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BEHAVIORAL WELFARE ECONOMICS AND FDA TOBACCO REGULATIONS

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ABSTRACT

The U.S. 2009 Tobacco Control Act opened the door for new anti-smoking policies by giving the Food and Drug Administration broad regulatory authority over the tobacco industry. We develop a behavioral welfare economics approach to conduct cost-benefit analysis of FDA tobacco regulations. We use a simple two-period model to develop expressions for the impact of tobacco control policies on social welfare. Our model includes: nudge and paternalistic regulations; an excise tax on cigarettes; internalities created by period 1 versus period 2 consumption; and externalities from cigarette consumption. Our analytical expressions show that in the presence of uncorrected externalities and internalities, a tax or a nudge to reduce cigarette consumption improves social welfare. In sharp contrast, a paternalistic regulation might either improve or worsen social welfare. Another important result is that the social welfare gains from new policies do not only depend on the size of the internalities and externalities, but also depend on the extent to which current policies already correct the problems. We link our analytical expressions to the graphical approach used in most previous studies and discuss the information needed to complete cost-benefit analysis of tobacco regulations. Finally, we use our model as a framework to re-examine the evidence base regarding the size of the relevant internalities.

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Introduction

Over the past 50 years the U.S. and other countries have enacted a range of anti-smoking policies including health information campaigns, excise tax hikes, and bans on smoking in public places. The U.S. 2009 Tobacco Control Act (TCA) opened the door for new anti-smoking policies by giving the Food and Drug Administration (FDA) broad regulatory authority over the tobacco industry. The TCA bans cigarette sales to minors, requires new graphic warning labels, bans flavored cigarettes other than menthol, and bans the use of misleading terms such as "light" in cigarette marketing. Beyond these specific requirements, the FDA is considering using its authority under the TCA to make additional product regulations such as banning menthol cigarettes, reducing cigarette nicotine content, and banning flavors in small cigars. The TCA does not allow the FDA to completely ban cigarettes or nicotine.

The TCA requires the FDA to design tobacco regulations to promote public health. However, regulations that promote public health do not necessarily improve consumer welfare. In the absence of the regulations, smokers could reap the same health benefits by voluntarily quitting or cutting down. FDA tobacco regulations potentially improve consumer welfare by preventing internalities when smokers fail to optimize. This poses a dilemma for applied welfare economics: when smokers fail to optimize, their observed consumption choices are not reliable indicators of the choices that would maximize their experience utilities.

We develop a behavioral welfare economics approach to measure the impact of FDA tobacco regulations on consumer welfare. While the TCA creates a public health standard for tobacco regulations, Executive Order 12866 also requires the FDA to conduct cost-benefit analysis (CBA) (FDA 2010, 2011, 2014, 2016). We contribute to an emerging line of research

that addresses the challenges of conducting CBAs of regulations that affect smoking and other addictive consumption (Weimer, Vining and Thomas 2009, Australian Productivity Commission 2010, Ashley, Nardinelli and Lavaty 2015, Cutler et al. 2015, Jin et al. 2015, Levy, Norton and Smith 2016).

The next section provides more background about FDA tobacco regulations and discusses the distinction between nudges versus paternalistic regulations that limit choices or create large disincentives. The following section uses a simple two-period model to develop expressions for the impact of tobacco control policies on social welfare. Our model is an example of the reduced-form approach to behavioral welfare economics (Mullainathan et al. 2012, Chetty 2015). Our model includes: nudge and paternalistic regulations; an excise tax on cigarettes; internalities created by period 1 versus period 2 consumption; and externalities from cigarette consumption. Our analytical expressions show that in the presence of uncorrected externalities and internalities, a tax or a nudge to reduce cigarette consumption improves social welfare. In sharp contrast, a paternalistic regulation might either improve or worsen social welfare. Another important result is that the social welfare gains from new policies do not only depend on the size of the internalities and externalities, but also depend on the extent to which current policies already correct the problems.

We then link our analytical expressions to the graphical approach used in most previous studies and discusses the information needed to complete CBAs of tobacco regulations. The key pieces of information needed are estimates of the internalities. We use our model as a framework to re-examine the evidence base for strong conclusions about the size of the internalities. The

next-to-last section examines the potential of different approaches to measure the internalities in more detail. We then provide a concluding discussion.

Categorizing FDA Tobacco Regulations

For our analysis we broadly categorize FDA tobacco regulations as either nudge regulations or paternalistic regulations. A few FDA tobacco regulations fit the definition of a nudge: an intervention "that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid." (Thaler and Sunstein 2008, p. 6) Nudges often involve framing or choice architecture, such as setting default options and automatic enrollments to encourage saving for retirement. One example of a tobacco nudge regulation is the TCA's ban of the use of misleading terms such as "light" in cigarette advertising and manufacturing. The ban is based on the argument that marketing low-tar and –nicotine cigarettes as "light cigarettes" misleadingly frames them as a healthier choice. The ban only changes the framing. After the ban, cigarettes formerly marketed as "light" remained on the market and in fact appear to have maintained most of their market share.[1] Another example of a tobacco nudge regulation is the TCA's requirement that advertisements that are likely to reach youth, including point-of-sale advertisements, must be black-and-white only.[2] The FDA's "The Real Cost" anti-smoking advertising campaign is another corrective nudge: it is designed to prevent youth smoking by making the harmful effects (the "Real Cost") of tobacco use more salient to adolescents.

[1] Authors' calculations from the National Survey on Drug Use and Health.

[2] This requirement has not been implemented due to court challenges.

More FDA tobacco regulations fall into the category of paternalistic regulations. A paternalistic regulation forbids options or changes incentives to encourage consumers to make choices that are more closely aligned with their fully optimizing choices.[3] An example of an almost literally paternalistic regulation is the TCA's ban of cigarette sales to minors. The ban is intended to prevent youth smoking by imposing significant new costs on underage potential purchasers (Abouk and Adams forthcoming). The FDA (2014, p. 13) notes that restrictions on youth access might also prevent youth smoking through social norms. We categorize regulations that stigmatize tobacco use as paternalistic regulations because they impose the direct utility cost of social disapproval. Another paternalistic regulation already implemented is the TCA's ban of flavors in cigarettes, other than menthol. As mentioned in the introduction, the FDA is considering other tobacco regulations including: banning menthol cigarettes, reducing cigarette nicotine content, and banning flavors in small cigars. Each of these potential regulations fits our definition of a paternalistic regulation: although designed to encourage healthier choices (by discouraging smoking) they forbid certain options and are not cheap or easy to avoid.

Tobacco regulations do not always fall neatly into our categories of nudges and paternalistic regulations. The TCA's graphic warning labels regulation is a prominent example. A graphic warning label might appear to be a nudge that increases the salience of the health consequences of smoking and serves as a counter-cue to smoking (Levy, Norton and Smith 2016, p. 26). However, the experimental study used to develop and test the proposed graphic warning

[3] To extend Thaler and Sunstein's imagery, paternalistic regulations could also be called "shoves."

labels did not find strong evidence that exposure to the labels improved smokers' awareness about health consequences (Nonemaker et al. 2010). Instead, the experiments find that exposure to the images on most of the labels elicited strong emotional responses including feeling "disgusted or grossed out" and that "the pack is difficult to look at." Consumer heterogeneity further complicates the categorization problem. Graphic warning labels might be nudges for some consumers, but to the extent they impose the direct utility cost of disgust, they also fit our definition of a paternalistic regulation.[4]

Our analysis does not consider the impact of FDA tobacco regulations on product manufacturing costs or new product entry. Many health, safety, and environmental regulations substantially increase manufacturing costs of products such as automobiles (Viscusi, Harrington and Vernon 2005, pp. 804 – 807). However, most of the implemented and proposed FDA tobacco regulations do not require major changes in manufacturing processes. For example, label changes to meet the graphic warning labels requirement create an estimated one-time cost of about $0.03 per pack.[5]

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[4] The Thaler and Sunstein definition of a nudge is intuitive but not precise, which raises hard-to-answer questions. Is the disgust created by graphic warning labels a significant change in economic incentives? In Canada and other countries that require graphic warning labels, some smokers purchase pack covers or store their cigarettes in non-labeled cases. Does the availability of aluminum cigarette cases for less than $CAN 5.00 mean that the graphic warning labels are cheap and easy to avoid? Avoiding the labels involves some inconvenience and cost, and smokers are still exposed to the labels when they make purchases.

[5] The total one-time costs of the labeling change are estimated to be in the range of $273 to $465 million (FDA 2011, p. 36735). 14.4 billion packs of cigarettes were sold in the U.S. in 2011 (Orzechowski and Walker 2011).

FDA tobacco regulations might have a more significant impact on the entry of new products, most notably vaping products. The FDA's deeming regulation extends its authority to regulate tobacco products to include vaping products (FDA 2016). After a grace period, vaping product manufacturers will be required to submit marketing applications in order to continue to sell their products. The FDA (2016, Tables 11a and 12a) estimates that manufacturers will face costs between $182,000 and $2 million per application for e-liquids and between $286,000 and $2.6 million per application for delivery systems. The FDA estimates that rather than face these costs, between 50 and 87.5 percent of current manufacturers of e-liquids and 50 percent of current manufacturers of delivery systems will not enter the new regulated market. The implications of regulation-induced entry costs for market concentration, prices, product variety and ultimately consumer welfare are beyond the scope of our analysis.

FDA Tobacco Regulations: Model and Welfare Analysis

A Two-Period Model of Smoking and FDA Regulations

We develop a simple two period model of smoking and FDA tobacco regulations. The model assumes that smoking only creates adverse consequences in period 2. The consumer can avoid all health consequences by reducing period 2 cigarette consumption: just-in-time (JIT) quitting. This assumption is based on evidence from epidemiologic and econometric studies that smokers who quit by around age 40 avoid almost all of the excess mortality risk associated with smoking (Doll et al. 2004, Jha et al. 2013, Darden, Gilleskie and Strumf 2016). Our JIT assumption is an approximation to capture the patterns shown in the survival curves in these studies. Our JIT assumption also abstracts away from the immediate morbidity risks of smoking.

Mortality risks are valued so much more heavily than morbidity risks that they dominate consumer decision-making and social welfare calculations.[6]

Period 1 decision utility (V_1) is assumed to be a quasi-linear function of the quality (G_1) and quantity (A_1) of cigarettes consumed and a composite commodity (Y_1):

$$V_1 = G_1 U(A_1) + Y_1 \quad \textbf{(1)}$$

Period 2 decision utility (V_2) includes terms for the consumer's perceived adverse consequences of cigarette consumption. We model these consequences as utility losses of $L_{2|1}$ of period 2 loss per unit of period 1 cigarette consumption and $L_{2|2}$ of period 2 loss per unit of period 2 cigarette consumption:

$$V_2 = G_2 U(A_2) + Y_2 - L_{2|1} A_1 - L_{2|2} A_2 \quad \textbf{(2)}$$

$L_{2|1}$ includes the perceived utility losses due to withdrawal costs: period 1 cigarette consumption increases the utility cost of reducing cigarette consumption in period 2. In this way, our model is a special case of the Becker and Murphy (1988) rational addiction model. $L_{2|2}$ includes the perceived utility losses due to the smoking-related mortality and morbidity if the individual continues to consume cigarettes in period 2.

Lifetime decision utility is given by:

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[6] For example, Sloan et al. (2004, Table 11.1, p. 252) estimate the present value of the private costs of smoking to a 24-year-old smoker in 2000. The morbidity and disability costs are only 17 percent the size of the mortality costs. In the data used in the Sloan et al. calculations (Table 9.5, p. 208) 85 percent of the most severe measure of disability due to smoking is experienced by smokers over the age of 50, which implies that more than 85 percent is experienced by smokers over the age of 40. Putting these estimates together suggests that abstracting from the immediate morbidity costs of smoking to smokers under the age of 40 misses less than 10 percent of the value of the adverse consequences of smoking.

$$V_1 + V_2 = G_1 U(A_1) + Y_1 + G_2 U(A_2) + Y_2 - L_{2|1} A_1 - L_{2|2} A_2 \quad \textbf{(3)}$$

Tobacco policies enter the model as follows. First, a cigarette tax T enters the standard lifetime budget constraint. The consumer faces exogenous period 1 and period 2 incomes (Z_1 and Z_2) and a cigarette price P which is a function of the tax: P = P (T).

Second, we assume that a corrective nudge regulation determines the fraction N of the experienced adverse consequences (denoted by superscript E) that are perceived by the consumer: $L_{2|1} = N\, L^E_{2|1}$ and $L_{2|2} = N\, L^E_{2|2}$. When N < 1 the consumer creates an internality for himself in period 2. We take a reduced-form approach to behavioral welfare economics and do not specify the source of the behaviors that create the internalities (Mullanaithan et al. 2012). Possible sources of the internalities include imperfect information, present bias, time inconsistency, and projection bias. Our simple approach to model the regulation captures the Thaler and Sunstein (2009) definition of a nudge. The nudge N does not enter the budget constraint or directly influence utility. Instead, increasing N helps correct consumers' mistakes and moves their perceptions of the adverse consequences of smoking closer to what they will actually experience.

Third, a paternalistic regulation R changes cigarette quality, which we assume scales the utility from consuming cigarettes. We assume unregulated quality is the same in both periods ($G_1 = G_2 = G$) and exogenous to the consumer.[7] Normalizing unregulated quality to 1, the paternalist regulation reduces cigarette quality to G = 1 – R.

[7] We do not explicitly model the choice of quality, but our approach is consistent with the assumption that in the unregulated market profit-maximizing firms provide the consumer's preferred quality level. The regulation prevents the market from providing that level of quality.

Substituting the policy variables into the model, the decision utility-maximizing choices of cigarette consumption A_1* and A_2* solve the first order conditions:

$$(1-R)\frac{\partial U_1}{\partial A_1} - P(T) - NL^E_{2|1} = 0 \quad \textbf{(4a)}$$

$$(1-R)\frac{\partial U_2}{\partial A_2} - P(T) - NL^E_{2|2} = 0 \quad \textbf{(4b)}$$

The first order conditions can be re-arranged to show the familiar condition that the consumer compares the marginal benefits of consuming cigarettes to the price:

$$(1-R)\frac{\partial U_1}{\partial A_1} - NL^E_{2|1} = P(T) \quad \textbf{(5a)}$$

$$(1-R)\frac{\partial U_2}{\partial A_2} - NL^E_{2|2} = P(T) \quad \textbf{(5b)}$$

Figure 1 illustrates the impact of a nudge regulation on the consumer's optional choice of cigarette consumption. The Figure shows the case of linear demand curves and assumes the initial levels of the policy variables are N*, R*, and T*. The period 1 and period 2 subscripts are supressed in the Figure. The left hand sides of equations (5a) and (5b) show the marginal benefits from consuming cigarettes, taking into account the reductions in quality due to the regulation paternalistic regulation R*, and net of the perceived adverse consequences. Because utility is in a money metric (through the assumed quasi-linear utility), these expressions correspond to the consumer's Observed Demand curve for cigarettes. In Figure 1, increasing the nudge regulation from the initial level N* to 1 shifts the demand curve down by the corrected internality given by (N* – 1) L^E. The consumer's cigarette consumption drops from A* to A**. Because a nudge regulation that reaches N = 1 fully corrects the internality, the new demand curve is labeled "Rational Demand;" this demand curve is used for social welfare analysis below.

Figure 2 illustrates the impact of a paternalistic regulation. The regulation scales marginal utility in the first order conditions, so increasing the paternalistic regulation from R* to R** rotates the demand curve downwards to the Post-Regulation Demand curve. In order to compare the different types of regulations, we show the case where the paternalistic regulation R** also reduces cigarette consumption from A* to A** (the level reached by the nudge regulation that reaches N=1).

Welfare Analysis

We now turn to develop expressions for the impact of tobacco regulations on social welfare. We assume social welfare depends on lifetime experience utility, not decision utility (Kahneman, Wakker and Sarin 1997). In particular, we assume that experience utility depends upon the true experienced consequences of cigarette consumption ($L^{E}_{2|1}$ and $L^{E}_{2|2}$), even though when making decisions the consumer only considers a fraction N of these consequences. We further assume that cigarette consumption creates an externality X per unit of consumption. The externality includes the health consequences of non-smokers' exposure to tobacco smoke. We assume tax revenues are re-distributed back to the consumer by lump-sum transfers.

Following Chetty's (2009) "sufficient statistics" approach to welfare economic and letting C ( ) be the cost function for producing cigarettes, social welfare is then given by:

$$W = \{max(1-R)U(A_1) + Z_1 - C(A_1) - TA_1 + (1-R)U(A_2) + Z_2 - CA2 - TA2 - L2|1EA1 - L2|2EA2 + TA1 + TA2 - XA1 - XA2 \quad \textbf{(6)}$$

The marginal impact of taxation on social welfare is given by:

$$\frac{\partial W}{\partial T} = \left\{(1-R)\frac{\partial U}{\partial A_1} - MC - T - L^E_{2|1}\right\}\frac{\partial A_1}{\partial T}$$

$$+\left\{(1-R)\frac{\partial U}{\partial A_2} - MC - T - L^E_{2|2}\right\}\frac{\partial A_2}{\partial T}$$

$$-A_1 + A_1 + T\frac{\partial A_1}{\partial T} - X\frac{\partial A_1}{\partial T}$$

$$-A_2 + A_2 + T\frac{\partial A_2}{\partial T} - X\frac{\partial A_2}{\partial T} \qquad \textbf{(7)}$$

As Chetty (2009) emphasizes, under assumptions of utility-maximization, profit-maximization and perfect competition, the envelope theorem quickly simplifies expressions like equation (7). Profit-maximization and perfect competition imply that marginal cost MC = C' ( ). If there are no behavioral biases, or equivalently if N = 1, the { } terms in equation (7) would equal zero by the first order conditions for utility maximization. With behavioral biases, to simplify equation (7) further we add and subtract $N\, L^E_{2|1}\, dA_1/dT$ and $N\, L^E_{2|2}\, dA_2/dT$. Exploiting the first order conditions now simplifies equation (7) to:

$$\frac{\partial W}{\partial T} = (T-X)\frac{\partial A_1}{\partial T} + (T-X)\frac{\partial A_2}{\partial T} + (N-1)L^E_{2|1}\frac{\partial A_1}{\partial T} + (N-1)L^E_{2|2}\frac{\partial A_2}{\partial T} \quad \textbf{(8)}$$

In a similar way, the expressions for the impact of nudge and paternalistic regulations on social welfare simplify to:

$$\frac{\partial W}{\partial N} = (T-X)\frac{\partial A_1}{\partial N} + (T-X)\frac{\partial A_2}{\partial N} + (N-1)L^E_{2|1}\frac{\partial A_1}{\partial N} + (N-1)L^E_{2|2}\frac{\partial A_2}{\partial N} \quad \textbf{(9)}$$

$$\frac{\partial W}{\partial R} = (T-X)\frac{\partial A_1}{\partial R} + (T-X)\frac{\partial A_2}{\partial R} + (N-1)L^E_{2|1}\frac{\partial A_1}{\partial R} + (N-1)L^E_{2|2}\frac{\partial A_2}{\partial R}$$

$$-\frac{\partial U}{\partial A_1}A_1 - \frac{\partial U}{\partial A_2}A_2 \qquad \textbf{(10)}$$

Equations (8), (9) and (10) demonstrate four important results about the impact of tobacco control policies on social welfare.

First, equations (8) and (9) show that in the presence of uncorrected externalities and internalities, a tax or a nudge to reduce cigarette consumption improves social welfare.[8] As other analyses of tobacco regulations recognize, a tax and a nudge have the same implications for social welfare (Cutler et al. 2015, Levy, Norton and Smith 2016).

Second, and in sharp contrast to a tax or a nudge, equation (10) shows that even in the presence of uncorrected externalities and internalities a paternalistic regulation might either improve or worsen social welfare. In equation (10) the social welfare gains from reducing externalities and internalities (given by the first four terms on the right-hand-side of equation 10) are balanced against the utility losses created by the regulation (given by the last two terms of equation 10). The paternalistic regulation is like a tax in that it creates losses for consumers, but there is no offsetting consumer gains from the lump-sum re-distribution of tax revenues (Glaeser 2006, Loewenstein and O'Donoghue 2006).

Third, equations (8), (9) and (10) show that the social welfare gains from new policies do not only depend on the size of the internalities and externalities, but also depend on the extent to which current policies already correct the problems. The terms $(N - 1)\, L^{E}_{2|1}$ and $(N - 1)\, L^{E}_{2|2}$ show the size of the uncorrected internalities. When N is a small fraction, the uncorrected

[8] Equations (8) and (9) and their derivations parallel Mullainathan et al. (2012, pp. 521 – 522) equations (6) and (7).

internalities are larger (in absolute value), so any of the policies – a tax, a further nudge, or a paternalistic regulation – tend to yield larger welfare gains. If N = 1 current policies already fully correct the internalities, so the only welfare gains stem from reducing externalities. Because the nudge policy is intended to correct consumer mistakes, it is natural to think of N as a fraction that cannot exceed one. However, consumer heterogeneity means that it is not always clear in which direction consumers should be nudged (Goldin 2015). For example, salience-based information campaigns have the potential to over-correct consumer perceptions of the adverse consequences. Surveys find that both smokers and non-smokers on average over-estimate the mortality risks of smoking (Viscusi 1990). If N > 1, new policies (T, N, or R) that reduce consumption exacerbate the welfare losses from the pre-existing over-correction of the internalities.[9]

Fourth, although internalities are the main focus of FDA regulations, equations (8), (9) and (10) show that welfare analysis of anti-smoking policies should include the value of reduced externalities.[10] However, it is crucial to take into account the extent to which current taxes already correct for the externalities. Chaloupka et al. (2015, p. 113) argue that failing to account for a reduction in non-smokers' exposure to tobacco smoke is a "major omission" in the FDA's CBA of graphic warning labels. Equations (8), (9), and (10) show that Chaloupka et al. are wrong because they ignore current cigarette taxes. Sloan et al. (2004, p. 256) conclude that at the

[9] But if there are uncorrected externalities, the new policies might still increase social welfare.

[10] Allcott, Mullanaithan and Taubinsky (2014, p. 76) show that an energy tax can improve social welfare through two channels: externality reduction and internality reduction. They call this an "internality dividend from externality taxes." Equations (9) and (10) show that there can be an externality dividend from internality regulations.

time of their study the average U.S. cigarette tax was about equal to the external cost per pack, i.e. $T \approx E$. Jin et al. (2015) point out that since the Sloan et al. study cigarette taxes have tripled, while other policies have independently decreased externalities from smoking. For example, from 2000–2009 the fraction of the U.S. population covered by smoke free worksite laws increased from 3 percent to 54 percent and the fraction covered by smoke free restaurant laws increased from 13 percent to 63 percent (Gonzalez, Sanders-Jackson, Song, Cheng & Glantz, 2013). The fraction of households with home smoking bans increased from 42 percent in 1992/1993 to 82 percent in 2010/2011.[11] We are not aware of estimates of external costs that update Sloan et al. (2004), and such an update is far beyond the scope of our study. We note the important possibility that current taxes might already over-correct for externalities. If $T > E$, new policies (T, N, or R) that reduce consumption exacerbate the welfare losses from the over-correction of the externalities. Hereafter we will adopt the simplifying assumption that $T = E$, which means the terms involving externalities drop out of equations (8), (9), and (10).

Information Needed for CBA of FDA Regulations

Information on FDA Regulations and Cigarette Demand

Equations (9) and (10) provide the behavioral welfare economics foundation for CBAs of an FDA nudge or paternalistic regulation. Integrating each equation provides an expression for the difference in social welfare with and without the regulation in question. The shaded areas in Figures 1 and 3 illustrate the welfare impacts. In both Figures 1 and 3, because we consider

[11] Authors' calculations from analysis of data from the Tobacco Use Supplements to the Current Population Survey.

regulations that reduce cigarette consumption by the same amount, the regulations create identical triangular areas of welfare gains from correcting the internalities. In Figure 3 there is an additional area that reflects the welfare losses from reducing cigarette quality and hence consumer utility.

The key pieces of information needed for CBA of tobacco regulation are estimates of the internalities smokers imposes on themselves: $(N^* - 1)\, L^E$. Figures 1 and 3 illustrate a useful way to describe the approach: conduct standard welfare analysis using the Rational Demand curve for cigarettes, which incorporates the true experienced adverse consequences L^E. In general, deriving Rational Demand from Observed Demand requires an estimate of the uncorrected internality.

Figure 1 shows the special case where the nudge changes from N* to 1, completely eliminating the internality. In this case, to measure the nudge regulation's impact on social welfare only requires estimating the pre- and post-regulation demand curves, because they correspond to the Observed and Rational Demand curves. This is consistent with the insight that observing consumers' responses to nudges provides information about the size of the internality (Levy, Norton, and Smith 2016, p. 26). In a non-tobacco example, Allcott and Taubinsky (2015) evaluate a field experiment where consumers were given information about the cost savings from adopting energy-efficient compact fluorescent lightbulbs (CFLs). Allcott and Taubinsky use the post-information demand curve to measure the benefits of correcting internalities that lead to under-use of CFLs.

To capture the general case when the nudge does not fully correct the internality, Figure 1 would be modified to show that the post-regulation demand curve remains higher than the

Rational Demand curve. In this case using the pre- and post-regulation demand curves provides a lower bound estimate of the welfare gain from the nudge. Because the nudge only partially corrects the internality, the post-regulation demand curve only partially captures the value of the internality. To completely measure the welfare gain from the nudge requires additional information about the size of the full internality, not just the part of the internality corrected by the nudge. Jin et al. (2015) use this approach in their retrospective CBA of U.S. anti-smoking policies: they attribute shifts in the observed demand for cigarettes to the combined impact on anti-smoking nudge policies (policies that improved consumer information about the consequences of smoking). As will be discussed in more detail below, they measure the size of the internality based on the cigarette demand by a comparison group of consumers whose choices are assumed not to involve internalities.

Figure 3 shows that in addition to an estimate of the internality, CBA of a paternalistic regulation also requires an estimate of the value of the utility loss from the regulation-induced decrease in product quality. Paternalistic regulations change tobacco product attributes that are valued by consumers. The value of the attributes can be estimated using revealed or stated preference data. A retrospective CBA of a paternalistic regulation can rely on revealed preferences and compare the pre- and post-regulation demand curves: the demand shift reveals the value of the attribute changed by the regulation. A separate estimate of the internality is still required to complete the CBA.[12]

[12] If a single policy functions partly as a nudge and partly as a paternalistic regulation, the shift in the demand curve does not separately identify the value of the internality and the value of the reduced product quality. For example, graphic warning labels might nudge some consumers but

A prospective CBA of a paternalistic regulation might also be able to rely on revealed preferences. In principle, observed choices between tobacco products with different attributes such as flavors and nicotine levels reveal the value consumers place on these attributes. In practice, it might often be difficult to identify and estimate structural preference parameters. The FDA regulations might also involve attribute changes beyond the range observed in the market, most notably when attributes like flavors or menthol are completely banned. In these situations, analysis of stated preference data from discrete choice models is a promising alternative approach (Pesko et al. 2016, Marti et al. 2016). As Louviere, Hensher and Swait (2000, pp. 228 – 230) put it, data from DCEs show "the world as it could be … if we wish to consider markets fundamentally different from existing ones."

A complete CBA of a paternalistic regulation requires information about heterogeneity in consumer preferences for the attributes changed by the regulation. The shaded area of welfare loss in Figure 2 is analogous to the "rectangle" loss of consumer surplus from a tax. The shape of the shaded area of welfare loss in Figure 3 captures another insight about the costs of paternalistic regulation: the marginal cost of the regulation is higher at lower levels of consumption. This reflects diminishing marginal utility combined with our modelling assumption that by reducing the good's quality the regulation scales utility and thus marginal utility. Although the result reflects a specific modelling assumption, the prediction is consistent with broad patterns in cigarette demand. Smokers who consume fewer cigarettes per day are

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impose direct utility costs on other consumers. Because both effects cause the demand curve to shift, additional information would be needed to determine the shift due to the nudge versus the shift due to direct utility costs.

more likely to smoke premium brands and pay higher prices.[13] Because lighter smokers are willing to pay more for higher-quality cigarettes, a paternalistic regulation that decreases cigarette quality imposes a relatively higher cost on lighter smokers and a relatively lower cost on heavier smokers.

The Consumer Surplus Offset

The first step of another approach to CBAs of tobacco regulations requires an estimate of the value of the health benefits from reduced cigarette consumption (FDA 2011, 2014, Ashley et al. 2014). In the second step, this estimate is combined with an estimate of the consumer surplus offset – how much of the benefits of improved health are offset by consumer surplus utility losses from the reduced consumption. The first step introduces an additional demand curve that corresponds to N = 0 and shows demand when none of the adverse consequences of cigarette consumption are taken into account. The vertical distance between this demand curve and the Observed Demand curve is given by $(N^* - 1) L^E$. The second step conducts standard welfare analysis of the change in consumption with respect to the Rational Demand curve. The second step – variously termed the consumer surplus offset, the utility offset, or the lost pleasure

[13] In a descriptive linear probability model of smokers' brand choice in the 2001 – 2014 National Survey on Drug Use and Health, light smokers are about 13 percentage points more likely to smoke a premium brand. In a descriptive ordinary least squares model of the price paid for cigarettes in the 2006 – 2012 TUS-CPS, light smokers pay on average about $0.47 more per pack. Results available upon request.

approach – has been quite controversial. Comments submitted to the FDA and commentaries in public health journals object to the concept of consumer surplus from tobacco consumption.[14]

The consumer surplus offset approach still requires an estimate of the size of the internality in order to calculate the offset (Levy, Norton and Smith 2016). As a simple example in our model, consider estimating the benefits that a marginal nudge creates for period 2 consumers. The health consequences of period 2 consumption are given by $L^{E}_{2|2}\, A_2$. The value of the health benefits (H) when the nudge reduces period 2 consumption is given by:

$$\frac{\partial H}{\partial N} = -L^{E}_{2|2}\,\frac{\partial A_2}{\partial N} \qquad \textbf{(11)}$$

The offset is one minus the ratio of the impact of the nudge on social welfare and its health benefits:

$$Offset = 1 - \frac{\partial W}{\partial N}\Big/\frac{\partial H}{\partial N} = 1 - \left[(N-1)L^{E}_{2|2}\right]/\left[-L^{E}_{2|2}\right]$$

$$= 1 + N - 1 = N \qquad \textbf{(12)}$$

When consumers make large mistakes and fail to consider almost all of the consequences of smoking, N is close to zero. In this case, almost all of the consequences are internalities. The health benefits from reduced consumption approximate the social welfare gains from reduced

[14] Levy, Norton and Smith (2015) provide a more detailed discussion of the consumer surplus offset controversy. FDA (2011, 2016) summarize the public comments received about the consumer surplus offset. Commentaries in public health journals criticizing the use offset include Song, et al. (2014), Chaloupka, et al. (2014) and Chaloupka et al. (2015). Popular press discussions include Tavernise (2014), New York Times Editorial Board (2014) and a Sunday Doonesbury comic strip by Garry Trudeau (September 14, 2014).

consumption: only a small fraction N of the health benefits are offset. If consumers are perfectly informed and rational, N = 1. In this case, there are no internalities because consumers make fully optimizing choices. None of the health benefits reflect social welfare gains: one hundred percent of the health benefits are offset. If existing nudges over-correct the internalities, N > 1. In this case, a further nudge reduces social welfare: more than 100 percent of the health benefits are offset by losses in consumer utility from reduced consumption. Our derivation and discussion of equation (12) parallels Levy, Norton and Smith's (2016) graphical analysis and discussion of the consumer surplus offset.

Re-examining the Evidence Base on Internalities

Recent reviews emphasize the difficulty of empirically measuring internalities in general and in the specific context of cigarette consumption (Mullanaithan, Schwartstein, and Congdon, 2012, FDA 2016, Levy, Norton and Smith 2016). However, two recent studies reach strong conclusions that cigarette consumption involves large internalities. In a commentary on the FDA's CBA of the graphic warning label regulation, Chaloupka et al. (2015, p. 117) argue that "Nearly all of the 'lost pleasure' from tobacco use, as represented by conventionally measured consumer surplus, should not be included as a cost in FDA analyses…." In a White Paper about methods to conduct CBA of regulations that affect addictive consumption, Cutler et al. (2015, p. 43) suggest that regulations that reduce cigarette consumption do not impose very large costs on consumers because: "people deterred from smoking have no utility loss;" and "most regulations will induce quitting among smokers who will not miss smoking in the long term." Both of these studies frame the question in terms of the consumer surplus offset and suggest that the offset ratio is very small. As discussed above, this conclusion is mathematically equivalent to the

conclusion that the internalities from cigarette consumption are very large. In this section we use our model as a framework to re-examine the evidence base for this strong conclusion.

Evidence Base from Chaloupka et al. (2015)

Chaloupka et al. (2015) base much of their argument about the size of the consumer surplus offset and internalities on what they term the "principle of insufficient reason." They argue that laws restricting youth access to cigarettes mean that for individuals under the legal age "society has clearly decided that the decision to initiate smoking is an irrational decision." (p. 116). In our model, the term $(N - 1)\, L^{E}_{2|1}$ captures the internalities adolescents' irrational decisions to smoke in period 1 impose on their future selves in period 2. Our model makes the important distinction between this internality and the internality created by continuing to consume cigarettes in period 2: $(N - 1)\, L^{E}_{2|2.}$ If insufficient reason in period 1 is the only source of consumer mistakes, currently rational adults will make consumption choices in period 2 that maximize their period 2 experienced utility. As a result, the terms involving $L^{E}_{2|2}$ envelope out of the welfare expressions in equations (9) and (10). In this case the welfare gains from tobacco regulations depend upon the size of the internality given by $(N - 1)\, L^{E}_{2|1|}$.

Available empirical evidence suggests that the distinction between the two types of internalities captured by the terms $L^{E}_{2|1}$ and $L^{E}_{2|2}$ is quite important. The term $L^{E}_{2|1}$ captures addiction and reflects the withdrawal costs in period 2 created by period 1 consumption. Cutler et al. (2015, p. 31) estimate that the utility cost of withdrawal is in the range from $6,200 to $20,100. By comparison, Cutler et al. (2015, Table 5, p. 30) estimate that the value of the

lifetime health consequences ($L^{E}_{2|2}$) is in the range from about $450,000 to $1.5 million.[15] Chaloupka et al. (p. 31) cite suggestive evidence that many adolescents under-estimate the difficulty of quitting, which implies that the relevant N is a small fraction. However, even if N is close to zero, the internality created by adolescents' failure to consider future withdrawal costs is likely to be small.

In addition to the principle of reason applied to internalities from period 1 consumption, Chaloupka et al. (2015) review evidence from surveys of smokers. The evidence helps establish that most smokers face internalities from period 1 and/or period 2 consumption. However, the evidence is not very informative about the size of the internalities. Chaloupka et al. (2015, p. 116) cite survey evidence that more than 90 percent of smokers agree or strongly agree with the statement: "If you had to do it over again, you would not have started smoking." This suggests most smokers experience internalities from their period 1 decision to start: $(N - 1)\, L^{E}_{2|1} > 0$. They also point out that in many surveys almost 70 percent of current smokers express an interest in quitting, but less than 3 percent of smokers quit each year. This suggests that many smokers are not able to make optimal period 2 consumption choices and continue to impose internalities on themselves: $(N - 1)\, L^{E}_{2|2} > 0$. Unlike contingent valuation surveys, the cited surveys were not designed to elicit stated preferences about the value consumers place on smoking or quitting. Nevertheless, they provide suggestive evidence of internalities: cigarette

[15] The ranges of the estimates reflect different assumptions about the appropriate social discount rate and value of a statistical life or QALY.

consumers make choices that they regret, and the decisions might be inconsistent with their experience utility.

Even if the survey responses are interpreted as meaning that most smokers fail to make optimal cigarette consumption choices, the responses provide very little information about the size of the internalities. For example, the survey responses might mean that 90 percent of smokers regret having imposed small internalities on themselves.[16] Evidence that 90 percent of smokers face internalities is not evidence that 90 percent of smokers receive no utility from smoking. Similarly, the gap between stated interest in quitting and quit behavior might reflect fairly small deviations in the optimal timing of quitting. Although the annual cessation rate is low, many smokers quit in time to avoid some or even most of the adverse health consequences of smoking: one-third of ever-smokers quit by the age of 40; one-half of ever-smokers quit by the age of 50; and two-thirds of ever-smokers quit by the age of 60.[17]

[16] Respondents to the survey cited by Chaloupka et al. (2014) indicated whether they strongly agreed, agreed, neither agreed nor disagreed, disagreed, or strongly disagreed with the statement about doing it over again. About 50 percent strongly agreed and 39 percent agreed. It seems reasonable to infer that the 50 percent who strongly agreed feel that they imposed relatively larger internalities on themselves, but it is hard to infer much about the absolute sizes of the internalities of the different groups of respondents.

[17] Authors' calculations from the TUS-CPS; detailed results available upon request. As noted above, epidemiologic and econometric studies provide evidence that quitting by the age of 40s avoid almost all of the excess mortality risk due to smoking. For example, Jha et al. (2013) estimate that of the 10 years difference in life expectancy between never-smokers and current smokers: smokers who quit by age 40 gain 9 years of life expectancy; smokers who quit by age 50 gain 6 years of life expectancy; and smokers who quit by age 60 gain 4 years of life expectancy.

Evidence Base from Cutler et al. (2015)

Cutler et al. (2015) develop a general approach and piece together evidence to quantify the size of the internalities from cigarette consumption. The goal of their analysis is to compare the consumer's lifetime utility with a new regulation to their utility in a counter-factual world without the regulation. In the notation of our model, this is the comparison of lifetime experience utility from consuming A_1** and A_2** with the regulation to lifetime experience utility from A_1* and A_2* without the regulation. The comparison can also be expressed as the difference between lifetime decision utilities each period (equations 1 and 2) adjusted for the difference in internalities:

$$\text{Lifetime utility gain} = V_1(A_1^{**}) - V_1(A_1^{*}) + V_2(A_2^{**}) - V_2(A_2^{*})$$

$$(N-1)L_{2|1}[A_1^{**} - A_1^{*}] + (N-1)L_{2|1}[A_1^{**} - A_1^{*}] \qquad \textbf{(13)}$$

Cutler et al. (2015) focus on the consumer surplus or utility offset. Equation (12) shows the offset ratio for a marginal change in a nudge regulation. The analogue for the offset ratio for a discrete change in a nudge regulation from N* to N** simplifies to:

Offset ratio = 1 – (Lifetime Utility Gain) / (Health Gain)

$$= \frac{[V_1(A_1^{**}) - V_1(A_1^{*}) + V_2(A_2^{**}) - V_2(A_2^{*})]}{\left[L^E_{2|1}(A_1^{*} - A_1^{**}) + L^E_{2|2}(A_2^{*} - A_2^{**})\right]} \qquad \textbf{(14)}$$

Cutler et al. (2015) piece together estimates of the terms of equation (14) to develop a range of empirical estimates of the offset. For the denominator of equation (13) they compute standard estimates of the value of the health consequences of smoking (Cutler et al. 2015, p.29). Their main focus is on developing new evidence about the terms in the numerator of equation

(14). More precisely, they focus on the utility losses, i.e. the negative of the numerator which shows the utility losses due to the regulation's impact on lifetime utility from cigarette consumption and other goods in periods 1 and 2:

$$V_1(A_1^{**}) - V_1(A_1^{*}) = GU(A_1^{**}) - PA_1^{**} \quad \textbf{(15a)}$$

$$V_2(A_2^{**}) - V_2(A_2^{*}) = GU(A_2^{**}) - PA_2^{**} \quad \textbf{(15b)}$$

It is important to stress that the regulation's impact on lifetime experience utility through improving health and avoiding addiction is already captured in the denominator of equation (14) and should not be double-counted in the numerator.

Revealed preference evidence casts doubt on Cutler et al.'s conclusion that deterred initiators suffer no utility loss. Of course, an inherent challenge for behavioral welfare economics is that internalities mean that revealed preferences are not a reliable guide to the consumption choices that maximize lifetime experience utility. However, to put together the pieces of equation (14) it is useful to first consider the simpler question: Is there is a loss in period 1 utility that offsets part of the period 2 health and addiction benefits from the nudge regulation? To use equation (15a) to analyze deterred initiation we assume that with the regulation at N** cigarette consumption and utility from cigarette consumption drop to zero. The expression for the utility loss then simplifies to: G U (A_1*) – P A_1*. The classic revealed preference argument is that because A_1* solves the consumer's maximization problem, the utility from consumption must exceed the costs: G U (A_1*) > P A_1*. Cutler et al. (2015, p. 35) estimate that the costs of cigarette consumption are $1,350 per year. Their problematic claim is that the utility from A_1* is approximately zero. This claim leads to their conclusion that the nudge regulation benefits consumers because it results in $1,350 of savings per year for deterred initiators. Revealed

preferences imply instead that in period 1 the regulation creates a net utility loss for consumers because the period 1 utility loss exceeds the savings.

The validity of the revealed preference argument does not require lifetime utility maximization, but rests on the much weaker assumption of period 1 utility maximization. Most discussions of the need for a behavioral economics approach to model cigarette consumption emphasize failures of inter-temporal optimization. For example, Gruber and Koszegi (2001) review evidence from psychology and behavioral economics research that suggests that consumers are time inconsistent. Based on this evidence they propose a model with quasi-hyperbolic discounting and present bias. Similarly, Chaloupka et al. (2015) emphasize time inconsistency and other biases in inter-temporal optimization. These studies do not provide an evidence base to conclude that period 1 consumption fails to maximize period 1 utility.[18]

Evidence from revealed and stated preferences also casts doubt on Cutler et al.'s conclusion that induced quitting does not create long-term utility losses in period 2. If the utility function does not change between period 1 and 2, the revealed preference argument from period 1 carries over: the utility from cigarette consumption must exceed its costs. From equation (15b) the utility loss from quitting ($A_2^{**} = 0$) simplifies to $G\,U(A_2^*) - P\,A_2^*$. The problematic claim

[18] As discussed in more detail below, Cutler et al. (2015, pp. 34-35) identify a comparison group of consumers whose smoking behavior might approximate consumer demand without internalities (in our notation, for whom $N = 1$). They estimate that 7 percent of this comparison group initiates smoking, compared to 17 percent of consumers with externalities. In terms of our Figure 1, this exercise compares Observed Demand to Rational Demand. The difference between these demand curves is due to the internality $(N - 1)\,L^E$, so the comparison does not shed light on the utility loss terms in the numerator of equation (14). That is, the comparison group is less likely to initiate smoking because they take the future consequences $L^E_{2|1}$ into account, not because they derive less utility from smoking in period 1.

is that the direct utility from period 2 consumption – G U (A_2*) – is very small. If the utility function has not changed, revealed preference again implies that the utility loss is larger than $1,350 per year and more than offsets the money cost savings. Note that the issue is not whether the former smoker will "miss smoking in the long term" (Cutler et al. 2015, p. 43). Instead, the utility loss is in comparison to the consumer's utility in a counter-factual world without the regulation.

Stated preference evidence suggests that changes in the utility function do not drive most changes in cigarette consumption between periods 1 and 2, i.e. quitting. Surveys of former smokers find that only a minority cite costs as the reason for quitting: in studies of the most important reason an average of 14 percent of former smokers mention cost; in studies that allowed multiple responses an average of 32 percent mentioned cost (McCaul et al. 2006). This is suggestive evidence that most quitting is not due to a change in the period 2 utility function that makes the utility from consumption no longer worth the monetary costs. More former smokers cite social concerns as the reason for quitting. This is suggestive evidence that for these smokers G is lower in period 2: anti-smoking norms reduce the utility from cigarette consumption, making the utility from consumption no longer worth the costs.[19] However, many more former smokers mention health concerns as the most important reason (average 47 percent) or among the reasons (75 percent) for quitting. This is suggestive evidence that if there were no

[19] Our model treats G as determined by regulations, but in a more complete model it could reflect social norms about smoking. The impact of the norms might vary over the life cycle. For example, in period 1 the utility from smoking might be scaled up to reflect the value of "looking cool," but this value might fade in period 2.

health consequences the majority of the smokers would find the period 2 utility from consumption worth the costs: G $U(A_2^*) > P A_2^{**}$. As above, we interpret the evidence as only suggestive because the surveys were not designed to elicit stated preferences about the value smokers place on different aspects of smoking.

The claim that the direct utility from period 2 consumption is very small rests on the argument that period 2 consumption is mainly driven by addiction and the desire to avoid withdrawal costs. Weimer, Vining and Thomas (2009) report results from a contingent valuation survey that elicited smokers' stated preferences for a treatment that would eliminate addiction. About 30 percent of smokers refused to make the purchase at the lowest bid price offered -- $50 for a treatment effective for one year. The preferred specifications of the bid functions yield an estimated median willingness to pay of around $200. This relatively low willingness to pay to eliminate addiction is consistent with the FDA's (2014) analysis of smokers' willingness to pay to quit smoking as revealed in the market for smoking cessation products. The evidence from these two studies that many smokers are not willing to pay much to avoid withdrawal costs suggests they derive other utility from consuming cigarettes.

Another source of revealed preference evidence that continued smoking is not driven by addiction and the desire to avoid withdrawal costs comes from the rates of re-initiation among groups of smokers who have quit for extended periods. Because many U.S. prisons and jails completely ban smoking, many prisoners undergo "forced abstinence". As many as 97 percent of inmates return to smoking as soon as they are released (Clarke et al. 2013). In data from the Pregnancy Risk Assessment Monitoring System over 50 percent of women who smoked prior to pregnancy reported quitting by the last three months of pregnancy. About half of those women

re-start smoking within approximately four months after delivery (Tong et al. 2013). The prisoners and pregnant women have gone through withdrawal and are no longer physically dependent on nicotine: they do not resume smoking to avoid nicotine withdrawal. Because they have quit in the past, it also seems likely that they are well-informed about the difficulty of quitting again in the future. To the extent decisions to re-initiate smoking after forced abstinence maximize experience utility, it follows that smokers' decisions to continue in the absence of forced-abstinence might also be rational choices that reveal a preference for the utility gained from smoking.

To sum up, in this section we have used our model as a framework to re-examine the empirical evidence base on the internalities from cigarette consumption. Our review suggests that the evidence base is thin and does not support the strong conclusions reached by Chaloupka et al. (2014) and Cutler et al. (2015) that the internalities are large. However, we agree with Cutler et al. (2015) on several key points. First, Cutler et al. (2015, p. 43) stress that CBA should not disregard "the utility losses people may experience from regulations aimed at curbing consumption of products with health risks." Second, throughout their study Cutler et al. discuss and present evidence that cigarette consumers will experience three types of utility losses from FDA regulations: short-term withdrawal costs; longer-term utility losses; and additional utility losses from the regulations we term paternalistic that remove valued product attributes. While we

agree with these points, for the reasons discussed above we disagree when Cutler et al. make the strong simplifying assumptions that the longer-term utility losses are approximately zero.[20]

Potential of Empirical Approaches to Estimate Tobacco-related Internalities

After using our model to re-examine the current evidence base on tobacco-related internalities, we now turn to examine the potential of empirical approaches in more detail. We begin by examining two approaches used in previous research: structural estimation, and comparison groups. We then turn to two less-developed approaches: subjective well-being, and consumer demand for commitment devices and nudges.

Structural Estimation of Models of Internalities

The first established approach to empirical behavioral welfare economics relies on structural estimation. Structural estimation is a demanding form of the revealed preference approach. By estimating the parameters of a fully specified behavioral model of consumer behavior, structural estimation identifies the extent to which observed consumer choices depart from the choices that maximize experience utility. In terms of our model, it identifies the size of the internalities $(N - 1) L^E$. In terms of Figures 1 or 3, the structural parameter estimates can be used to identify both the Observed Demand curve and the Rational Demand curve. Chetty (2015) points out that behavioral welfare economics based on structural estimation relies on strong modeling assumptions. This is particularly problematic when results are highly model-specific. In a non-tobacco example, Abaluck and Gruber (2011) use a structural model to analyze

[20] As a corollary, we also disagree with the Cutler et al. estimate that the money savings from deterred initiation and induced quitting should be counted as a net benefit for consumers.

Medicare Part D choices and conclude that "welfare would have been 27 percent higher if patients had all chosen rationally." Ketcham et al. (forthcoming) re-analyze the data and conclude that "AG's evidence of welfare reducing optimization mistakes is driven primarily by their assumptions about the parametric form of utility and by interpreting econometric error as consumer mistakes….A simpler version of AG's model that assumes people maximize expected utility often makes better out-of-sample predictions."

The FDA (2011, 2014) and Ashley et al. (2015) use the structural approach to complete CBAs of tobacco regulations. They rely on parameter estimates and assumptions from Gruber and Koszegi's (2001) structural model of cigarette addiction with quasi-hyperbolic discounting.[21] Three of the key structural parameters are common to rational and behavioral addiction models: the effect of past consumption on the marginal utility of current consumption (adjacent complementarity); the rate at which the stock of addictive capital depreciates; and the standard exponential discount rate δ. The fourth structural parameter is the extra discount rate β that captures the essence of hyperbolic discounting and leads to present bias: "the discount factor between consecutive future periods (δ) is larger than between the current period and the next one β that captures the essence of hyperbolic discounting and leads to present bias ($\beta\ \delta$)." (Gruber and Koszegi 2001, p. 1280). Based on a range of values for the structural parameter estimates, Gruber and Koszegi (2001, p. 1291) present a range of estimates of the optimal tax on cigarettes to correct internalities. The optimal tax provides a way to estimate the size of the internality and

[21] In an earlier and related approach, Colman and Remler (2008) use the Gruber and Koszegi results to explore the regressivity of cigarette taxes in a behavioral economics model.

the difference between the Observed Demand curve and the Rational Demand curve. Ashley et al. (2015) use Gruber and Koszegi's results to estimate that the consumer surplus offset ratio is in the range from 67 percent to 99 percent. Recalling the relationship between the offset ratio and the size of the internalities, these estimates imply the internalities are moderate to very small.

Because Gruber and Koszegi's estimates rely on strong modeling assumptions, they provide an uncertain evidence base about the size of the internalities. Gruber and Koszegi estimate a rational addiction model and compare it with their behavioral model with time-inconsistent addiction. They conclude that "we are unable to empirically distinguish the two with our data." (p. 1263). The empirical challenge is to use consumer responses to price changes at different points in the future to back out the two discounting parameters β and δ. Laporte, Dass and Ferguson (2016) conduct Monte Carlo experiments and find that in the rational addiction model the presence of an unstable root to the consumer's optimal control problem makes it difficult to extract the exponential discount rate δ. Structural estimation that separately identifies β and δ is even more challenging. Instead, based on evidence from psychological research Gruber and Koszegi (2001) assume values for β and δ. In the rational addiction model, which Gruber and Koszegi cannot rule out, all cigarette consumption choices are optimizing. The evidence from Gruber and Kocegi (2001) thus rests on modeling assumptions and cannot rule out the possibility that there are no internalities so the correct offset ratio is zero.

Evidence from Comparison Groups of Consumers

A second established approach to estimate internalities is to use evidence from comparison groups whose consumption choices appear likely to reveal their true preferences over experience utility. In our notation, these consumers do not impose internalities on

themselves so N = 1 and their demand curve corresponds to the Rational Demand curve in Figures 1 and 3. Using the information from the comparison group to estimate the Rational Demand curve, the welfare impacts of the regulations can be measured as the areas shown in Figure 1 and 3. In a non-tobacco example of this approach, Ketcham et al. (2015) evaluate consumers' choices over Medicare Part D prescription drug insurance plans. 42 percent of consumers were categorized as making suspect choices that involve internalities, either because their choices violated basic axioms of rational choice or because the consumers making the choices were badly informed. Ketcham et al. calibrate the preferences of the subset of consumers who made suspect choices based on proxy measures derived from the behavior of observationally similar consumers who made non-suspect choices.

Jin et al. (2015) and Cutler et al. (2015) use the comparison group approach to estimate the impact of anti-smoking policies and regulations on consumer welfare. Both studies use a comparison group based on the smoking behavior of highly educated consumers aged 30 – 45.[22] The age restriction focuses on adult consumers who made the decision to start smoking well after the health consequences of smoking were well-established and widely publicized. The restriction to highly educated consumers focuses on consumers most able to align their behavior with their well-informed preferences.

Although the restrictions used by Jin et al. (2015) and Cutler et al. (2015) probably rule out most consumers with internalities, they might also rule out cigarette consumption differences

[22] In an alternative approach, Cutler et al. (2015) use a measure of nicotine addiction to identify consumers who make non-suspect choices about smoking.

that reflect heterogeneity in consumers' true preferences over experience utility. Consumers with less schooling might value smoking differently due to differences in time and risk preferences (Barksy et al. 1997). [23] Moreover, as shown in Table 1 consumers with different levels of schooling make different choices across various domains: consumers with less than a high school education are less likely to purchase hardcover books, listen to classical music, or play golf, and are more likely to enjoy watching religious television.

The evidence about differences in preferences and consumer behavior by schooling level casts doubt on whether highly educated consumers are an appropriate source of information about the non-suspect choices of less educated consumers. Bernheim and Rangel (2005, p. 3) stress the need for a unified framework for behavioral welfare economics: "If we can classify, say, the consumption of an addictive substance as contrary to an individual's interests, what about choices involving literature, religion, or sexual orientation?" We do not think behavioral economics provides a principled rationale to over-ride the choices less-educated consumers make about books, music, television, and golf. Similarly, the various sources of non-suspect preference heterogeneity make it problematic to use highly educated consumers as a comparison group to identify the Rational Demand curve of less-educated consumers.

Internalities and Subjective Well-Being

A third and less-developed approach to behavioral welfare economics is to use data from surveys of subjective well-being (Chetty 2015). Surveys of subjective well-being (SWB) ask

[23] Time-inconsistent smoking choices that reflect present bias due to hyperbolic discounting should be considered suspect. But smoking choices that reflect higher conventional discount rates should be considered non-suspect.

respondents to rate their happiness or life-satisfaction. On the assumption that SWB provides a measure of individual utility and social welfare, the potential approach is to estimate the impact of policies on SWB, i.e. estimate dW/dT, dW/dN or dW/dR (the left-hand-sides of equations 9, 10, and 11).

Some previous research estimates the reduced-form relationship between tobacco control policies and SWB. In a study using U.S. data from 1973-1998, Gruber and Mullanaithan (2005) find that higher cigarette taxes lead to higher SWB of consumers likely to smoke. They interpret this as evidence that a high tax serves as a commitment device that improves the experienced utility of time-inconsistent smokers. However, subsequent research yields very mixed results about the relationships between taxes or smoking bans and smokers' SWB. For example, Odermatt, Reto & Alois Stutzer (2015) use data for 40 European countries between 1990 and 2011 and find that higher cigarette prices reduce SWB of likely smokers. Within the group of smokers, higher cigarette prices even reduce SWB of smokers who want to quit. However, the results suggest that smoking bans improve SWB among smokers who want to quit.[24] In contrast, Brodeur (2013) uses U.S. data and finds no differential effects of higher taxes on smokers' versus non-smokers' SWB. He finds that smoking bans improve the SWB of smokers who do

[24] Instead of examining the impact of a tobacco control policy on SWB, Weinhold and Chaloupka (2016) examine the association between smoking status and SWB. They find that former smoker status is not associated with lower well-being and in some specifications is associated with higher well-being. Because smoking status is endogenously chosen, their results tend to support the rational model. The results are not informative about whether current smokers' consumption involves internalities.

not quit. He suggests this might reflect smokers' feeling less guilty because with the bans their smoking does not impose externalities on others.

An important limitation to the use of SWB data for behavioral welfare economics concerns the assumption that SWB provides a measure of individual utility and social welfare. After noting the potential value of SWB data, Chetty (2015) points out: "Self-reported measures of happiness can be systematically distorted by transient contextual factors, are affected by selective memory and projection bias, and do not have a clear cardinal interpretation." Adler (2016) stresses that by highlighting widespread failures of utility-maximization, behavioral economics research might even weaken the case for the use of SWB data. If people commonly make mistakes about which choices will improve their experience utility, their answers to questions about life satisfaction also might not be very informative about their experience utility.

Fully incorporating SWB analysis into CBA raises additional unresolved issues. Even putting aside more recent research and taking the evidence from Gruber and Mullanaithan (2005) at face value, it provides an estimate that higher cigarette taxes reduce the probability that consumers who are likely to smoke respond that they are "not happy." Interpreted as informative about equation (8), the Gruber and Mullanaithan estimate implies non-zero internalities but does not provide evidence about the size of the internalities in a dollar metric. A related problem is how to compare changes in SWB to the costs of a regulation. Bronsteen, Buccafusco and Masur (2013) use SWB to conduct an analysis of the impact of an environmental regulation on social welfare. They use an estimate of the impact of an exogenous increase in income on SWB to translate the regulation's costs into a SWB-metric. After reviewing this study and the unresolved questions it raises, Sunstein (2016, p. 117) argues that their exercise represents the state-of-the-

art but "involves far too much guesswork…The most sensible conclusion is that studies of reported well-being cannot be used as anything like a substitute for cost-benefit analysis, and that they should not yet play a significant role in regulatory analysis."

Consumer Demand for Commitment Devices and Nudges

Another less-developed approach to behavioral welfare economics is to analyze consumer demand for commitment devices and nudges. When consumers recognize that they make time-inconsistent choices that impose internalities on their future selves, they value commitment devices and nudges. Revealed preferences in the form of consumer demand for commitment devices and nudges thus sheds light on the size of the internalities. Equations (9) and (10) above can be re-interpreted as showing the consumer's marginal willingness to pay for devices and nudges that reduce the internalities they impose on themselves.[25] In principle, either a structural approach or a reduced-form sufficient statistic approach could be used to analyze consumers' revealed preferences and infer the value of tobacco regulations. To the best of our knowledge, neither approach has been used in this market. Scattered evidence sheds light on the extent of consumer demand for commitment devices and nudges.

Some smokers appear to limit their consumption by purchasing cigarettes by the pack rather than more inexpensively by the carton. Khwaja, Sloan, and Silverman (2007) find that 27 percent of surveyed current smokers at least somewhat agree with the statement that they buy packs rather than cartons to limit their smoking. DeCicca, Kenkel and Liu (2014) find that smokers who are more interested in quitting – as indicated by their past attempts to quit or their

[25] In this re-interpretation, the terms involving the externalities drop out.

stated future intentions to quit – are about seven to eight percentage points more likely to purchase cigarettes by the pack. Purchasing by the pack increases the price of cigarettes by about 30 percent. Putting these pieces of evidence together with the estimate that the average smoker spends $1,250 on cigarettes annually, it appears that perhaps 10 to 20 percent of smokers are willing to pay about $400 annually to limit their smoking. Khwaja et al. (2007) find that in a response to an open-ended question 81 percent of smokers report using some sort of commitment device or strategy. Most of the listed strategies, such as actions to distract themselves from thinking about smoking, appear to involve low costs. Consumer choices to buy packs or use lower-cost strategies can be thought of as tracing out a demand curve for commitment devices. Although the evidence base is thin, the market demand for these commitment devices appears to be small relative to the demand for cigarettes.

Consumer demand for analogues to potential FDA regulations is another source of evidence about consumer preferences about internalities. If graphic warning labels provide a valuable nudge, consumers should be willing to pay extra for packs that carry the warnings. Evidence from experimental auctions suggests this is true for only a small sub-set of smokers (Thrasher et al. 2011, Rousu et al. 2104). In the experimental auctions subjects bid on cigarette packs that either carried versions of a text-only warning label or a graphic warning label. On average, subjects bid about $0.50 (about 15 percent of the average price) less for packs that carried a graphic warning label. Almost half of the subjects bid the same amount for packs with and without a graphic warning label. Only ten percent of the subjects bid more for packs that carried a graphic warning label.

Evidence on revealed preferences in actual markets also tends to suggest that not many consumers value graphic warning labels as a nudge to help them limit their smoking. The potential demand for graphic warning labels as a nudge creates a potential profit opportunity for manufacturers to voluntarily adopt graphic warnings and market the labeled packs to smokers interesting in quitting or cutting down. To the best of our knowledge, there is not a significant private market for cigarettes with voluntarily adopted graphic warning labels. However, in countries that require graphic warning labels there is an active market in cigarette cases and covers that help consumers avoid seeing the labels.

The potential FDA ban on menthol cigarettes also has a private analogue: menthol smokers can voluntarily switch to non-menthol cigarettes. In data from the 2010-11 TUS-CPS, about four percent of menthol smokers who attempted to quit in the past year report having switched to non-menthol in order to try to quit (authors' calculations).

Over the past 10 years or so, a private market in commitment contracts has emerged. Cigarette consumers can now use these services to limit or quit smoking. In these contracts, smokers set a goal of quitting within a specified time period and agree to a financial stake that is lost if they fail to meet their goal. They can also agree to a third-party referee to monitor their progress towards the goal. The company stickK advertises that their commitment contracts have resulted in over 16 million cigarettes not smoked.[26] Without the details about this estimate, it is impossible to precisely compare private sales of commitment contracts to the size of the cigarette

[26] Web page accessed September 9, 2016: www.stickk.com

market, but it appears to be very small.[27] In an online survey of a national sample of smokers, 19 percent of smokers were at least somewhat interested in a commitment contract to quit smoking (Kenkel et al. 2016).

The approach of using revealed willingness to pay for private sector commitment devices and nudges to estimate the value of tobacco regulations faces two challenges. First, many private sector devices and nudges are fundamentally different from regulations because they are voluntary. Decisions to buy a pack rather than a carton of cigarettes, to buy a pack with a voluntarily adopted graphic warning label, or to switch to non-menthol only bind smokers until their next purchases in a day or two. Smokers who recognize the internalities they impose on themselves might not be willing to pay much for many private sector devices and nudges because they are non-binding over longer time periods. Second, only smokers who are sophisticated enough to recognize their internalities are willing to pay for commitment devices and nudges. A small willingness to pay might reflect a small internality as in equations (9) and (10), or naïveté about the existence of a large internality.

Discussion

In this paper we develop expressions for the impact of tobacco regulations on social welfare. We use the expressions to re-examine the existing evidence base and to judge the future potential of empirical approaches to conduct CBAs of FDA tobacco regulations. The analytical

[27] From footnote 5, annual consumption of cigarettes is around 14.4 billion packs, which corresponds to 288 billion cigarettes. The 16 million cigarettes not smoked make up only a tiny fraction of total consumption. Even if stickK has a small share of the national market for commitment contracts, the market demand appears to be very small compared to the market for cigarettes.

and empirical challenges are not unique to tobacco regulation, or even to regulations that affect addictive consumption. Instead, CBAs of consumer financial protection regulations, environmental regulations, and many other types of regulations face similar challenges. Fortunately, practitioners conducting regulatory CBAs required by Executive Order 12866 can look to the rapidly growing body of academic research on behavioral welfare economics (Mullanaithan et al. 2012, Chetty 2015). Our paper helps bridge research on behavioral welfare economics in general to the specific context of FDA tobacco regulations.

We do not contribute new empirical evidence on the costs and benefits of FDA tobacco regulations, but throughout our discussion we cite empirical evidence and discuss the information that is needed to shed more light on the magnitudes of key parameters. The most important information needed for CBAs of tobacco regulations are estimates of the internalities created by tobacco consumption. Our review of previous research identifies not-so-promising and promising approaches to measure the internalities. Structural estimation of behavioral models, finding appropriate comparison groups, and analysis of subjective well-being data face daunting challenges. More promising is the careful analysis of revealed and stated preferences, including preferences for private sector commitment devices and nudges. An important need is to move past establishing that internalities exist to the difficult step of measuring the size of the internalities.

Our critical review suggests that the evidence base is thin and does not support strong conclusions that the internalities from cigarette consumption are large. The balance of the evidence tends to suggest that the internalities might be modest or small. A retrospective CBA of U.S. anti-smoking policies from 1964 – 2010 provides important context for this tentative

conclusion (Jin et al. 2015). Warner (2007) calls the drop in smoking over this period "the developed world's greatest public health achievement in the past half-century." The retrospective CBA provides an estimate of the dollar value of the achievement: the 1964-present value of consumer benefits is $573 billion, which is larger than the 1964-present value of actual cigarette sales from 1964-2010. Our analytical expressions show that the welfare gains from future anti-smoking policies diminish when past policies have already partly corrected for internalities. Put differently, the past public health achievement is perhaps reflected in the empirical evidence that currently internalities from smoking are modest or small. In this context, it would not be surprising to find that new tobacco regulations only have limited potential to improve social welfare.

The question then becomes: What, if any, new anti-smoking policies are justified by internalities? Nudge regulations can improve social welfare, but there might not be that many more opportunities to nudge consumers towards smoking less. Prominent FDA tobacco regulations are paternalistic: they are like taxes that impose costs on smokers but do not generate any offsetting tax revenues. Another lesson from our analysis is that tobacco tax hikes might be a better policy approach than paternalistic regulations.

Chetty (2015) offers a pragmatic perspective on the implications of behavioral economics for public policy. He argues that behavioral economics research makes three types of contributions: it suggests new policy tools such as nudges; it provides better predictions about the effects of existing policies; and it yields new implications for social welfare. The regulatory impact analyses of the FDA and other federal agencies rely on the insight from behavioral welfare economics that internalities mean that regulations *might* improve social welfare.

However, to a large extent tobacco regulations are not corrective nudge policies but instead remove options and impose significant costs on smokers. A useful direction for future research and policy is to explore insights from behavioral economics about new policy tools that might simultaneously reduce smoking, improve health, and improve social welfare.

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Figure 1: The Impact of a Nudge Regulation

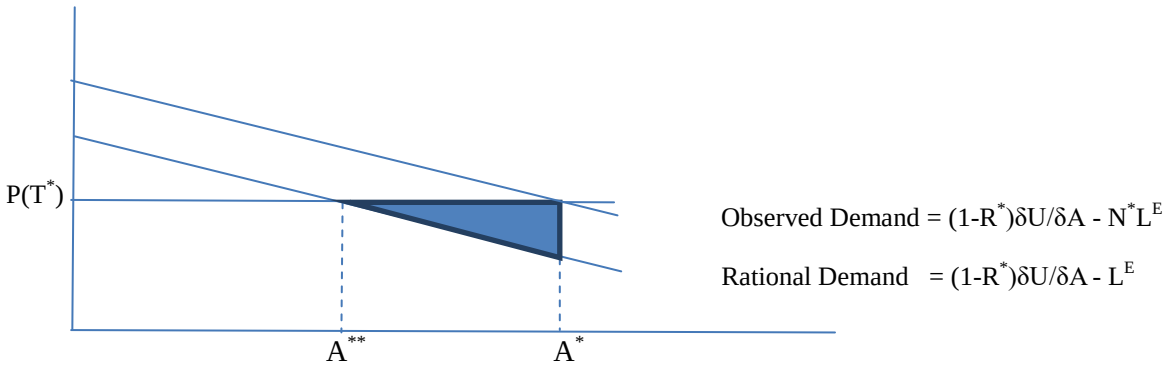
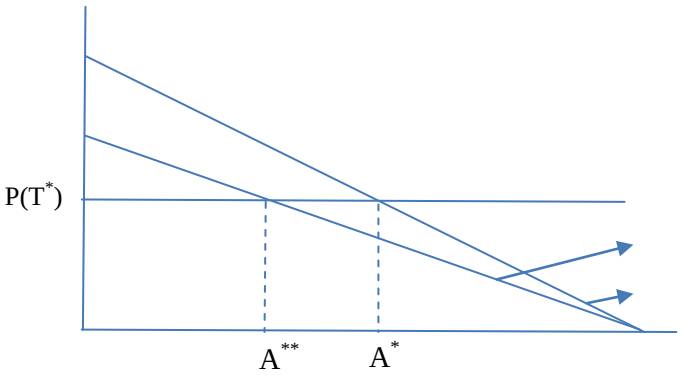


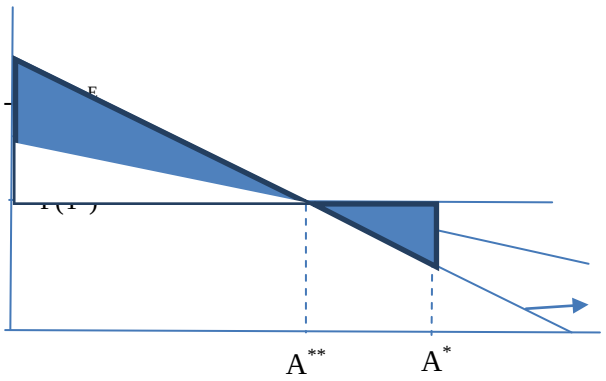
Figure 2: The Impact of a Paternalistic Regulation



Post Reg Demand = $(1-R^{**})\delta U/\delta A - N^{*}L^{E}$

Observed Demand = $(1-R^{*})\delta U/\delta A - N^{*}L^{E}$

Figure 3: The Welfare Impact of a Paternalistic Regulation



Post Reg Demand = $(1-R^{**})\delta U/\delta A - N^{*}L^{E}$

Rational Demand = $(1-R^{*})\delta U/\delta A - L^{E}$

Table 1: Consumer Choices by Schooling Level

	Purchased hardcover book	Prefer classical music	Enjoy watching religious TV	Play golf
Less than high school	14%	6%	18%	6%
High school	25%	10%	13%	10%
Some college	40%	15%	9%	15%
College grad	51%	24%	6%	20%

Source: Authors' calculations from the Simmons National Consumer Survey 2000 – 2009.