 1) + \Phi(q, \beta_i), \quad (13)$$

where $\Phi(q, \beta_i) = \int_{\beta_i}^{\beta_H} (1 - \hat{\beta}) \frac{\partial^2 x(q; \hat{\beta})}{\partial \hat{\beta}^2} d\hat{\beta} > 0$ and $\Phi(q, \beta_i)$ is increasing in the level of self-control problems (decreasing in β). As expected, the corrective effect of the tax is the larger, the more consumption $x^*(q; \beta_i)$ differs from the quantity chosen by the rational consumer, $x^*(q; 1)$. Further, the magnitude of the corrective effect exceeds the difference $x^*(q; \beta_i) - x^*(q; 1)$. Importantly, the difference between the corrective effect and the monetary cost of the tax is increasing in the level of self-control problems: therefore, relatively irrational individuals prefer a higher tax rate than those who are relatively rational.

To illustrate, consider again the example where $v(x) = \frac{\varepsilon}{\varepsilon-1} x^{\frac{\varepsilon-1}{\varepsilon}}$ and $h(x) = gx$. With these functional forms, the self-control benefit from taxation can be expressed as

$$-(1 - \beta_i) \delta h'(x^*(q; \beta_i)) \frac{\partial x^*(q; \beta_i)}{\partial q} = \varepsilon (\delta g + q) x_i^{\frac{\varepsilon+1}{\varepsilon}} - \varepsilon x_i.$$

It is easy to see from this expression that the self-control benefit increases more than linearly with the quantity consumed, which in turn is an increasing and convex function of self-control problems. Hence the self-control benefits increase more rapidly than monetary costs (which depend linearly on consumption), and the individual's preferred tax rate is increasing in the level of self-control problems.

The specific functional forms used in the previous example serve to illustrate the mechanism behind Proposition 4. However, the property that self-control benefits increase more rapidly than monetary costs is more general, as Proposition 4 holds for all functional forms that satisfy Assumption 1. The intuition is apparent when

we examine the three components that affect the magnitude of self-control benefits: Firstly, the harm function has been assumed to be either linear or convex. Secondly, the sensitivity of demand to tax changes increases with self-control problems. Finally, these two effects are multiplied by the level of self-control problems, $(1 - \beta_i)$. Hence, these three forces reinforce each other, causing the self-control benefits to quite generally increase more than linearly in the level of consumption.

It is interesting to note that even in the present case where the optimal level of consumption in the absence of taxes is positive, there may be circumstances under which the redistributive motive for taxation implies that the median voter prefers not to consume in equilibrium, and will vote for the tax rate that maximises revenue. We have shown in the proof of Proposition 4, however, that single-crossing holds regardless of whether the median voter consumes the good in equilibrium or not. Therefore there cannot be situations where a coalition of near-rational users and highly irrational heavy-users vote for highest taxes, and are pitted against voters with an intermediate degree of rationality²³.

Let us next turn to the comparison between the equilibrium and the optimum. Proposition 4 implies that the equilibrium tax rate is now given by

$$\tau^* = \frac{(1 - \beta_{med})\delta h'(x^*(q; \beta_{med})) \left| \frac{\partial x^*(q; \beta_{med})}{\partial q} \right| - x^*(q; \beta_{med}) + E_\beta [x^*(q; \beta)]}{E_\beta \left| \frac{\partial x^*(q; \beta)}{\partial q} \right|}.$$

The term $E_\beta [x^*(q; \beta)] - x^*(q; \beta_{med})$ in the above formula captures the fact that if $x^*(q; \beta_{med}) < E_\beta [x^*(q; \beta)]$, sin taxes imply a transfer of income towards the median voter. This will typically occur if the distribution of β is skewed to the left so that $\beta_{med} > E[\beta]$ (though it can also occur in other cases, depending on the exact functional form of x^*). In such circumstances, the median voter then votes for a higher tax than he would in the absence of redistribution. Nevertheless, we can show that the equilibrium tax rate is again typically below the socially optimal level:

Proposition 5 *Assume that revenue from sin taxes is distributed equally among con-*

²³It appears that this property might be related to our assumption of quasilinear preferences, and the implied zero income elasticity of demand for good x . Whether more general assumptions about preferences can give rise to voting coalitions where highly irrational consumers and fully rational consumers vote for higher taxes than consumers with an intermediate level of rationality, is left as a question for further research. See Epple and Romano (1996) for an analysis - albeit in a very different context - where the preferred level of public expenditure and taxation is non-monotonic in consumer type (in their case income) when the income elasticity of demand exceeds the (absolute value of the) price elasticity.

sumers. If $(1 - \beta) \frac{\partial^2 x(q; \beta)}{\partial \beta^2}$ is non-increasing in β and the distribution of β is not too much skewed to the right, the socially optimal tax rate is higher than the tax rate chosen in a majority voting equilibrium.

Proof. See the appendix. ■

In the appendix, we show that if $(1 - \beta) \frac{\partial^2 x(q; \beta)}{\partial \beta^2}$ is non-increasing in β , the derivative (12) is not only increasing, but also a convex function of the level of self-control problems. The result therefore again has a very intuitive explanation: the convexity of (12) implies that the marginal welfare benefit of high taxation for relatively irrational individuals is higher than the corresponding welfare loss for close to rational individuals. The condition that $(1 - \beta) \frac{\partial^2 x(q; \beta)}{\partial \beta^2}$ should be non-increasing in β again holds for many commonly used functional forms, for example when v is of the CRRA or CARA-variety or quadratic, and when the harm function is linear or $h(x) = x^s$ where $s \geq 2$.

Further, in order to interpret the condition that $(1 - \beta) \frac{\partial^2 x(q; \beta)}{\partial \beta^2}$ should be non-increasing in β , we show in the appendix that this holds (approximately) if a price change affects the health of irrational consumers (heavy users) more than the health of rational consumers. This holds given Assumption 1.

Proposition 5 shows that despite the fact that high sin taxes result in a transfer of income towards the median voter, the equilibrium tax rate is lower than the socially optimal tax: the income transfer is not sufficient for the median voter to fully internalise the benefit that would accrue to highly irrational individuals, if the tax rate was increased.

For the case of moderately harmful consumption, therefore, our result is identical to the benchmark case where sin taxes have no redistributive effects. If harm from consumption is very low, this result is intuitive: in this case even rational consumers consume a lot of the good in question, and the concern for alleviating distortions in consumption is stronger than the motive for redistributing tax revenue. This case therefore resembles the case where taxation has no redistributive effects, discussed above, and the results are the same for the two cases - equilibrium taxes tend to be too low.

However, in contrast to the case where sin taxes have no redistributive effects, it is important to note that the conclusion that equilibrium taxes tend to be too low holds in the present case for *all* levels of harm. We turn next to the interesting case of very harmful consumption.

4.2.2 The case of very harmful consumption

Consider again the case where consumption is so harmful that at zero taxes, the optimal choice is to abstain from consuming the commodity x . The (minimum) tax rate (τ^o) needed to implement the social optimum is then given by (11).

The condition for the result $\tau^* < \tau^o$ to hold in this case is especially mild, namely that β_{med} does not coincide with the lowest level of β . Further it is important to note that this result does not depend on Assumption 1, but holds for *any* functional forms of $v(x)$ and $h(x)$:

Proposition 6 *Assume that revenue from sin taxes is distributed equally among consumers and consumption is so harmful that the optimal level of consumption at zero taxes is zero. Then, for any distribution of self-control problems where $\beta_{med} > \beta_L$, the socially optimal tax rate is higher than the tax rate chosen in a majority voting equilibrium.*

Proof. Since no agent consumes at $\tau = \tau^o$, no tax revenues are collected in the social optimum. Suppose that, starting from $\tau = \tau^o$, the tax rate is lowered by a small amount $d\tau$. Then the least rational consumers (β_L), who were just indifferent between consuming and not consuming, are triggered to consume a small amount

$$x(\beta_L; \tau^o - d\tau) = -\frac{d\tau}{v''(0) + \beta_L h''(0)} > 0.$$

Also, tax revenues increase from zero to $-\frac{\tau^o d\tau}{v''(0) + \beta_L h''(0)}$. Consumers other than type β_L still consume no x , and the welfare of this majority group increases, due to transfers from type β_L . The redistributive motive for taxation then implies that the level of taxes that eliminates all consumption cannot arise as a political equilibrium. ■

5 Extension: third-best sin taxes

Our analysis can be easily generalised to the case where sin taxes not only have a corrective role, but the government also has a revenue raising objective. Total social welfare is now taken to be the sum of the utility from private consumption and from public funds. Let μ denote the marginal social value of revenue from the sin tax (or the marginal cost of raising revenue from other tax bases)²⁴. Previously, we have had that

²⁴For simplicity, we consider a partial equilibrium set-up where demands for other goods are assumed to be independent of the demand for the good under consideration and consequently, other tax bases are unaffected by the taxes in question. It is therefore also natural to assume that μ is constant with respect to τ .

$\mu = 1$, since all tax revenue has been returned to consumers and we have assumed that the marginal utility of (private) income is 1. However, now we allow for the possibility that part of the tax revenue is used for public goods and services. In the general case where the marginal value of public consumption differs from the marginal value of private consumption, we have that $\mu \neq 1$.

Social welfare is now given by

$$W(q, \mu) = E_\beta [V(q, \mu; \beta)] = E_\beta [v(x^*(q; \beta)) - \delta h(x^*(q; \beta)) - (1 + (1 - \mu)\tau)x^*(q; \beta)] + B.$$

This extension does not affect the comparison between the equilibrium and the socially optimal tax rate²⁵. To see this, note that the individual's policy preference function is now given by

$$\tilde{V}(q; \beta_i) = v(x^*(q; \beta_i)) - \delta h(x^*(q; \beta_i)) - qx^* + \mu\tau E_\beta [x^*(q; \beta)] + B$$

and its derivative is

$$\begin{aligned} \frac{\partial \tilde{V}(q; \beta_i)}{\partial q} = & -(1 - \beta_i)\delta h'(x^*(q; \beta_i)) \frac{\partial x^*(q; \beta_i)}{\partial q} \\ & - x^*(q; \beta_i) + \mu \left\{ E_\beta [x^*(q; \beta)] + \tau E_\beta \left[\frac{\partial x^*(q; \beta)}{\partial q} \right] \right\}. \end{aligned}$$

It is important to note that the part of this derivative that depends on β is independent of μ , and therefore $\frac{\partial \tilde{V}(q; \beta_i)}{\partial q}$ is still increasing and convex in the level of self-control problems, as above. The equilibrium tax rate is therefore typically lower than the socially optimal tax also in this third-best setting. We can therefore state the following proposition:

Proposition 7 *Assume that sin taxes are used for revenue raising purposes. If $(1 - \beta)\frac{\partial^2 x(q; \beta)}{\partial \beta^2}$ is non-increasing in β and the distribution of β is not too much skewed to the right, the third-best optimal sin tax is higher than the tax rate chosen in a majority voting equilibrium.*

However, even though the qualitative comparison between the socially optimal and the equilibrium tax rate is not altered, incorporating a revenue raising objective into

²⁵This holds as long as we make the conventional assumption that consumers' and the social planner's valuations of public funds are identical. See Pirttilä and Tenhunen (2007) for an analysis where those valuations may differ.

the social welfare function does affect the actual levels of taxes. Consider the socially optimal tax rate. The third-best optimal sin tax is given by

$$\tau^{TB} = \frac{1}{\mu} \frac{E_{\beta} \left[(1 - \beta) \delta h' (x^* (q; \beta)) \frac{\partial x^* (q; \beta)}{\partial q} \right]}{E_{\beta} \left[\frac{\partial x^* (q; \beta)}{\partial q} \right]} + \frac{(1 - \mu) E_{\beta} [x^* (q; \beta)]}{\mu E_{\beta} \left[\frac{\partial x^* (q; \beta)}{\partial q} \right]}. \quad (14)$$

The first term in (14) reflects the corrective role of sin taxes, whereas the second term reflects the standard public finance argument for taxation. The corrective part enters the optimal tax formula additively, in accordance with the additivity principle familiar from the context of environmental taxation (Sandmo 1975). If $\mu = 1$, we get the formula in (5). Typically, however, if other taxes are distortionary, $\mu > 1$ and the public finance term is positive. The direct effect of public finance considerations is therefore to increase the socially optimal sin tax.

On the other hand, for $\mu > 1$ the corrective part of the tax is scaled down. The fact that the corrective part is lower than in the case where taxation only has a corrective role is analogous to the principle of incomplete internalisation of environmental externalities in the presence of distortive taxation (Bovenberg and de Mooij 1994). This feature can be explained by the fact that the marginal costs of harm reduction increase with the marginal cost of public funds.

The overall effect of public finance considerations on the magnitude of the optimal sin tax is in general ambiguous. However, it is self-evident that in the case where $\mu > 1$, that is when tax revenue has a higher weight in the social welfare function than private consumption, the third-best optimal sin tax is higher than the tax rate given in (5) if and only if (5) is on an upward-sloping segment of the Laffer curve.

In some cases, for example if a part of tax revenue is wasted (for example due to administrative costs) a case where $\mu < 1$ may be relevant. In this case, the second term in (14) is negative whereas the first part is scaled up. Again, it is worth emphasising that our result regarding the comparison between τ^* and τ^o does not depend on the value of μ . Therefore, the result that the optimal tax rate exceeds the equilibrium level of taxes holds even in the case where part of tax revenue is wasted.

6 Conclusions

We have shown that optimal sin taxes will typically exceed the average distortion caused by self-control problems in the economy: this result arises due to the asymmetric effects

of sin taxes on the welfare of those with severe self-control problems on the one hand, and on (close to) rational individuals on the other hand. As the median voter does not take such asymmetries into account, the sin taxes chosen in a majority voting equilibrium are in most cases below the socially optimal level.

The view that emerges from previous empirical literature seems to be that for example excise duties on cigarettes are in most countries very high compared to the external costs of smoking. However, the present analysis provides a theoretical argument that suggests that such taxes may nevertheless be too low from a social point of view.

The analysis also suggests a reason for why it may be optimal to impose quantity restrictions on the consumption of certain highly harmful substances (such as illicit drugs), rather than using price instruments alone: if we were to rely solely on tax policy to regulate the consumption of such substances, the optimal outcome may not be reached.

It should be noted that throughout the analysis, we have assumed that individuals are sophisticated - that is, they are fully aware of their self-control problem. Individuals thus value sin taxes as a self-control device, and vote for positive taxes. However, if some individuals are partially naive, their preferred tax rate will be lower than the level indicated by our results - indeed, fully naive individuals would vote for a zero tax, as they are fully unaware of their self-control problem. In the case where some individuals are either partially or fully naive, therefore, the problem of sub-optimally low equilibrium taxes would be exacerbated.

Appendix

Preliminaries

The following derivatives are used a number of times in the analysis:

$$\frac{\partial x^*(q, \beta)}{\partial \beta} = \frac{\delta h'(x^*)}{v''(x^*) - \beta \delta h''(x^*)} < 0 \quad (15)$$

$$\frac{\partial x^*(q, \beta)}{\partial q} = \frac{1}{v''(x^*) - \beta \delta h''(x^*)} < 0.$$

Given these results, the corrective effect of taxation can be written as

$$-(1 - \beta_i) \delta h'(x^*(q; \beta_i)) \frac{\partial x^*(q; \beta_i)}{\partial q} = (1 - \beta_i) \frac{\partial x(q; \beta)}{\partial \beta}. \quad (16)$$

Proof of Proposition 1

Since $E_\beta \left[\frac{\partial x^*}{\partial q} \right] < 0$, $\tau^o > \delta E_\beta [(1 - \beta) h'(x^*(q; \beta))]$ if $Cov_\beta \left[(1 - \beta) h'(x^*), \frac{\partial x^*}{\partial q} \right] < 0$.

When $h''(x) \geq 0$, $(1 - \beta) h'(x^*(q; \beta))$ is decreasing in β . Therefore, $Cov_\beta \left[(1 - \beta) h'(x^*), \frac{dx^*}{dq} \right] < 0$ if $\frac{\partial^2 x^*(q; \beta)}{\partial q \partial \beta} > 0$. This derivative is given by

$$\frac{\partial^2 x^*(q; \beta)}{\partial q \partial \beta} = \frac{-[v'''(x^*) - \beta \delta h'''(x^*)] \frac{\partial x^*}{\partial \beta} + \delta h''(x^*)}{[v''(x^*) - \beta \delta h''(x^*)]^2}.$$

It can be shown that $\frac{\partial^2 x^*(q; \beta)}{\partial q \partial \beta} > 0$ if (sufficient conditions) $v'''(x) \geq 0$ and

$$\frac{h'''(x) h'(x)}{[h''(x)]^2} < \frac{\beta \delta h''(x) - v''(x)}{\beta \delta h''(x)}.$$

Clearly $\frac{\beta \delta h''(x) - v''(x)}{\beta \delta h''(x)} > 1$. Thus the above condition is less demanding than

$$\frac{h'''(x) h'(x)}{[h''(x)]^2} \leq 1.$$

Proof of Proposition 2

In this proof, we first show that the right hand side of (5) is larger than the right hand side of (9). Secondly, we derive a condition that guarantees $\frac{dW(q)}{dq} - \frac{\partial V(q; \beta_{med})}{\partial q} \geq 0$. Thirdly, we interpret this condition, and use an approximation to show that it holds in our model.

i) In the text we show that the proposition holds for a linear $h(x)$. If $h(x)$ is not linear, then

$$E_\beta [(1 - \beta) h'(x^*(q; \beta))] \neq (1 - \beta_{med}) h'(x^*(q; \beta_{med}))$$

even if $\beta_{med} = E[\beta]$. In particular, if $\xi(\beta) = (1 - \beta) h'(x^*(q; \beta))$ is a convex function of β , then the Jensen inequality implies that

$$E_\beta [(1 - \beta) h'(x^*(q; \beta))] > (1 - E[\beta]) h'(x^*(q; E[\beta])) = (1 - \beta_{med}) h'(x^*(q; \beta_{med})).$$

We therefore need to show that $\frac{d^2 \xi(\beta)}{d\beta^2} > 0$. Now,

$$\frac{d\xi(\beta)}{d\beta} = -h'(x^*) + (1 - \beta) h''(x^*) \frac{dx^*}{d\beta},$$

$$\frac{d^2 \xi(\beta)}{d\beta^2} = \left[(1 - \beta) \frac{d^2 x^*}{d\beta^2} - 2 \frac{dx^*}{d\beta} \right] h''(x^*) + (1 - \beta) h'''(x^*) \left(\frac{dx^*}{d\beta} \right)^2.$$

It can be shown that $\frac{d^2\xi(\beta)}{d\beta^2} > 0$ if $v'''(x) \geq 0$ and

$$\frac{h'''(x)h'(x)}{[h''(x)]^2} > -2 \frac{v''(x^*) - \beta\delta h''(x^*)}{v''(x^*)} \frac{\delta h''(x^*) - v''(x^*)}{\delta h''(x^*)}. \quad (17)$$

Clearly,

$$\frac{v''(x^*) - \beta\delta h''(x^*)}{v''(x^*)} \frac{\delta h''(x^*) - v''(x^*)}{\delta h''(x^*)} > 1$$

Thus (17) is less demanding than

$$\frac{h'''(x)h'(x)}{[h''(x)]^2} \geq -2. \quad (18)$$

Therefore $\xi(\beta) = (1 - \beta)h'(x^*)$ is a convex function of β if $v'''(x) \geq 0$ and (18) holds (sufficient conditions). The condition (18) essentially states that $h'''(x)$ should not be too small, or equivalently, $h'(x)$ should not be too concave: harm and therefore also self-control benefits from consumption depend on $h'(x)$. Excessive concavity of $h'(x)$ might thus offset the effect of increasing sensitivity to taxation as self-control problems get worse.

ii) Next, we show that $\frac{dW(q)}{dq} - \frac{\partial V(q; \beta_{med})}{\partial q} \geq 0$. For the remaining proofs, we find it useful to adopt the notation $\rho \equiv 1 - \beta$, where ρ measures the degree of self-control problems directly: for fully rational consumers $\rho = 0$, and for fully myopic consumers $\rho = 1$.

Using (16), $\frac{\partial V(q; \rho)}{\partial q}$ can therefore be written as

$$\begin{aligned} \frac{\partial V(q; \rho)}{\partial q} &= [\tau - \rho\delta h'(x^*(q; \rho))] \frac{\partial x^*(q; \rho)}{\partial q} = \tau \frac{\partial x^*(q; \rho)}{\partial q} + \rho \frac{\partial x^*(q; \rho)}{\partial \rho} \\ &= \frac{\partial V(q; \rho_L)}{\partial q} + \int_{\rho_L}^{\rho} \left[\tau \frac{\partial^2 x^*(q; \hat{\rho})}{\partial q \partial \hat{\rho}} + \hat{\rho} \frac{\partial^2 x^*(q; \hat{\rho})}{\partial \hat{\rho}^2} + \frac{\partial x^*(q; \hat{\rho})}{\partial \hat{\rho}} \right] d\hat{\rho}. \end{aligned}$$

Adopting the notation

$$\Psi(q, \rho) = \tau \frac{\partial^2 x^*(q; \rho)}{\partial q \partial \rho} + \rho \frac{\partial^2 x^*(q; \rho)}{\partial \rho^2} + \frac{\partial x^*(q; \rho)}{\partial \rho}, \quad (19)$$

we know that $\frac{\partial V(q; \rho)}{\partial q}$ is a convex function of ρ if

$$\frac{\partial \Psi(q, \rho)}{\partial \rho} \geq 0. \quad (20)$$

Given this convexity, $E_\rho \left[\frac{\partial V(q;\rho)}{\partial q} \right] > \frac{\partial V(q;E[\rho])}{\partial q}$ for all q . Also, since $\frac{\partial^2 V(q;\rho)}{\partial q \partial \rho} > 0$, we can conclude that

$$\frac{dW(q)}{dq} = E_\rho \left[\frac{\partial V(q;\rho)}{\partial q} \right] > \frac{\partial V(q;\rho_{med})}{\partial q}$$

if

$$\rho_{med} \leq E[\rho]. \quad (21)$$

Therefore the equilibrium tax is lower than the socially optimal tax if (20) and (21) hold (sufficient conditions).

iii) Next, we proceed to interpreting condition (20). First note that (16) implies that

$$\frac{\partial x^*(q;\rho)}{\partial \rho} = -\delta \frac{\partial h(x^*(q;\rho))}{\partial q}. \quad (22)$$

This is the effect of a price change on health. First-order Taylor series approximation with respect to ρ and q yields

$$\frac{\partial x^*(q;\rho)}{\partial \rho} \simeq \frac{\partial x^*(1;0)}{\partial \rho} + \rho \frac{\partial^2 x^*(q;\rho)}{\partial \rho^2} + \tau \frac{\partial x^*(q;\rho)}{\partial \rho \partial q}$$

(note that the derivatives are evaluated at (q,ρ)). Solving the above expression for $\tau \frac{\partial x^*(q;\rho)}{\partial \rho \partial q}$ and substituting into (19) yields

$$\Psi(q,\rho) \simeq 2 \frac{\partial x^*(q;\rho)}{\partial \rho} - \frac{\partial x^*(1;0)}{\partial \rho}.$$

The second term in this expression is a constant. Therefore, $\Psi(q,\rho)$ is increasing in ρ , if $\frac{\partial x^*(q;\rho)}{\partial \rho}$ is increasing in ρ . Condition (20) therefore states that a price change affects the health of irrational consumers (heavy users) more than the health of rational consumers. Finally, we can check that this holds in our model:

$$\frac{\partial \left(-\delta \frac{dh(x(q;\rho))}{dq} \right)}{\partial \rho} = -\delta \left[h'(x(q;\rho)) \frac{\partial x(q;\rho)}{\partial q} \frac{\partial x(q;\rho)}{\partial \rho} + h''(x(q;\rho)) \frac{\partial x^2(q;\rho)}{\partial q \partial \rho} \right] > 0.$$

The inequality follows from Assumption 1, which guarantees that $\frac{\partial x^2(q;\rho)}{\partial q \partial \rho} > 0$.

Proof of Proposition 4

To prove the existence of a majority voting equilibrium, we have to show that the Spence-Mirrlees single-crossing condition is satisfied. Since we assume quasi-linear preferences this reduces to showing that $\frac{\partial \tilde{V}(q; \rho)}{\partial q}$ is monotonic in ρ .

The effect of a marginal tax change on the welfare of type ρ is now given by (12). Note that

$$x(q; \rho) = x(q; \rho_L) + \int_{\rho_L}^{\rho} \frac{\partial x(q; \hat{\rho})}{\partial \hat{\rho}} d\hat{\rho} = x(q; \rho_L) + \rho \frac{\partial x(q; \rho)}{\partial \rho} - \rho_L \frac{\partial x(q; \rho_L)}{\partial \rho} - \int_{\rho_L}^{\rho} \hat{\rho} \frac{\partial^2 x(q; \hat{\rho})}{\partial \hat{\rho}^2} d\hat{\rho}. \quad (23)$$

Substituting (16) and (23) into (12) shows that

$$\frac{\partial \tilde{V}(q; \rho)}{\partial q} = \frac{\partial \tilde{V}(q; \rho_L)}{\partial q} + \int_{\rho_L}^{\rho} \hat{\rho} \frac{\partial^2 x(q; \hat{\rho})}{\partial \hat{\rho}^2} d\hat{\rho}. \quad (24)$$

Differentiating with respect to ρ yields

$$\frac{\partial^2 \tilde{V}(q; \rho)}{\partial q \partial \rho} = \rho \frac{\partial^2 x(q; \rho)}{\partial \rho^2} \geq 0. \quad (25)$$

Notice that these results hold even when some individuals do not consume in equilibrium, that is, $x(q; \rho) = 0$ for $\rho \in [\rho_L, \tilde{\rho}(q)]$, where $\tilde{\rho}(q)$ is given by

$$v'(0) - (1 - \tilde{\rho}) \delta h'(0) - q = 0 \Leftrightarrow \tilde{\rho}(q) = 1 - \frac{v'(0) - q}{\delta h'(0)}.$$

Then

$$\begin{aligned} \frac{\partial \tilde{V}(q; \rho)}{\partial q} &= \frac{d\tilde{V}(q; \rho_L)}{dq} = E_{\rho} [x(q; \beta)] + \tau E_{\rho} \left[\frac{\partial x(q; \rho)}{\partial q} \right] \text{ for } \rho \in [\rho_L, \tilde{\rho}(q)] \\ \frac{\partial \tilde{V}(q; \rho)}{\partial q} &= E_{\rho} [x(q; \rho)] + \tau E_{\rho} \left[\frac{\partial x(q; \rho)}{\partial q} \right] + \tilde{\rho}(q) \frac{\partial x(q; \tilde{\rho}(q))}{\partial \rho} + \int_{\tilde{\rho}(q)}^{\rho} \hat{\rho} \frac{\partial^2 x(q; \hat{\rho})}{\partial \hat{\rho}^2} d\hat{\rho} \text{ for } \rho > \tilde{\rho}(q). \end{aligned}$$

Proof of Proposition 5

From (24), $\frac{\partial \tilde{V}(q; \rho)}{\partial q}$ is a convex function of ρ if $\rho \frac{\partial^2 x(q; \rho)}{\partial \rho^2}$ is increasing in ρ . Given this convexity, the same argument as in the Proof of Proposition 2 shows that $\frac{dW(q)}{dq} > \frac{\partial \tilde{V}(q; \rho_{med})}{\partial q}$.

To interpret the condition that $\rho \frac{\partial^2 x(q; \rho)}{\partial \rho^2}$ should be increasing in ρ , a first-order Taylor approximation shows that the health effect of taxation can be written as

$$-\delta \frac{\partial h(x(q; \rho))}{\partial q} = \frac{\partial x^*(q; \rho)}{\partial \rho} \simeq \frac{\partial x(q; 0)}{\partial \rho} + \rho \frac{\partial^2 x(q; \rho)}{\partial \rho^2}.$$

Again, we therefore require that a price change affects the health of irrational consumers (heavy users) more than the health of rational consumers.

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Essay 3.

Paternalism and tax competition*

Kaisa Kotakorpi

Abstract

When consumers make mistakes, the government may wish to use paternalistic taxation as a corrective measure. We analyse the extent to which tax competition undermines the feasibility of paternalistic taxation. We show that the paternalistic component of a tax on a harmful good is reduced when there is cross-border shopping, but it does not disappear altogether. In a model with tax competition between two countries, only one of which has a paternalistic objective, we show that a minimum tax rate requirement can be Pareto improving despite the divergence in policy objectives. Tax harmonisation, however, reduces welfare in the non-paternalistic country.

Keywords: commodity taxation, tax competition, paternalism

JEL: H21, H73, H77, I18

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1 Introduction

When the government's and consumers' preferences differ, the government may wish to influence consumer choice through public policy. One particular example is a situation where consumers do not fully take into account the future negative effects caused by the consumption of certain goods, and therefore consume too much of such goods, even from the point of view of maximising their own lifetime utility. An important example is excessive consumption of goods with negative health effects (such as unhealthy food, cigarettes and alcohol) by consumers with self-control problems. It can be argued that market solutions to such self-control problems are unlikely to be effective (see Köszegi (2005)), and taxation is a potential tool for correcting the distortion in consumption. Taxation in such a context has been considered for example by O'Donoghue and Rabin (2003; 2006) and Gruber and Köszegi (2004). In general, policies of this kind are an example of paternalism, and their alleged purpose is to protect individuals in cases where they act against their own best self interest. Accordingly, we use the term "paternalistic taxation" to refer to taxation that is implemented so as to move private consumption closer to its optimal level (as evaluated according to the government's preferences)¹.

The objective of this paper is to analyse the feasibility of implementing paternalistic taxation in the presence of cross-border shopping and commodity tax competition. As is well known from previous literature, commodity tax competition between neighbouring countries can have the negative effect of eroding a country's tax base, when consumers take advantage of the opportunity of making cheaper purchases abroad. When governments wish to pursue paternalistic policies, tax competition causes a further externality which has thus far not been analysed in the literature: the possibility of cross-border shopping may undermine a government's attempts to control harmful consumption by relatively high taxation at home.

An interesting example is provided by recent developments in the Nordic countries. The excise duty on spirits was reduced by 45% in Denmark in October 2003. This change was at least in part prompted by relatively low prices of alcohol in Germany, and the desire to curtail cross-border shopping. Similarly, alcohol taxes were reduced in Finland on average by 33% in 2004, as a response to the lower alcohol taxes and prices in central Europe and in Estonia. A major motivation was that due to the removal of

¹The possibility of government failure may reduce the effectiveness and desirability of paternalistic policies. Despite the importance of this consideration, we abstract from this issue in the current paper. See for example Thaler and Sunstein (2003) for arguments in favour of paternalism, and Glaeser (2006) for a critical view.

restrictions on alcohol purchases from Estonia, high taxes on alcohol were expected to become an inefficient tool for controlling alcohol consumption in Finland. In response to the new Danish and Finnish policies, also Sweden has been under considerable pressure to lower its taxes on alcohol, which are currently among the highest in the EU (European Commission, 2004).

In the current paper, we first consider a country whose government wishes to use taxation to reduce the consumption of a harmful good when consumers have an option to purchase the good more cheaply abroad. In this analysis we take the foreign price as exogenous. We show that the paternalistic component of the tax is reduced due to the possibility of cross-border shopping, but it does not disappear altogether. The intuition is that cross-border shopping causes taxes to be a less effective means for controlling harmful consumption, but not completely so: due to transportation costs, the increase in purchases made abroad caused by a domestic tax increase is smaller than the corresponding reduction in domestic purchases. Hence taxation can still be used to lower *total* consumption, albeit to a lesser extent than in the absence of cross-border shopping.

In addition to analysing how cross-border shopping affects the optimal tax on a harmful good when foreign prices can be taken as exogenous, we examine the implications of tax competition. We assume that consumer preferences are identical in the two countries, but one of the governments wishes to pursue paternalistic taxation whereas the other does not. Building on the model of Haufler (1996), we show that in this case an asymmetric Nash equilibrium exists, where the paternalistic country has a higher tax rate on the harmful good than the other country.

We further analyse whether policy coordination can be used to alleviate problems arising from tax competition in this context. From the point of view of the non-paternalistic country, tax competition simply causes a negative effect on tax revenues, whereas from the point of view of the paternalistic country, it has the further negative effect of increasing harmful consumption. Building on the analysis in Kanbur and Keen (1993), we show that harmonisation to a common tax rate is always harmful for the low-tax country and has ambiguous welfare effects for the high-tax country.

On the other hand, we show that both countries can benefit from a minimum tax rate requirement, despite the divergence in policy objectives. Under a quadratic transport cost function, we show that a stronger paternalistic concern in one of the countries makes it *more* likely that the policy is Pareto improving: firstly, the paternalistic country is then more likely to benefit from the reduction in consumption caused by a higher foreign tax rate; and secondly, the paternalistic country is then more likely to respond

to the minimum tax rate requirement by increasing its tax rate in turn, which is beneficial for the low-tax country as it alleviates the tax revenue externality caused by tax competition.

As a practical example of coordination in setting tax rates on harmful goods, the EU has minimum rates for excise duties on most types of alcohol. These were binding on a number of member states when the policy was adopted in 1992, but do not seem to be so anymore. Accordingly, the European Commission has recommended an inflation adjustment of the minimum rates, but no further harmonisation is planned due to the differences in views on alcohol taxation between the member states. (European Commission, 2004).² However, the proposed adjustment to the minimum rates has recently faced opposition from some member countries that would be affected by the reform. Regarding the excise duty on tobacco products, a tightening of the EU minimum rate requirements was introduced in 2002, along with measures that lead to greater harmonisation in the rates. Health concerns are specifically mentioned as a motivation for the tightening of the minimum rates. (Directive 2002/10/EC; European Commission, 2001).

Our paper is closely related to previous literature on commodity tax competition³, and in particular to the paper by Haufler (1996). Haufler considers commodity tax competition in a setting where governments of the two countries differ in their valuation for public goods. As in his model, we assume that producer trade is taxed under the destination principle (that is, taxes on the traded goods are levied in the destination country), whereas origin-based taxation is applied to cross-border purchases by consumers. Such a mixed tax system is currently in place in the EU (as a result of the abolition of border controls for consumer purchases), and the framework is therefore particularly well suited to analyse the issues that we are interested in. Haufler's paper also extends the earlier analysis of Kanbur and Keen (1993) by allowing governments to care not only about tax revenue but also about private consumption. Our paper differs from Haufler's analysis in that we allow the government's preferences to differ from those of consumers in one of the countries. Therefore, even though the government takes consumer surplus into account, increases in consumption are not always beneficial for social welfare. As was explained above, tax competition then has the further negative effect of undermining the government's ability to control harmful consumption.

²See also Cnossen (2006) for an analysis of alcohol taxation in Europe.

³We will not attempt to summarise this large literature here, but refer to the seminal contribution on commodity tax competition by Mintz and Tulkens (1986), to Haufler (2001) for a recent survey of the literature, and to Lockwood (2001) for a synthesis of various results from the previous literature.

Our analysis has particular similarities also with the analysis of commodity tax competition in the presence of externalities: negative health effects (in the case of consumers with self-control problems) or "internalities"⁴, as well as negative externalities, are both harmful effects not taken into account by consumers, and governments might wish to alleviate these effects through taxation. Indeed, mathematically, the harmful effect in our model could be interpreted as an externality. However, there are clear reasons for why the internality interpretation of our model is more plausible (and indeed for why a similar model has not been developed in the literature on environmental taxation). Firstly, many environmental externalities are transboundary in nature, and most of the literature on environmental taxation in an international context has concentrated on such a setting (see for example Cremer and Gahvari (2005) and Aronsson and Blomquist (2003) and the references therein). In our context, the negative effects of consumption are local in the sense that they accrue only on the country whose consumers consume the harmful good. Secondly, when the issue is whether the government should adopt a paternalistic policy or not (rather than whether the government should engage in pollution abatement), it is perhaps more plausible to assume that governments of otherwise identical countries may have different policy objectives. Cooperation may thus be more difficult to achieve in our context than in the case of (global) environmental externalities.⁵

Christiansen (2003; 2006) analyses optimal commodity taxation in the presence of local externalities and cross-border shopping. Aronsson and Sjögren (2005) consider the particular problem of alcohol taxation when the local externalities of alcohol consumption are taken into account, and consumers can avoid domestic taxes either through cross-border shopping or illegal production. The focus in these papers is however distinctly different from ours (namely the interaction between taxes on the cross-border traded good and other taxes), and they do not consider tax competition explicitly, nor

⁴See Herrnstein *et al* (1993).

⁵A third difference is that in the case of many types of externality-generating consumption, the government is likely to have direct instruments that can be used domestically to control consumption. Assume for example that the commodity subject to cross-border shopping are cars, and driving causes a negative externality. The negative consequences of cross-border shopping are likely to be less severe than in our context, as there are other instruments besides taxes on car purchases, that can be used domestically to control the amount of driving (notably gasoline taxes or usage fees). However, it is hard to think of instruments that the government could use domestically, to control the consumption of alcohol bought abroad. See Cremer and Gahvari (2005) for an analysis where they show that in the presence of commodity tax competition, externalities should be tackled through emissions taxes. There is also literature on setting environmental standards and capital taxation in the presence of local environmental externalities and capital mobility - see for example Oates and Schwab (1988) and Wilson (1996).

the potential for policy coordination.⁶

The rest of the paper proceeds as follows. In Section 2, we present the model. In Section 3, we analyse paternalistic taxation when consumers can go cross-border shopping in a neighbouring country with an exogenously given, lower tax rate. In Section 4, we analyse the equilibrium with tax competition. In Sections 5 and 6 we consider the welfare effects of two coordination measures, a minimum tax rate requirement and tax harmonisation. Section 7 concludes.

2 The model

We use a partial equilibrium model of cross-border shopping between two countries, A and B . Each country has a representative consumer who derives utility from consuming a good (c) that can be purchased either in the home country or abroad. Total consumption of this good by the citizen of country i , $i = A, B$, is denoted by c^i , which is the sum of the amount purchased at home (c_j^i) and the amount purchased abroad (c_j^i).⁷

If the good is purchased abroad, the consumer in country i incurs a transportation cost $\tau(c_j^i)$. As in previous literature, the transportation cost function is assumed to be continuously differentiable and to have the following properties: $\tau'(c_j^i) > 0$, $\tau''(c_j^i) > 0$ if $c_j^i > 0$; and $\tau(0) = \tau'(0) = 0$, $\tau''(0) > 0$. We therefore assume for simplicity that the transport cost functions are the same in both countries⁸.

We assume that producer trade is taxed under the destination principle (that is, taxes on the traded goods are levied in the destination country). Under such a tax system, producer arbitrage equalises producer prices in the two countries, and we normalise these prices to 1. Consumer prices are denoted by $q^i = 1 + t^i$ and we assume that in the case of consumer trade, taxes are levied under the origin principle, so that consumers pay taxes in the country where they purchase the good. Consequently, if $t^i > t^j$, consumers in country i purchase part of their consumption in country j , until the point where $t^i = t^j + \tau'(c_j^i)$. We refer to this condition as the consumer arbitrage

⁶Another related paper is Haaparanta (2006), who examines multilateral tariff reforms in the presence of merit goods.

⁷As we are primarily interested in trade in goods such as alcohol, concentrating on a single homogeneous good seems appropriate. Tax competition with trade in differentiated goods has been analyzed for example in Lockwood (2001). See also Christiansen (2003; 2006) for analyses where some goods are cross-border traded while others are only purchased at home.

⁸This assumption is a sufficient condition for the existence of a Nash equilibrium in the tax setting game we set out below. Haufler (1996) has shown (in a model without paternalism) that this type of a game has a Nash equilibrium if the second derivatives of the transport cost functions are equal in the two countries.

condition.

As in Haufler (1996), we distinguish between two different "regimes" according to whether country i has a higher tax rate than the other country. We thus refer to the high-tax country as being in regime I and to the low-tax country as being in regime II. This distinction is crucial in the model of tax competition, since a part of the tax revenues created by the consumption of the citizens of the high-tax country accrue on the low-tax country. If a country is in regime I, the budget constraint of its citizen is given by $(1 + t^i) c_i^i + (1 + t^j) c_j^i + \tau (c_j^i) = Y^i$, where Y^i is the consumer's income which we assume to be exogenous. If the country is in regime II, the budget constraint is $(1 + t^i) c^i = Y^i$. Following Christiansen (1994), we find it useful to define $s^i = s^i(t^i, t^j) = (1 + t^i) c_j^i - (1 + t^j) c_j^i - \tau (c_j^i)$, which can be thought of as the income saved by the citizens of the high-tax country due to the possibility of cross-border shopping (i.e. due to buying the quantity c_j^i abroad rather than at home). Further, define $(1 + t^i) c^i = b^i$. The regime-specific budget constraints can then be rewritten as $b^i - s^i = Y^i$ for regime I, and $b^i = Y^i$ for regime II.

The consumer's utility function is $u(c^i)$, and this is maximised subject to the regime-specific budget constraint. This maximisation yields the regime-specific (total) demand functions $c_I^i(t^i, b^i - s^i)$ and $c_{II}^i(t^i, b^i)$, as well as the indirect utility functions $v_I^i(t^i, b^i - s^i)$ and $v_{II}^i(t^i, b^i)$. As in Haufler (1996), the comparative statics of the consumption levels with respect to each of the tax rates (or equivalently, consumer prices q_i) are completely determined by the consumer arbitrage condition and regime-specific budget constraints. They are given by the following expressions:

$$\begin{aligned}
 R I \quad &: \quad \frac{\partial c_j^i}{\partial q^i} = \frac{1}{\tau''} > 0, \quad \frac{\partial c_i^i}{\partial q^i} = \frac{-c_i^i}{q^i} - \frac{1}{\tau''} < 0, \quad \frac{\partial c^i}{\partial q^i} = \frac{-c_i^i}{q^i} < 0 \\
 \frac{\partial c_j^i}{\partial q^j} &= \frac{-1}{\tau''} < 0, \quad \frac{\partial c_i^i}{\partial q^j} = \frac{-c_j^i}{q^i} + \frac{1}{\tau''} < > 0, \quad \frac{\partial c^i}{\partial q^j} = \frac{-c_j^i}{q^i} < 0 \\
 R II \quad &: \quad \frac{\partial c^i}{\partial q^i} = \frac{-c^i}{q^i} < 0, \quad \frac{\partial c^i}{\partial q^j} = 0
 \end{aligned} \tag{1}$$

We allow the government's valuation of private consumption to differ from the citizen's valuation: specifically, we assume that the government values consumption according to⁹ $\bar{u}(c^i) = u(c^i) - h(c^i)$. The function $h(c^i)$ denotes harm caused by consumption that is not taken into account by the consumer, with $h' > 0$, and h can be either concave or convex as long as $u'' - h'' < 0$. For example in the case of alcohol

⁹Racionero (2001) uses a similar functional form to examine optimal taxation in the presence of merit goods.

consumption, h is most likely to be either convex or linear (see for example Johansen *et al.* (2005), White, Altmann, and Nanchahal (2002)). Our formulation captures the example of self-control problems mentioned in the introduction.¹⁰

Our choice of $\bar{u}(c^i)$ implies that private consumption is excessive from the government's point of view. There is then scope for paternalism in policy making: the government can aim to influence private consumption decisions towards its favoured outcome through its choice of the tax rate.

Total social welfare is taken to be the sum of utility from private consumption and from public funds. Let γ denote the marginal social value of tax revenue from the tax on the cross-border traded good (or the marginal cost of raising revenue from other tax bases).¹¹ Using the notation $\bar{v}(\cdot) = v(\cdot) - h(\cdot)$, the government therefore chooses the tax rate to maximise $W_I^i = \bar{v}_I^i(t^i, b^i - s^i) + \gamma t^i c_i^i$ if it is in regime I. In regime II, the total welfare function to be maximised is $W_{II}^i = \bar{v}_{II}^i(t^i, b^i) + \gamma t^i (c^i + c_i^j)$.

3 Paternalistic taxation with cross-border shopping

Let us consider the optimal tax on the harmful good when cross-border shopping is possible. Let country A be the home country whose tax decision we are interested in, and assume that there exists a neighbouring country B with a lower, exogenously given level of taxes. Country A is then in regime I: consumers in country A purchase part of their consumption in country B , until the point where $t^B = t^A + \tau'(c_B^A)$ and their consumption is such that the budget constraint $b^A - s^A = B^A$ is satisfied.

The government's objective function is $W_I^A = \bar{v}^A(t^A, b^A - s^A) + \gamma t^A c_A^A$ and the first-order condition is

$$-\alpha c_A^A - h'(c^A) \frac{\partial c^A}{\partial q^A} + \gamma \left(c_A^A + t^A \frac{\partial c_A^A}{\partial q^A} \right) = 0. \quad (2)$$

¹⁰To see this, assume that consumption has delayed utility costs equal to $\bar{h}(c^i)$ that accrue in the period following consumption, and let $h(c^i) = (1 - \beta) \delta \bar{h}(c^i)$, where δ is the standard exponential discount factor. Our simple static formulation then captures the case where the government wants to maximise the lifetime utility of an individual who uses a quasi-hyperbolic discount function with parameter β (see for example Laibson (1997)).

¹¹We use a partial equilibrium set-up where demands for other goods are assumed to be independent of the demand for the good under consideration and consequently, other tax bases are unaffected by the taxes in question. A similar assumption is (often implicitly) made in most of the cross-border shopping literature. It is therefore also natural to assume that γ is constant with respect to t^i , as for example in Christiansen (1994).

Rearranging this condition yields the optimal tax rule, which is given by

$$t^A = \frac{h'(c^A) \eta^A c^A}{\gamma \eta_A^A c_A^A} - \frac{(1 - \alpha/\gamma) q^A}{\eta_A^A}, \quad (3)$$

where $\eta_A^A = \frac{\partial c_A^A}{\partial q^A} \frac{q^A}{c_A^A}$ and $\eta^A = \frac{\partial c^A}{\partial q^A} \frac{q^A}{c^A}$.

The second term in (3) reflects the standard public finance argument for taxation. It indicates that the demand elasticity that is relevant from the public finance point of view is the elasticity of *domestic* demand, since this is the quantity that determines the tax base in the case of cross-border shopping¹². Using (1), it is easy to show that $|\eta_A^A| > |\eta^A|$, where the latter elasticity is the elasticity of demand in the absence of cross-border shopping. The public finance part of the tax rule is therefore scaled down due to the increased elasticity of the domestic tax base in the presence of cross-border shopping.

The term $1 - \alpha/\gamma$ merits some discussion, as it appears several times in the analysis. The parameter α is the marginal utility of income, γ is the shadow price of tax revenues, and α/γ is therefore the inverse of the shadow cost of public funds. When taxation is distortive, we know that $1 - \alpha/\gamma > 0$. However, in the case of paternalistic taxation, taxes have also a corrective role and it is not clear a priori, whether α/γ is larger or smaller than unity. The difference is clear from (2): in the absence of paternalism, the first-order condition implies that $1 - \alpha/\gamma > 0$, but when the government has a paternalistic objective, the sign of $1 - \alpha/\gamma$ is in general ambiguous. In what follows we assume that taxation is distortive - that is, at the optimum, taxation is used in excess of what would be required to correct the distortion in the consumption of the harmful good. This seems to be a reasonable assumption, since it is unlikely that a corrective tax on alcohol, say, will be sufficient to satisfy a modern government's revenue requirement. We therefore assume throughout the paper that $1 - \alpha/\gamma > 0$.

The first term in (3) reflects paternalistic concerns. It enters the optimal tax formula additively, in accordance with the additivity principle familiar from the context of environmental taxation (Sandmo 1975). Since $h'(c^A) > 0$, this term is positive and if the harm function is convex, it is the larger the higher is consumption (and therefore, the further away equilibrium consumption is from optimal consumption). Paternalistic concerns therefore lead to higher taxation, as expected.

To further analyse the paternalistic part of (3), it is interesting to compare it with the first-best optimal tax, which is given by $t^{A,FB} = \frac{h'(c^A)}{\alpha}$. Firstly, note that

¹²Christiansen (1994) obtains a similar result in a model without paternalism (see Proposition 1 in his paper).

$h'(c^A)$ in (3) is divided by γ : in the presence of distortionary taxation ($\gamma > \alpha$), the paternalistic part of the tax is lowered relative to the first-best tax. This is analogous to the principle of incomplete internalisation of externalities in the presence of distortive taxation (Bovenberg and de Mooij 1994), and follows from the fact that the marginal cost of harm reduction increase with the marginal cost of public funds.

Further, the paternalistic term in the tax rule is multiplied by $\frac{\eta^A c^A}{\eta_A^A c_A^A}$: in the presence of cross-border shopping, the paternalistic component of the tax is increasing in the ratio of the elasticity of total demand to the elasticity of domestic demand. This finding has an intuitive explanation: since the harmfulness of consumption is determined by total demand, this ratio of elasticities describes the effectiveness of tax policy as a means of reducing harmful consumption in an open economy.

Recalling that $c^A = c_A^A + c_B^A$, we can derive another useful formulation of the optimal tax rule, which enables us to evaluate the magnitude of the multiplier on the paternalistic term. Equation (3) can be written as

$$t^A = \frac{h'(c^A)}{\gamma} \left(1 + \frac{\eta_B^A c_B^A}{\eta_A^A c_A^A} \right) - \frac{(1 - \alpha/\gamma) q^A}{\eta_A^A}, \quad (4)$$

where $\eta_B^A = \frac{\partial c_B^A}{\partial q^A} \frac{q^A}{c_B^A}$. The paternalistic term is now multiplied by $1 + \frac{\eta_B^A c_B^A}{\eta_A^A c_A^A}$. Using the comparative statics results given in (1), it can be seen that $-1 < \frac{\eta_B^A c_B^A}{\eta_A^A c_A^A} < 0$. Our results therefore show that as a response to cross-border shopping, the paternalistic component of the tax is scaled down¹³. The intuition for this result is that taxation has become a less efficient means for controlling harmful consumption, since the benefit from harm-abatement must now be traded off against inducing costly cross-border shopping.

However, it is interesting to note that the paternalistic component is not reduced to zero, and paternalistic concerns therefore continue to play a role in optimal tax policy even with cross-border shopping. It is worth stressing that this result does not depend for example on the strength of the paternalistic objective, or on the magnitude of transport costs.

The intuition for the result that paternalism continues to play a role in tax policy despite cross-border shopping is the following: even if there is extensive cross-border shopping, changes in the domestic tax rate cause larger changes in domestic demand

¹³It should be noted that the discussion in this section suffers from the common problem that the "scaling down" refers to the components of the (implicit) tax rule, and not necessarily to the level of taxes when the economy moves between the two different equilibria considered. Limitations of this type are very common in the optimal taxation literature, and have recently been discussed for example by Gaube (2005).

(c_A^A) than in the amount of cross-border shopping (c_B^A) (see (1)); this is because transport costs imply that cross-border shopping is an imperfect substitute for domestic consumption. Increases in the domestic tax rate will therefore reduce overall consumption regardless of the level of transport costs. As the level of total consumption determines the amount of harm from consumption, a paternalistic consideration will always be present in the optimal tax formula. The magnitude of the adjustment to the paternalistic component of the optimal commodity tax does, however, depend on the shape of the transport cost function: $\frac{\eta_B^A c_B^A}{\eta_A^A c_A^A} \rightarrow -1$ when $\tau'' \rightarrow 0$ and $\frac{\eta_B^A c_B^A}{\eta_A^A c_A^A} \rightarrow 0$ when $\tau'' \rightarrow \infty$. Therefore, as expected, the paternalistic part of the tax is high when transport costs are highly convex, and low when transport costs are close to linear (and cross-border shopping is therefore more sensitive to changes in the domestic tax rate).

Our results on how cross-border shopping affects paternalistic commodity taxation are summarised in the following proposition:

Proposition 1 *Assume that a government wishes to use paternalistic taxation to affect the consumption of a commodity. When this commodity is subject to cross-border shopping, the paternalistic component of the tax on the commodity is scaled down, but it is not reduced to zero. The paternalistic component of the tax is the higher the more elastic total demand is relative to domestic demand.*

4 Tax competition

4.1 Existence of a symmetric equilibrium

Let us next analyse the equilibrium under tax competition in a symmetric setting. In addition to assuming that individuals in the two countries have the same preferences, in the following analysis we will further assume that incomes in the two countries are identical ($Y^i = Y^j = Y$). In the current subsection we further assume that the two governments have identical preferences; this assumption will subsequently be relaxed.

As a first step, we need to derive the reaction function of country i , taking into account that it can in principle be either the high-tax or the low-tax country, depending on the policy chosen by its neighbour. As in Hauffer (1996), we therefore first derive separate reaction functions for the cases where the country is in either regime, taking into account that in regime I, the tax rate of country i has to be at least as high as the tax rate of country j , and vice versa in regime II. We then show that the reaction

function is continuous at the point where the country switches regime (that is, at the point $t^{i*} = t^j$). This guarantees the existence of equilibrium in the tax setting game¹⁴.

The first-order conditions for the government's optimisation problem in the two regimes are given by

$$R I : \begin{cases} \frac{\partial W_I^i}{\partial t^i} = -\alpha c_i^i - h'(c^i) \frac{\partial c^i}{\partial q^{i*}} + \gamma \left(c_i^i + t^{i*} \frac{\partial c_i^i}{\partial q^i} \right) = 0 & \text{if } t^{i*} \geq t^j \\ t^{i*} = t^j & \text{otherwise.} \end{cases} \quad (5)$$

$$R II : \begin{cases} \frac{\partial W_{II}^i}{\partial t^i} = -\alpha c^i - h'(c^i) \frac{\partial c^i}{\partial q^{i*}} + \gamma \left(c^i + t^{i*} \frac{\partial c^i}{\partial q^{i*}} + c_i^j + t^{i*} \frac{\partial c_i^j}{\partial q^{i*}} \right) = 0 & \text{if } t^{i*} \leq t^j \\ t^{i*} = t^j & \text{otherwise.} \end{cases} \quad (6)$$

Substituting in the expressions for the partial derivatives in (5) and (6), we obtain

$$R I : \begin{cases} \frac{\partial W_I^i}{\partial t^i} = -\alpha c_i^i + h'(c^i) \frac{c_i^i}{q^{i*}} + \gamma \left(\frac{c_i^i}{q^{i*}} - \frac{t^{i*}}{\tau''} \right) = 0 & \text{if } t^{i*} \geq t^j \\ t^{i*} = t^j & \text{otherwise.} \end{cases} \quad (7)$$

$$R II : \begin{cases} \frac{\partial W_{II}^i}{\partial t^i} = -\alpha c^i + h'(c^i) \frac{c^i}{q^{i*}} + \gamma \left(\frac{c^i}{q^{i*}} + c_i^j - \frac{t^{i*}}{\tau''} \right) = 0 & \text{if } t^{i*} \leq t^j \\ t^{i*} = t^j & \text{otherwise.} \end{cases} \quad (8)$$

The above equations define the reaction function $t^{i*}(t^j)$ of country i . Since $c_i^j \rightarrow 0$ and $c_i^i \rightarrow c^i$ as $t^i \rightarrow t^j$, the reaction function is continuous. If both countries have the same objective function, there therefore exists a symmetric Nash equilibrium where $t^{i*} = t^{j*}$.

4.2 Asymmetric equilibrium when one country has a paternalistic objective

Consider as a starting point a symmetric case where neither country has a paternalistic objective. In this case, the term $h'(c^i) \frac{\partial c^i}{\partial q^{i*}}$ in the above reaction functions is zero for both countries and there is a symmetric equilibrium. Now consider a change where in one of the countries, say in country A , a government with a paternalistic objective comes into power, whereas in the other country the situation remains unchanged. We

¹⁴The second-order conditions are reported in the appendix.

know from equation (4), that this causes an increase in the tax rate in country A (corresponding to an outward shift in country A 's reaction function).

Country B , on the other hand, is now in regime II and has no paternalistic objective. Its reaction function is therefore given by

$$\frac{\partial W_{II}^B}{\partial t^B} = R^B(t^B, t^A) = -\alpha c^B + \gamma \left(c^B + t^{B*} \frac{\partial c^B}{\partial q^{B*}} + c_B^A + t^{B*} \frac{\partial c_B^A}{\partial q^{B*}} \right) = 0. \quad (9)$$

Totally differentiating (9), the slope of country B 's reaction function is $\frac{dt^B}{dt^A} = -\frac{\partial R^B(t^B, t^A) / \partial t^A}{\partial R^B(t^B, t^A) / \partial t^B} = -\frac{\partial^2 W_{II}^B(t^B, t^A) / \partial t^B \partial t^A}{\partial^2 W_{II}^B(t^B, t^A) / (\partial t^B)^2}$. The denominator of this expression is the second-order condition for country B , and is therefore negative. The numerator is given by

$$\frac{\partial R^B(t^B, t^A)}{\partial t^A} = \gamma \left(\frac{\partial c_B^A}{\partial q^A} + t^{B*} \frac{\partial^2 c_B^A}{\partial q^B \partial q^A} \right)$$

This expression is simplified by assuming that the total transport cost function is quadratic, which is a common simplifying assumption in the literature on commodity tax competition (see for example Kanbur and Keen (1993) and Haufler (1996; 2001)). We therefore assume from now on that the transport cost function is $\tau = 1/2\theta (c_j^i)^2$, $\theta > 0$. In this case the amount of cross-border shopping is linear in the difference in tax rates ($c_B^A = \frac{q^A - q^B}{\theta}$), and we therefore have that $\frac{\partial^2 c_B^A}{\partial q^B \partial q^A} = 0$. Using this together with (1), we find that $\frac{\partial R^B(t^B, t^A)}{\partial t^A} > 0$ and hence that $\frac{dt^B}{dt^A} > 0$. Therefore, the two tax rates are strategic complements from the point of view of country B , and the policy shift in country A causes country B 's tax rate also to increase.

To determine the relative magnitude of the increase in country B 's tax rate, we substitute the comparative statics results from (1), as well as the transport cost function into the expression for $\frac{dt^B}{dt^A}$. After some manipulations, we obtain

$$\frac{dt^B}{dt^A} = \frac{1}{2 + \theta \left(\frac{2}{q^{B*}} - \frac{\alpha}{\gamma} \right) \frac{c^B}{q^{B*}}} \quad (10)$$

Since we have assumed that $1 - \alpha/\gamma > 0$, this expression is smaller than 1 (in fact, smaller than 1/2), and the tax rate in country B increases by less than the tax rate in country A .¹⁵ Therefore, there exists an asymmetric Nash equilibrium, where the paternalistic country has the higher tax rate. We can state the following proposition:

¹⁵The original equilibrium therefore satisfies the "stability" conditions of Nash equilibrium (see Dixit (1986)), which are equivalent to $\left| \frac{dt^B}{dt^A} \right| < 1$.

Proposition 2 *Starting from a symmetric equilibrium where neither government has a paternalistic objective, consider a small change whereby one country adopts paternalistic taxation to reduce the consumption of a harmful good. Both countries' tax rates increase, and there is an asymmetric equilibrium where the paternalistic country has the higher tax rate.*

5 Minimum tax rates

Let us next turn to the question whether policy coordination can be beneficial when the starting point is the equilibrium examined in the previous section. In the current section, we examine whether welfare can be increased by setting a binding minimum tax rate requirement. In the following section, we will analyse the effects of tax rate harmonisation. Both are key measures that have been proposed in the EU to curtail excessive cross-border shopping.

5.1 Welfare effect on the high-tax country

As country A is in regime I and has a paternalistic objective, its social welfare function is $W_I^A = \bar{v}_I^A(t^A, b^A - s^A) + \gamma t^A c_A^A$. The derivative with respect to country B 's tax rate is

$$\begin{aligned} \frac{\partial W_I^A}{\partial t^B} &= -\alpha c_B^A - h'(c^A) \frac{\partial c^A}{\partial q^B} + \gamma t^A \frac{\partial c_A^A}{\partial q^B} \\ &= \left(-\alpha + \frac{h'(c^A)}{q^A} \right) c_B^A + \gamma t^A \left(\frac{-c_B^A}{q^A} + \frac{1}{\tau''} \right) \end{aligned} \quad (11)$$

From this expression, we can isolate two effects, identified in previous literature (see Mintz and Tulkens (1986) and Haufler (1996)), of an increase in the low-tax country's tax rate on the high-tax country's welfare: firstly, the private consumption effect, which is given by the two first terms in (11), is the direct welfare effect of the reduction in private consumption, caused by the increased cost of cross-border shopping. Secondly, the public consumption effect (or the tax revenue effect), given by the last term in (11), gives the effect of the increase in the low-tax country's tax rate on government revenue in the high-tax country¹⁶.

¹⁶These effects have been aggregated into the "consumer price spillover" in Lockwood (2001). Lock-

Consider first the private consumption effect. The nature of this effect is in our context very different from the standard case: in our setting, high consumption is not necessarily beneficial for welfare, and a tax increase in the low-tax country therefore generates a positive spillover not analysed in previous literature. In the standard case without paternalism, the private consumption effect is always negative, and consists only of the very first term in (11), $-\alpha c_B^A$: this is a terms of trade effect, as consumers experience a loss due to more expensive cross-border shopping. However, the paternalistic objective implies that the sign of the private consumption effect may be reversed: in the case with paternalism, the reduction in consumption has an additional positive effect (given by the term $-h'(c^A) \frac{\partial c^A}{\partial q^B}$), as the harm caused by consumption is thereby reduced¹⁷. In net, the sign of the private consumption effect is thus in our case ambiguous. From (11), it is positive if $q^A < \frac{h'(c^A)}{\alpha}$. The high-tax country is therefore more likely to benefit from the tax increase in the low-tax country when the marginal harm created by consumption is high and the paternalistic objective therefore plays a stronger role.

The last term in (11) refers to the public consumption effect. This effect is identical to the standard case, as presented in Haufler (1996). The public consumption effect can be either positive or negative, depending on whether an increase in the low-tax country's tax rate increases or reduces domestic demand. The latter case, which may seem paradoxical, can be explained by the fact that a tax increase in the low-tax country reduces not only cross-border shopping, but also *total* demand c^A due to an income effect. Whether the domestic tax base increases or decreases when the foreign tax rate is increased, depends on how responsive cross-border shopping is to changes in the tax rate differential; this in turn depends on the shape of the transport cost function. Let us again consider the special case of quadratic transport costs. As in Haufler (1996), the public consumption effect is then unambiguously positive: domestic demand is then given by $c_A^A = \frac{1}{q^A} \left(1 - \frac{q^A - q^B}{\theta} - \frac{(t^A)^2 - (t^B)^2}{2\theta} \right)$ and therefore $\frac{\partial c_A^A}{\partial q^B} = \frac{q^B}{\theta q^A} > 0$.

However, the ambiguity about the sign of the private consumption effect is not resolved by assuming quadratic transport costs, as it depends primarily on the extent of harm from consumption and therefore on the strength of the paternalistic objective. Further analysis is therefore needed to determine whether the overall effect in (11) is

wood further discusses two other tax spillovers, namely producer price spillovers and rent spillovers. These effects however are only present when there is imperfect factor mobility or imperfect competition, respectively, and therefore do not arise in our model.

¹⁷Christiansen (2006) has independently obtained similar results in a context where there are negative externalities from the consumption of a cross-border traded good (see Proposition 4 in his paper). The emphasis in his paper - the effect of cross-border shopping on the optimal commodity tax structure - is distinctly different from ours.

positive or negative. Noting again that with quadratic transport costs $c_B^A = \frac{q^A - q^B}{\theta}$, the expression for $\frac{\partial W_I^A}{\partial t^B}$ becomes

$$\frac{\partial W_I^A}{\partial t^B} = \left[-\alpha + \frac{h'(c^A)}{q^{A*}} + \frac{\gamma}{q^{A*}} \frac{(q^{A*} - 1) q^{B*}}{(q^{A*} - q^{B*})} \right] c_B^A > 0.$$

This expression can easily be shown to be positive by comparing it with the high-tax country's first-order condition (7). Therefore, if transport costs are quadratic, the sum of the private and public consumption effects is positive, and the paternalistic country benefits from a binding minimum tax rate requirement on the low-tax country.

5.2 Welfare effect on the low-tax country

Let us next consider the effect of a binding minimum tax rate requirement on welfare in the low-tax country. If the required increase in the tax rate of the low-tax country is small, then the welfare effect depends only on the reaction of the high-tax country. We therefore need to examine firstly, how country B 's welfare is affected by changes in country A 's tax rate, and secondly, how country A 's tax rate reacts to a (small) increase in country B 's tax rate.

The effect of a change in country A 's tax rate on welfare in country B is $\frac{\partial W_{II}^B}{\partial t^A} = \gamma t^B \frac{\partial c_B^A}{\partial q^A} > 0$: an increase in the high-tax country's tax rate would unambiguously increase the amount of cross-border shopping and it would thus have a positive public consumption effect on country B . Therefore, if the tax rates are strategic complements also from the point of view of country A , and an increase in country B 's own tax rate therefore induces country A also to increase its tax rate, then the minimum tax rate requirement increases welfare in country B .

Next, we need to examine how country A 's tax rate reacts to an increase in country B 's tax rate. Country A is in regime I and has a paternalistic objective, and its reaction function (from (7)) is therefore given by

$$\frac{\partial W_I^A}{\partial t^A} = R^A(t^B, t^A) = -\alpha c_A^A + h'(c^A) \frac{c_A^A}{q^{A*}} + \gamma \left(\frac{c_A^A}{q^{A*}} - \frac{t^{A*}}{\tau''} \right) = 0 \quad (12)$$

By a similar argument as in the previous section, $\text{sign} \left(\frac{dt^A}{dt^B} \right) = \text{sign} \left(\frac{\partial R^A}{\partial t^B} \right)$. Differentiating (12) yields

$$\frac{\partial R^A(t^B, t^A)}{\partial t^B} = \left(-\alpha + \frac{h'(c^A)}{q^{A*}} + \frac{\gamma}{q^{A*}} \right) \frac{\partial c_A^A}{\partial q^B} + h''(c^A) \frac{\partial c_A^A}{\partial q^B} \frac{c_A^A}{q^{A*}}. \quad (13)$$

The sign of this expression is in general ambiguous. We can however again analyse the special case of quadratic transport costs. In this case we know that $\frac{\partial c^A}{\partial q^B} > 0$. It can also be observed from (12) that $-\alpha + \frac{h'(c^A)}{q^{A*}} + \frac{\gamma}{q^{A*}} > 0$. With quadratic transport costs, the first half of (13) is therefore positive.

However, the sign of the latter part, $h''(c^A) \frac{\partial c^A}{\partial q^B} \frac{c^A}{q^{A*}}$, hinges on whether the harm function is concave or convex. The sign of $\frac{\partial R^A(t^B, t^A)}{\partial t^B}$ therefore remains ambiguous even with quadratic transport costs, and it is guaranteed to be positive only if the harm function is not too convex. When the harm function is very convex, the reduction in consumption caused by higher taxation in country B already causes a large reduction in harm, and the case for domestic tax increases in country A is therefore weakened.

It is interesting to note that with quadratic transport costs, a stronger paternalistic concern in country A makes it more likely that (13) is positive: the stronger the paternalistic concern, the more likely it is that country A increases its tax rate in response to a tax increase in country B . In the previous subsection we concluded that a stronger paternalistic concern also makes it more likely that the high-tax country benefits from the minimum tax rate requirement. Therefore, the presence of a stronger paternalistic concern - implying that there is more divergence in the policy objectives of the two countries - makes it more likely that a binding minimum tax rate on the low-tax country is Pareto improving.

Further, if we consider the example of alcohol, recent medical research has provided evidence that the harm function from alcohol consumption may in fact be linear (Johansen *et al.* 2005). If this is the case, the last term in (13) vanishes, and a policy of minimum tax rate requirement will be Pareto improving.

We summarise the results of this section in the following proposition:

Proposition 3 *Starting from a symmetric equilibrium where neither government has a paternalistic objective, consider a small change whereby one country adopts paternalistic taxation to reduce the consumption of a harmful good. In the resulting asymmetric equilibrium, the welfare effect of a binding minimum tax rate requirement is in general ambiguous. With quadratic transport costs, the following results hold:*

- (i) *the welfare effect on the high-tax country is positive.*
- (ii) *the welfare effect on the low-tax country is positive if the harm function is not too convex.*
- (iii) *a stronger paternalistic objective makes it more likely that the policy is Pareto improving.*

Our analysis has therefore shown that even when countries have very different

views about the proper role of alcohol taxation - whether it should be used for revenue raising purposes only, or as part of national health policy - they can benefit from policy coordination. The different views about alcohol taxation held for example by different member states of the EU should therefore not be an obstacle to policy coordination aimed at eliminating harmful tax competition.

6 Tax harmonisation

Let us finally analyse another possible coordination measure which has been discussed by European policy makers, namely tax rate harmonisation. Our argument in this section is most closely related to the analysis of tax harmonisation in Kanbur and Keen (1993). However, Kanbur and Keen as well as various authors building on their analysis (see Nielsen (2001) and Ohsawa (1999)) assume that the governments' objective is to maximise tax revenue. We consider also the effects on private consumption, taking into account the fact that in our context, increases in private consumption are not always welfare improving¹⁸.

We take harmonisation to mean that taxes in the two countries are set at a common, intermediate level between the initial tax rates. Such a reform eliminates all cross-border shopping, and might therefore seem like an attractive remedy for the problems stemming from cross-border shopping and tax competition.

However, it is easy to see that the low-tax country would lose from harmonisation to any tax rate $t \in (t^{B*}, t^{A*})$ ¹⁹. Under tax harmonisation, welfare in the (previously) low-tax country, country B , is given simply by $W^{B,H} = v(t) + \gamma t c^B(t)$. For any given tax rate, welfare is therefore lower with tax harmonisation than without it: for any tax rate t , the level of consumption is the same as in the previous equilibrium, but tax revenue is lower since the country loses all revenue from foreign cross-border shoppers. We therefore have that $W^{B,H}(t) < W^B(t)$ for all t , and in particular $W^{B,H}(t) < W^B(t^{B*})$: tax harmonisation is certain to reduce welfare in country B .

Turning next to effects in the high-tax country, we can gain useful insights by exam-

¹⁸See also Keen (1987, 1989) for seminal contributions to the literature on tax harmonisation (looking at destination-based taxes) and Lopez-Garcia (1996) and Kotsogiannis, Lopez-Garcia and Myles (2005) for analyses with origin-based taxation. These papers consider tax harmonisation in a setting with differentiated goods, and do not model cross-border shopping or transport costs explicitly. Lockwood (2001) provides a synthesis of many results from the previous literature, but he does not consider harmonisation of origin-based taxes.

¹⁹As in Kanbur and Keen (1993), we do not consider the possibility of transfers between countries, but look at each country separately and concentrate on whether actual Pareto improvements could be obtained by harmonisation.

ining the effects of harmonisation at either of the original tax rates, t^{B*} and t^{A*} . Firstly, harmonisation at t^{B*} would be certain to reduce welfare in the high-tax country, since we know that $W^A(t^{A*}(t^B), t^B) > W^A(t^B, t^B)$. Secondly, let us consider harmonisation at t^{A*} . We know that total private consumption will necessarily fall: consumers were maximising their consumption at the original equilibrium by doing some cross-border shopping, and therefore private consumption must fall in the new situation where there is no cross-border shopping but domestic consumption is as expensive as before. Government revenue, on the other hand, will increase due to an increase in the tax base: using the consumer budget constraint, we know that in the original equilibrium, government revenue is given by $\frac{Y - \tau(c_B^A) - q^{B*}c_B^A}{q^{A*}}t^{A*}$, whereas in the new situation it is simply $\frac{Y}{q^{A*}}t^{A*}$.

Thus we have established that in the (previously) high-tax country, private consumption falls and government revenue increases after harmonisation at t^{A*} . In our context, it is not clear whether reductions in consumption are harmful from the social point of view, due to the harm generated by consumption but not taken into account by consumers - see the previous section, where we argued that the private consumption effect may be either positive or negative in the high-tax country in the original equilibrium. In principle, there would therefore be two cases to consider - the one where consumption is too high in the original equilibrium, and the one where consumption is too low. However, since the government's objective function is not monotonic in the level of consumption, it is not possible to derive unambiguous results for the welfare effect on country A in either of these cases²⁰.

As an aside, it is interesting to note that the result in Kanbur and Keen (1993), that harmonisation to t^A (or any tax rate sufficiently close to it) would always be welfare improving in the high-tax country, does not seem to be robust - in the conventional setting where increases in consumption are beneficial - to extending the government's welfare function beyond simple revenue maximisation. When increases in consumption are beneficial, country A might either benefit or lose out from harmonisation to t^{A*} , depending on the relative weights given to private and public consumption in the social welfare function.

How about the welfare effects in country A of harmonisation at some tax rate $t \in (t^{B*}, t^{A*})$? Since harmonisation at t^{B*} strictly lowers welfare in country A , by continuity, there is a threshold tax rate $\hat{t} \in (t^{B*}, t^{A*})$ below which harmonisation will

²⁰Even in the case where consumption was initially too high and a marginal reduction in consumption would therefore be beneficial, we cannot conclude that welfare would be increased by a discrete increase in country B 's tax rate from t^{B*} to t^{A*} , as consumption in country A might then be reduced too much.

certainly be welfare reducing for country A . However, harmonisation above \hat{t} will have an ambiguous effect on welfare in country A .

We summarise our findings on the welfare effects of tax harmonisation in the following proposition:

Proposition 4 *There exists a tax rate \hat{t} , such that tax harmonisation at any $t \in (t^{B*}, \hat{t})$ is welfare reducing for both countries. The welfare effect of harmonisation at $t \in (\hat{t}, t^{A*})$ is negative for country B and ambiguous for country A .*

We can therefore say that even though the two countries with different policy objectives can benefit from coordination as shown in Proposition 3, the coordination should be done through minimum tax rate requirements rather than through tax rate harmonisation. Welfare is not reduced by cross-border shopping per se, but by tax rates being too low. The more effective remedy is therefore to implement mandatory increases in tax rates, rather than to eliminate cross-border shopping by tax harmonisation.

7 Conclusions

We have analysed how the possibility of using taxation as a tool to control the consumption of a harmful good is affected by cross-border shopping and commodity tax competition. In a context where a paternalistic country has a neighbour with an exogenously given, lower tax rate, we showed that cross-border shopping leads to a reduction of the paternalistic component of the tax on the harmful good: with the possibility of cross-border shopping, domestic taxation is an inefficient instrument for reducing harmful consumption. However, paternalism still continues to play a role in tax policy.

We also analysed explicitly the outcome of tax competition between two countries, one of which has a paternalistic objective whereas the other one does not. In such a situation, the paternalistic country has the higher tax rate. We further examined whether welfare could be improved by policy coordination, and showed that the welfare effects of tax harmonisation would be negative on the low-tax country and ambiguous on the high-tax country.

However, the prospects for welfare gains from minimum tax rate requirements seem more promising. It was shown that in a model with quadratic transport costs, the paternalistic country would benefit from a small increase in the other country's tax rate. The low-tax country would also benefit, if the harm function from consumption is not too convex.

Further, it is interesting to note that a stronger paternalistic objective makes it more likely that the policy of a minimum tax rate requirement is Pareto improving: firstly, the paternalistic country is then more likely to benefit from the reduction in consumption caused by a higher foreign tax rate; and secondly, the paternalistic country is then more likely to respond to the minimum tax rate requirement by increasing its tax rate in turn, which is beneficial for the low-tax country as it alleviates the tax revenue externality caused by tax competition.

Our analysis therefore indicates that even countries with very different attitudes towards paternalism can benefit from policy coordination. The divergent views about alcohol taxation held for example by different member states of the EU should therefore not be an obstacle to policy coordination aimed at eliminating harmful tax competition.

The current paper has concentrated on analysing the effects of paternalism and tax competition on commodity taxation. An interesting issue for further research would be to conduct a similar analysis in a context with several policy instruments. In a more general framework, it might become optimal to adjust other taxes or the pattern of public spending in a way that is conducive to harm abatement (putting more emphasis on health care spending, for instance). The presence of multiple policy instruments might also open up new possibilities for policy coordination.²¹

Appendix

The second-order condition in the tax competition game for regime I (the high-tax country) is

$$\frac{\partial^2 W_I^i(t^i, t^j)}{\partial t^{i2}} = \left(-\alpha + \frac{h'(c^i)}{q^{i*}} + \frac{\gamma}{q^{i*}} \right) \frac{\partial c_i^i}{\partial q^i} - (\gamma + h'(c^i)) \frac{c_i^i}{(q^{i*})^2} + h''(c^i) \frac{\partial c_i^i}{\partial q^i} \frac{c_i^i}{q^{i*}} - \frac{\tau'' - \frac{\tau'''}{\tau''} t^{i*}}{(\tau'')^2} < 0.$$

The first term is negative by (1) and (7). The second term is also negative. The third term is non-positive if the harm function is convex or linear, which we have argued to be the most likely case. Finally, the last term is negative for example if the transport cost function is quadratic (this is a sufficient, though not a necessary condition).

In the case of regime II (the low-tax country), the second-order condition is

²¹See Keen and Marchand (1994) for an analysis of how fiscal competition affects the pattern of public spending (in the absence of paternalism), and Pirttilä and Tenhunen (2007) for an analysis of how public spending is affected by paternalism (in the absence of fiscal competition).

$$\frac{\partial^2 W_{II}^i(t^i, t^j)}{\partial t^{i2}} = \left(-\alpha + \frac{2h'(c^i)}{q^{i*}} + \frac{2\gamma}{q^{i*}} \right) \frac{\partial c^i}{\partial q^i} + h''(c^i) \frac{\partial c^i}{\partial q^i} \frac{c^i}{q^{i*}} - \frac{(1 + \gamma) \tau'' + \frac{\tau'''}{\tau''} t^{i*}}{(\tau'')^2} < 0.$$

The first term is guaranteed to be negative given our assumption that $\gamma > \alpha$ and if the tax rate in the low-tax country is less than 100% of the producer price (a sufficient but not a necessary condition). As above, the second term is negative if the harm function is convex or linear, and the last term is negative for example if the transport cost function is quadratic (again a sufficient but not a necessary condition).

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Essay 4.

Access Price Regulation, Investment and Entry in Telecommunications*

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Abstract

We consider a model with a vertically integrated monopolist network provider who faces rival operators in the retail market. We examine the network operator's incentives for infrastructure investment. We find that investments are below the social optimum even when there is no regulation, and access price regulation further reduces investment incentives. We show that the underinvestment problem may have negative effects on the viability of competition. Access price regulation does not necessarily reduce the likelihood of foreclosure, and in the presence of regulation, rivals are most likely to be foreclosed when they would bring highest benefits to consumers.

Keywords: access pricing, regulation, investment, foreclosure

JEL: L22, L43, L51, L96

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1 Introduction

We analyse the effect of access price regulation on a local telecommunications network provider's incentives to invest in infrastructure. We consider a vertically integrated incumbent who provides network access to a fringe of rival operators in the retail sector.

We find that spillovers to rivals' demand reduce investment when access prices are regulated: as the incumbent is not allowed to make a profit on access provision, investment incentives are lower than in the absence of regulation. Further, if rivals benefit more from the investment than the incumbent, no investment takes place. Investments are below the social optimum, and the underinvestment problem may have negative effects on the viability of competition. Further, we find that in the presence of access price regulation, rivals are most likely to be foreclosed precisely when they would bring highest benefits to consumers. The issues discussed in this paper are relevant for today's regulators, who are concerned about encouraging investment in communications networks and ensuring competition in service provision.

Our paper is related to literature on investment spillovers and R&D (see for example Arrow (1962), Spence (1984), D'Aspremont and Jacquemin (1988), Kamien, Muller and Zang (1992), Auriol (1998)), as well as to literature on foreclosure (see for example Rey and Tirole (2005)). Access pricing and investment in network industries have been examined by Gans (2001), Pindyck (2004), Economides and Lehr (1994) and Valletti and Cambini (2005).¹

The paper closest to ours is Foros (2004), who examines an integrated access provider's incentives to upgrade its network to broadband, when it faces a Cournot competitor in the retail market. We model the rivals as a competitive fringe, which seems justifiable, as we assume that fixed costs in the retail market are negligible. The competitive fringe model has been used also in the seminal literature on access pricing (see for example Armstrong (2002, Section 2)). Further, we assume vertical differentiation, which can arise for example due to switching costs that customers incur if they subscribe to the fringe instead of the incumbent. These assumptions make our model suitable for analysing the effect of the incumbent's investment decision on entry.

¹ See Kotakorpi (2004) for a more detailed comparison to previous literature and more references.

2 The model

We denote a consumer's basic willingness to pay for the incumbent's service by x and assume that x is uniformly distributed on $(0,1)$ with density 1. There is vertical differentiation, so that a customer's valuation for the fringe's services is γx , $\gamma \in (0,1)$.

We investigate the incumbent's incentives to invest in a network technology that increases consumers' willingness to pay for services. An example would be upgrading a narrowband telecommunications network to broadband. We assume that an investment that causes all consumers' valuation for the incumbent's services to increase by m costs $\frac{1}{2}\psi m^2$, $\psi > 0$. As the rivals use the incumbent's network, infrastructure investments have a positive effect on the rivals: consumers' valuation for the fringe's services increases by βm , $\beta \geq 0$. This specification allows for the possibility that spillovers are incomplete, in which case $0 \leq \beta < 1$. On the other hand, in some cases investment might be more beneficial for the fringe than the incumbent ($\beta > 1$). This can occur for example if the rivals' ability to use the new technology to provide new, value added services is better than the incumbent's.

We assume that consumers have unit demands, so that a customer who subscribes to firm i ($i = 1, 2$) pays p_i for a single unit of telecommunications services. We use subscript 1 to refer to the incumbent and 2 to the fringe. We normalize the utility from not buying to 0. The person with the highest valuation buys from the incumbent if $1 + m - p_1 > 0$ and $1 + m - p_1 > \gamma + \beta m - p_2$. This condition is needed for it to be possible for the incumbent and the rivals to be active in the market simultaneously, and we assume that it holds. The market is segmented such that the incumbent serves consumers with the highest valuation and the fringe those with an intermediate valuation, and consumers with a low valuation might not purchase at all². The demand functions are given by³

$$\begin{aligned} q_1(p_1, p_2, m) &= 1 + \frac{1}{1-\gamma} [(1-\beta)m - p_1 + p_2] \\ q_2(p_1, p_2, m) &= \frac{1}{1-\gamma} \left[\frac{\beta-\gamma}{\gamma} m + p_1 - \frac{1}{\gamma} p_2 \right] \end{aligned} \quad (1)$$

² Shaked and Sutton (1982) show that such an equilibrium (where consumers with highest willingness to pay buy from the highest quality firm and so on) typically arises in models with vertical differentiation.

³ See Kotakorpi (2004, 8) for a more detailed derivation.

We assume that there is a fixed cost f of network operation but fixed costs in the retail market are negligible. The incumbent incurs a marginal cost c per customer of originating and terminating calls on the network. We assume that the firms have equal marginal costs in the retail sector, and we normalize these to zero.

We denote the access charge by a . In equilibrium, the fringe firms set $p_2 = a$ and make zero profit. When both firms are active in the market, the incumbent's profits are

$$\pi(p_1, a, m) = \left[1 + \frac{1}{1-\gamma} ((1-\beta)m - p_1 + a) \right] (p_1 - c) + \frac{1}{1-\gamma} \left[\frac{\beta-\gamma}{\gamma} m + p_1 - \frac{1}{\gamma} a \right] (a - c) - \frac{1}{2} \psi m^2 - f, \quad (2)$$

where the first term is the profit from retail sales to the incumbent's own customers and the second term is the profit from selling access to the fringe. When there is foreclosure (that is when $q_2(p_1, p_2, m) = 0$), the incumbent's profit function is

$$\pi^M(p_1, m) = (1 + m - p_1)(p_1 - c) - 1/2 \psi m^2 - f. \quad (3)$$

3 Unregulated access charge

The timing of the model without regulation is as follows. First, the incumbent chooses m . Second, the incumbent sets p_1 and a . The model is solved by backwards induction. The profit-maximizing levels of p_1 and a are

$$\begin{aligned} p_1^*(m) &= \frac{1}{2}(1 + m + c) \\ a^*(m) &= \frac{1}{2}(\gamma + \beta m + c) \end{aligned}, \quad (4)$$

which imply that

$$\begin{aligned}
q_1^*(m) &= \frac{1-\gamma+(1-\beta)m}{2(1-\gamma)} \\
q_2^*(m) &= \frac{(\gamma-1)c+(\beta-\gamma)m}{2\gamma(1-\gamma)}.
\end{aligned} \tag{5}$$

The profit-maximizing level of investment can be calculated after substituting (4) into (3) and is given by

$$m^* = \frac{(1-\gamma)(\gamma-\beta c)}{2\beta\gamma-\beta^2-\gamma+2\gamma\psi(1-\gamma)}. \tag{6}$$

In order to analyse how the incumbent's investment decision affects market outcomes, we make the following assumptions: Firstly, we assume that $\gamma < \beta$; otherwise, the incumbent's pricing decisions alone imply foreclosure (see Equation (5)). Secondly, we assume that $c < \frac{\gamma}{\beta}$, which guarantees that m^* is positive. A third assumption we make throughout the paper is that $c < \gamma$, so that both final products could be profitably supplied by a monopolist.

The properties of equilibrium investment are summarized in the following proposition:

Proposition 1. When there is no access price regulation (i) spillovers have a positive effect on investment. (ii) Investment is below the socially optimal level.

Proof. See the Appendix for the proofs of all Propositions.

The result that spillovers have a positive effect on investment when there is no regulation is not surprising, given that the incumbent can earn monopoly profits from the access market.⁴ Nevertheless, investments are below the social optimum⁵.

Inserting (6) into (5), the equilibrium quantities are

⁴ Foros (2004) obtains a similar result.

⁵ In general, a monopolist can have too high or too low incentives to invest in quality (Spence 1975).

$$\begin{aligned}
q_1^* &= \frac{\beta[\gamma - \beta + (\beta - 1)c] + 2\gamma\psi(1 - \gamma)}{2[2\beta\gamma - \beta^2 - \gamma + 2\gamma\psi(1 - \gamma)]} \\
q_2^* &= \frac{\beta - \gamma + (1 - \beta)c - 2c\psi(1 - \gamma)}{2[2\beta\gamma - \beta^2 - \gamma + 2\gamma\psi(1 - \gamma)]}.
\end{aligned} \tag{7}$$

The rivals' output is positive if and only if⁶

$$c < c^f \equiv \frac{\beta - \gamma}{\beta - 1 + 2\psi(1 - \gamma)}. \tag{8}$$

If condition (8) fails, the rivals are foreclosed from the market. The condition $\gamma < \beta$ implies that rivals' output is increasing in investment and therefore low output by the rivals (or foreclosure) is a symptom of low investment. From (8), if the marginal cost of production is too high or if the cost of investment increases too rapidly, high investment is not profitable and foreclosure becomes more likely. When (8) is violated, the incumbent becomes a monopolist also in the retail market. It is straight-forward to show that there is underinvestment also in this case.

Further, as the right hand side of (8) is increasing in β , we can state the following proposition:

Proposition 2. When there is no regulation, foreclosure is most likely to occur when investment spillovers are low.

A low value of the spillover parameter β implies that investment has only a small positive impact on rivals' demand. In the absence of regulation, the incumbent can make a monopoly profit also on access provision. Low investment spillovers therefore discourage investment and make foreclosure more likely.

⁶ Foreclosure is not ruled out by our assumptions on c as there are parameter values for which $\gamma > c^f$ and $\frac{\gamma}{\beta} > c^f$.

4 Regulated access charge

Let us next consider the effects of access price regulation. We assume that the access charge is the only instrument available for the regulator. This corresponds closely to current European practice, as the new regulatory framework for electronic communications emphasizes that retail level regulation is justified only if wholesale measures cannot be used (Directive 2002/22/EC, Article 17). Further, we share the view expressed by Pindyck (2004, 5), that most network investments in telecommunications are irreversible. We therefore assume that the regulator is unable to make a credible commitment to an access pricing regime prior to the investment stage.⁷ The timing of the model is as follows. First, the incumbent chooses the level of investment. Second, the regulator sets the access charge. Third, the incumbent sets its retail price.

We take social welfare to be the sum of consumer surplus and profits. Inserting the incumbent's profit-maximizing pricing rule $p_1^*(a, m) = \frac{1}{2}[1 - \gamma + (1 - \beta)m + 2a]$ into the social welfare function, and taking the total derivative with respect to a , it can be shown that the socially optimal access charge is in the present model equal to the marginal cost of network provision, that is, $a_R = c$. Equilibrium quantities as a function of investment are

$$\begin{aligned} q_{1,R}^*(m) &= \frac{1 - \gamma + (1 - \beta)m}{2(1 - \gamma)} \\ q_{2,R}^*(m) &= \frac{(1 - \gamma)(\gamma - 2c) + (2\beta - \gamma - \beta\gamma)m}{2\gamma(1 - \gamma)}. \end{aligned} \quad (9)$$

To make this case comparable with the case without regulation, we continue to assume that $\beta > \gamma$. The rivals' output is again increasing in m and $c < \frac{\gamma}{2}$ would be a sufficient condition for the rivals to be active in the market. In order to find a necessary condition, we again examine the incumbent's investment decision. Profit-maximizing investment is now

$$m_R^* = \frac{(1 - \gamma)(1 - \beta)}{2\psi(1 - \gamma) - (1 - \beta)^2}. \quad (10)$$

⁷ Also Foros (2004) makes this assumption. Valletti and Cambini (2005) argue for and use the alternative assumption that the regulator sets the access price before the investment stage.

The properties of equilibrium investment under regulation are summarized in the following proposition:

Proposition 3. When the access charge is regulated, (i) spillovers have a negative effect on investment. (ii) If $\beta \geq 1$, there is no investment. (iii) Investment is below the socially optimal level and (iv) it is lower than in the absence of regulation.

The results in Proposition 3 are explained by the fact that under access price regulation, the incumbent cannot make a profit on access provision. Spillovers therefore discourage investment⁸, and investments are lower than in the absence of regulation.

The equilibrium quantities are

$$\begin{aligned} q_{1,R}^* &= \frac{\psi(1-\gamma)}{2\psi(1-\gamma) - (1-\beta)^2} \\ q_{2,R}^* &= \frac{(\beta-1)[\gamma - \beta + (\beta-1)c] + \psi(1-\gamma)(\gamma - 2c)}{\gamma[2\psi(1-\gamma) - (1-\beta)^2]} \end{aligned} \quad (11)$$

and the rivals' output is positive if and only if⁹

$$c < c_R^f \equiv \frac{(1-\beta)(\beta-\gamma) + \gamma\psi(1-\gamma)}{2\psi(1-\gamma) - (1-\beta)^2}. \quad (12)$$

Condition (12) refers to the case where $\beta < 1$ and investment is positive. If $\beta \geq 1$, the incumbent undertakes no investment and the stricter condition $c < \frac{\gamma}{2}$ has to hold for the rivals to be active in the market (see Equation (9)). We can therefore state the following proposition:

Proposition 4. When there is access price regulation, foreclosure is most likely to occur when investment spillovers are high ($\beta \geq 1$).

⁸ When rivals have market power, the disincentive effect of spillovers on investment is weaker than in our model (see Foros, 2004).

⁹ It can be shown that $c_R^f < \gamma$.

Further, by comparing c^f in (8) and c_R^f in (12) it can be shown that the effect of access price regulation on the likelihood of foreclosure is ambiguous. For example, if $\beta = 1.1$, $\gamma = 0.9$, $c = 0.5$, and $\psi = 1.45$, foreclosure occurs in the regulated but not in the unregulated case. Therefore even though the aim of access price regulation is to facilitate competition, it can in some cases increase the likelihood of foreclosure.

5 Conclusions

We have analysed a vertically integrated monopolist telecommunications network provider's incentives to invest in infrastructure, when it provides network access to rival operators. We have demonstrated that the incumbent underinvests relative to the social optimum and the problem is exacerbated by regulation.

The underinvestment problem deserves attention from regulators for three reasons. Firstly, like any other market distortion, insufficient investments imply losses to welfare. Secondly, the underinvestment problem can have adverse effects on competition. Thirdly, in the case of access price regulation, the exclusion of competitors is most likely precisely when they would bring highest benefits for consumers.

We have only considered the case of a monopoly network. With network competition, the problem of foreclosure would be eliminated. However, the underinvestment problem as well as some other inefficiencies might still remain (see Valletti and Cambini (2005)).

We have assumed that the regulator cannot commit to an access pricing regime prior to the incumbent's investment decision. If credible commitment were possible, the regulator would set $a^R > c$ to boost investment incentives. However, as long as the regulator has only one instrument, it has to settle a trade-off between providing investment incentives and ensuring allocative efficiency. Therefore, even if commitment were possible, the lessons of our paper would not lose their relevance: some mitigating effect of regulation on investment incentives is likely as long as selling access is less profitable than selling services directly to final customers.

Appendix

Proof of Proposition 1

We first check that the prices in (4) and therefore the investment level m^* in (6) are a global optimum by examining the possibility that the incumbent sets $a = \infty$. Profit would then be given by (3). Profit-maximizing price and investment would be $p_1^M = 1/2(1+m+c)$ and $m^M = (1-c)/(2\psi-1)$, with the second order condition $\psi > 1/2$. Now, $\pi^M(p_1^M, m^M) - \pi(p_1^*, a^*, m^*) = \frac{-[\beta(1-c)+c-\gamma-2c\psi(1-\gamma)]^2}{(2\psi-1)[2\beta\gamma-\beta^2-\gamma+2\gamma\psi(1-\gamma)]} < 0$, given $\psi > 1/2$ and the second order condition for profit-maximizing investment under competition,

$$2\beta\gamma - \beta^2 - \gamma + 2\gamma\psi(1-\gamma) > 0. \quad (\text{A1})$$

(i) The derivative $\frac{\partial m^*}{\partial \beta} = \frac{(1-\gamma)\{\gamma - \beta^2 - 2\gamma\psi(1-\gamma)\}c + 2\gamma(\beta - \gamma)}{[2\beta\gamma - \beta^2 - \gamma + 2\gamma\psi(1-\gamma)]^2}$ is positive if

$$c < \frac{2\gamma(\beta - \gamma)}{\beta^2 - \gamma + 2\gamma\psi(1-\gamma)}, \text{ which holds given (8), (A1), } \psi > 1/2, \text{ and } \beta > \gamma.$$

(ii) Taking social welfare to be the sum of consumer surplus and profits, socially optimal investment is $m^{so} = \frac{3(1-\gamma)(\gamma - \beta c)}{3(2\beta\gamma - \beta^2 - \gamma) + 4\gamma\psi(1-\gamma)}$, with the second order condition

$$3(2\beta\gamma - \beta^2 - \gamma) + 4\gamma\psi(1-\gamma) > 0. \quad (\text{A2})$$

Now, $m^{so} - m^* = \frac{2\gamma\psi(\gamma - \beta c)(1-\gamma)^2}{[2\beta\gamma - \beta^2 - \gamma + 2\gamma\psi(1-\gamma)][3(2\beta\gamma - \beta^2 - \gamma) + 4\gamma\psi(1-\gamma)]}$. The denominator is positive by (A1) and (A2). Further, we know that $\gamma - \beta c > 0$ has to hold for the profit-maximizing investment level to be positive. Therefore $m^{so} - m^* > 0$.

Proof of Proposition 2

The derivative $\partial c^f / \partial \beta = \frac{(1-\gamma)(2\psi-1)}{(\beta-1+2\psi(1-\gamma))^2}$ is positive given $\psi > 1/2$ and $\gamma < 1$.

Proof of Proposition 3

$$(i) \frac{\partial m_R^*}{\partial \beta} = \frac{(\gamma-1)[2\psi(1-\gamma)+(1-\beta)^2]}{[2\psi(1-\gamma)-(1-\beta)^2]^2} < 0.$$

(ii) The second order condition for profit-maximizing investment under regulation is

$$2\psi(1-\gamma)-(1-\beta)^2 > 0. \quad (A3)$$

Given this condition and $\gamma < 1$, the investment level in (10) is positive if and only if $\beta < 1$.

$$(iii) \text{ Socially optimal investment under regulation is } m_R^{SO} = \frac{(1-\gamma)(\beta\gamma+3\gamma-4\beta c)}{\beta(\beta\gamma-4\beta+6\gamma)-3\gamma+4\gamma\psi(1-\gamma)},$$

with the second order condition

$$\beta(\beta\gamma-4\beta+6\gamma)-3\gamma+4\gamma\psi(1-\gamma) > 0 \quad (A4)$$

$$\text{Further, } m_R^{SO} - m_R^* = \frac{2(1-\gamma)[2\beta(1-\beta)(\beta-\gamma+c(1-\beta))+\psi(1-\gamma)(\gamma+3\beta\gamma-4\beta c)]}{[2\psi(1-\gamma)-(1-\beta)^2][\beta(\beta\gamma-4\beta+6\gamma)-3\gamma+4\gamma\psi(1-\gamma)]}. \text{ This is}$$

positive given (A3), (A4) and $c < \gamma < \beta < 1$.

$$(iv) m^* - m_R^* = \frac{\beta(1-\gamma)[(1-\beta)(\beta-\gamma+c(1-\beta))+2\psi(\gamma-c)(1-\gamma)]}{[2\beta\gamma-\beta^2-\gamma+2\gamma\psi(1-\gamma)][2\psi(1-\gamma)-(1-\beta)^2]}. \text{ This is positive given (A1),}$$

(A3) and $c < \gamma < \beta < 1$.

Proof of Proposition 4

$$c_R^f - \frac{\gamma}{2} = \frac{(1-\beta)(2\beta-\gamma-\beta\gamma)}{2[2\psi(1-\gamma)-(1-\beta)^2]}. \text{ This is positive by } \gamma < \beta < 1 \text{ and (A3).}$$

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