Regulating Misinformation

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Abstract

Governments have responded to misleading advertising by banning it, engaging in counter-advertising and taxing and regulating the product. In this paper, we consider the welfare effects of those different responses to misinformation. While misinformation lowers consumer surplus, its effect on social welfare is ambiguous. Misleading advertising leads to over-consumption but that may be offsetting the under-consumption associated with oligopoly outputs. If all advertising is misinformation then a tax or quantity restriction on advertising maximizes welfare, and other policy interventions are inferior. If firms undertake quality improving investments that are complementary to misinformation, then combining taxes or bans on misleading advertising with other policies can increase welfare.

1 Introduction

How should government policy respond to misleading advertising? The classic economic papers on advertising assume either that advertising provides useful information about consumer products (Nelson, 1970) or that advertising shapes preferences (Dixit and Norman, 1978, Becker and Murphy, 1993). Sometimes, however, advertising makes claims that are misleading, especially about the long term health consequences of products. In the nineteenth century, a variety of false claims were made about the health benefits of patent medicines that were just disguised alcohol. In the 1940s and 1950s, cigarette companies tried to convince consumers that their products were healthy (Cutler and Glaeser, 2006). Today, plaintiffs allege that fast food companies have misleadingly understated the health consequences of their products. If firms are providing misinformation, then is the appropriate policy response to ban false claims, to tax the product, or to produce government advertisements with an alternative viewpoint?

In this paper, our model and discussion focuses on misinformation about the health consequences of products. Misinformation may also exist regarding other attributes of a product, such as the ultimate financial cost of a subprime loan or a credit card, perhaps because terms have been "shrouded" as in Gabaix and Laibson (2006). In those cases, the scope for misinformation comes from the complexity of the contract while in the cases that we discuss, the scope for misinformation comes from the difficulty that any individual consumer faces in assessing long-term health consequences of a product.

While the model fits patent medicines and cigarettes as much as it does hamburgers, this paper is particularly motivated by the growing obesity-related debate around common food products, like sodas and hamburgers. Cities have required chain restaurants to post caloric information. Both McDonald's and Coca Cola have been sued for making allegedly misleading claims about their products. Some advocates have urged an obesity tax and one justification for that tax is that children supposedly do not understand the health costs of sugar-filled products.

One laissez-faire view is that there is little cause for government intervention because these public relations efforts are ineffective. While there are many reasons to be suspicious about government intervention, it is implausible that firms would spend significantly on misinformation if that spending did nothing. A second view is that despite the flaws of private decision-making, government decision-making is worse (Glaeser, 2006). Without disputing that view, we present a simple model to examine the potential benefits of different policy responses to misinformation.

We assume that Cournot oligopolists sell a good with unobserved health costs or benefits. While the structure of our model builds on Dixit and Norman (1978), we assume that firms invest in belief-manipulating misinformation, as in Mullainathan, Schwartzstein and Shleifer (2008).

If consumers receive none of the firms' profits, then misinformation always reduces consumer surplus, when surplus is defined to reflect true health costs. If all profits accrue to consumers, then misinformation is only harmful if it increases consumption beyond the level that would occur in a competitive market with perfect information. Since consumers typically underconsume the products of an oligopoly, small amounts of misinformation are welfare-enhancing because they help to correct this underconsumption. This result is similar to the idea that public misinformation overstating the private costs of risky behavior (like unsafe sex) may be optimal if that behavior has externalities.

Firms invest in misinformation and we assume that advertising is product, not supplier, specific. This might be because of pre-existing regulations restricting firm-specific health claims,[1] or because advertising the health benefits of one brand of cigarettes inevitably spills over into beliefs about the health benefits of all cigarettes. This assumption means that firms don't internalize the benefits that their advertising has for other firms, and leads to the prediction that advertising will decrease with the number of firms. In competitive markets, misinformation may be either too high or too

[1] For example, direct-to-consumer advertising of prescription drugs that names a specific product is prohibited in every developed country except the US and New Zealand

low, but since monopolists always internalize the industry-wide impact of advertising on profits, misinformation in monopolistic markets is always too high.

We consider three different forms of government intervention commonly used to regulate misinformation about medicines, cigarettes or food products: taxes or bans on advertising, counter-advertising and taxes on profits or sales. If advertising is just misinformation, then taxes or bans on advertising yield second best options that weakly dominate all other government interventions. Counter-advertising where the government tries to refute private firms is sub-optimal because it creates a costly advertising response by the private firms. Taxes on consumption can be welfare enhancing, but this may be offset by reduced production.

Bans or taxes on advertising are less effective if firms can undertake investments that improve product quality. This investment could represent lowering tar content in cigarettes or reducing trans fats in fast food, or it could represent utility-increasing advertising, as in Becker and Murphy (1993). In our model, misinformation that increases demand makes quality improving investments more valuable. This complementarity means that the regulator would like to limit misleading advertising while forcing firms to make quality improving investments. Combining the direct regulation of misleading advertising with counter-advertising or product taxes can serve this purpose

If there are multiple market segments, then firms will target segments of consumers that are more elastic in their consumption decisions. In some cases, younger consumers may have more elastic demand. This may mean that banning advertising towards the young raises social welfare even if the young are no more likely to be confused than the more mature.

The welfare effects of advertising have been studied by a large literature, surveyed in Bagwell (2007). Our benchmark model is related to Dixit and Norman (1978), with the important difference that advertising is a public good and investment in it takes place before production. This is why in our model a small amount of misinformation may be socially desirable and monopoly is worse than competition, in contrast to Dixit and Norman. The regulation of advertising is dealt with by fewer papers. Boyer and Laffont (1989) consider the misrepresentation of regular vs. promotional prices, and show that penalizing such misinformation improves the informativeness of the price system. Hamilton and Zilberman (2006) study the optimal government certification policy when firms can make fraudulent claims about the eco-friendliness of their products. Anderson and Renault (2006) show that requiring full disclosure of product characteristics may not improve on the unregulated equilibrium when firms can advertise both prices and product attributes. Empirical studies of advertising regulation include Peltzman (1981), Sauer and Leffler (1990), Farr et al. (2001), and Nelson (2005).

We are not suggesting that there are markets where government action against misinformation is currently warranted. Indeed, one of our results is that misinformation may not be so bad. However, this paper does show that if all advertising is misinformation, then bans on advertising raise welfare more than alternative policies, such as government attempts to advertise an alternative view. Conversely, when firms engage in both misinformation and welfare enhancing advertising or

other quality improvements, then it is welfare improving to have both bans on advertising and counter-advertising.

2 Misinformation and policy

We now review cases where the government has responded to misleading advertising with a variety of interventions including advertising bans, counter-advertising and product taxes.

2.1 Medicines

At the end of the nineteenth century, sixty million dollars of patent medicine was being sold annually. "In many instances, however, the medicines were ineffectual. Some of the syrups contained as much as 80 per cent alcohol; many of the tonics used cocaine and morphine. Some of the medicines destroyed health, and make drunkards and dope addicts out of their users" (Weinberg and Weinberg, 1961, p. 176). The advertisements can be stunning in their audacity. Weinberg and Weinberg (1961) cite an ad for Dr. Bye run in the socialist journal Appeal to Reason that claimed "cancer cured with soothing balmy oils." Adams (1905, contained in Weinberg and Weinberg, 1961) describes "Peruna" which was "at present the most prominent proprietary nostrum in the country." Despite the fact that Peruna's active ingredient appears only to have been alcohol, it was advertised as preventive against yellow fewer and "no matter what you've got, you will be not only enabled, but compelled, after reading Dr. Hartman's Peruna book, The Ills of Life, to diagnose your illness as catarrh, and to realize that Peruna alone will save you."

Firms spent a lot of money misinforming consumers about patent medicines, and the ads seem to have been effective. The president of the National Association of Patent Medicine Men claimed in 1900 that between one-third and one-half of patent medicine revenues were spent on advertising the products. It is hard to imagine that this expenditure would have occurred if it didn't have an effect. Many patent medicines had identical medical properties to other cheaper substitutes (i.e. whiskey) and sold for much more. The price difference between whiskey and patent medicine would be hard to understand if the advertising didn't have an effect.

The government response to the patent medicine trade was the Pure Food and Drug Act of 1906. Among other things, the act forbade the sale of misbranded food or drugs "the package or label of which shall bear any statement, design, or device regarding such article, or the ingredients or substances contained therein which shall be false or misleading in any particular way." The government did not engage in counter-advertising (i.e. saying that patent drugs were bad for you) or taxation. It just banned misleading advertising.

One of the consequences of the Food and Drug Act was to insert supposedly more informed intermediaries - doctors - between the consumer and the drug. Since that time, drug companies have focused much of their sales attention on these intermediaries, at least for prescription drugs. More recently, however, there has been an increase in the direct-to-consumer advertising (DTCA) of

prescription drugs, which has now reached $4 billion per year and renewed the debate on this topic. For example, the American College of Physicians believes that "DTCA leaves patients confused and misinformed" (quoted in Auton, 2006).

Our model cannot directly address this topic, since we assume that consumers directly purchase the product in question (as they did during the patent medicine age), but the range of policy options in play in this market matches exactly those discussed in our simpler model. Public counter-information is popular with some advocates, such as the Institute of Medicine (2007, p198), which favors using tax dollars to fund health information campaigns that will provide patients with more "balanced" information. Conventional regulatory instruments, such as taxes on DTCA are also widespread. For example, in 2007 the US government introduced a fee of $41,390 for each television advertisement of prescription drugs submitted to the FDA for advisory review.[2] Labeling and other information disclosure requirements also impose costs on sales and production. Hollon (2005) calls for public health education campaigns funded by a tax on DTCA.

2.2 Cigarettes

Since the 1906 ban on false advertising, there are no cases quite as egregious as 19th century patent medicines, but cigarette advertisers certainly tried to make their products seem healthy. For example, one advertisement claimed:

> "Repeated nationwide surveys show that more doctors smoke Camels than any other cigarette. A few years ago, 113,597 doctors in every branch of the medical profession were asked this question: What cigarette do you smoke, doctor? The brand named most was Camel...you see, doctors smoke for pleasure just as you and I. So what do they look for? Flavor and mildness. So smoke the cigarette that so many doctors smoke."[3]

These claims may not have been factually incorrect, but they do give the misleading impression that cigarettes were medically attractive. Of course, Camels were not the only cigarette trumpeting their appeal to doctors. Another slogan ran "Doctors recommend Phillip Morris." Old Golds were sold with the line "Not a Cough in a Carload."

The Cigarette industry didn't stop with catchy slogans. In the wake of the 1952 Reader's Digest article "Cancer by the Carton" that brought the medical research linking cigarettes and cancer to the wider public, tobacco firms organized "Tobacco Industry Research Committee." The scientific director of this committee, Dr. Clarence Little, then appeared on Edward R. Murrow's "See It Now," and in response to Murrow's question "have any cancer-causing agents been identified in cigarettes," Little responded "none whatsoever." After giving even-handed treatment to Little and his opponents, Murrow declared that "we have no credentials for reaching conclusions on this

[2] http://www.fda.gov/cder/ddmac/user_fees/default.htm

[3] Text is from a television advertisement available at http://video.google.com/videoplay?docid=-1259818256007769353&q=cigarette+commercials&pl=true.

subject." Murrow continued smoking the cigarettes that would lead to his death at age 57 from lung cancer.[4]

The earliest public response to misleading advertising of cigarettes followed the route of the FDA. The Federal Trade Commission first complained about cigarette companies misleadingly suggesting health benefits from their brands and in 1950 received a court injunction to stop an Old Gold advertisement that claimed it was "lowest in nicotine and tars." In 1954, the FTC insisted that "no advertising should be used which refers to either the presence or absence of any physical effect of smoking." Early lawsuits, such as Cooper v. R. J. Reynolds in 1957, tried unsuccessfully to sue firms for misleadingly advertising a cancer causing product.

The Surgeon General's Report of 1964 was a major example of what we will refer to as counter-advertising: an attempt by the government to push an alternative viewpoint. The Surgeon General's report led to health warnings on cigarette packages. Continuing the counter-advertising trend, the Federal Communications Commission ruled that fairness required television stations to broadcast anti-cigarette advertising that would counter their cigarette advertising. This policy led to free air time for the public health opponents of smoking. In 1970, cigarette ads on television ended completely, although anti-cigarette advertising continued.

Litigation eventually managed to impose large judgments on cigarette companies and misleading advertising was a prominent justification for the judgments. While the early settlements, such as the 1996 Liggett Group settlement involved a lump-sum transfer, later settlements more closely resembled taxes on future sales. The Master Settlement between State Attorneys General and the tobacco industry required payments of more than $200 billion over 25 years, but those payments were indexed to operating revenue, which makes them essentially a sales tax.

Regulatory activity in this market is on-going: as recently as June 2009 the US Senate passed the Family Smoking and Tobacco Control Act, banning candy and fruit-flavored cigarettes considered appealing to youths, prohibiting tobacco companies from using misleading terms such as "low tar," "light" or "mild" on labels and packages, and restricting the advertising of tobacco products.[5]

2.3 Responding to obesity

Between the early 1970s and today, the share of adult Americans who are obese has increased from 16 to 34 percent.[6] Among teenagers, obesity has increased from five to almost 18 percent in 25 years.[7] Obesity has significant health consequences, such as increased risk of diabetes and heart disease, and increased obesity is primarily associated with increased consumption of calories, especially prepared foods and soda (Cutler, Glaeser and Shapiro, 2003).

The rising health consequences of a heavier nation have led many advocates to conclude that certain foods need the same treatment that cigarettes received in an earlier era. For example, New

[4] Text is available at http://tobaccodocuments.org/ness/31311.html
[5] http://www.cnn.com/2009/POLITICS/06/12/tobacco.bill/index.html
[6] http://www.cdc.gov/nchs/pressroom/07newsreleases/obesity.htm
[7] http://www.cdc.gov/obesity/childhood/index.html

York's Governor Paterson explicitly called for an obesity tax with the words "Just as the cigarette tax has helped reduce the number of smokers and smoking-related deaths, a tax on highly caloric, non-nutritional beverages can help reduce the prevalence of obesity."[8]

Misinformation also lies at the center of other obesity-related policy debates. For example, a lawsuit filed in 2002 alleges that McDonald's misleadingly represented its food as part of a balanced diet that could be consumed every day. There were also more precise complaints about misinformation, such as the supposedly incorrect claim that McDonald's lowered the sodium content of all of its food. The lawsuit demanded damages because of health costs associated with childhood obesity.

Coca-Cola has also been sued for providing allegedly misleading advertising about Vitaminwater, a drink that appears healthy but that also has considerable sugar content. The Australian Competition and Consumer Commission forced Coca-Cola to publish corrections to earlier advertisements that suggested that Coke didn't cause obesity. Richard Posner, in his blog, argues that one conceivable justification for taxing high calorie sodas is that "The sellers advertise very heavily to children, who do not have the knowledge or the self-control that they would need to be able to resist such advertising."[9] Posner, however, believes that banning advertising is a more sensible approach to this problem than taxation.

The interest in either banning food advertising or taxing sugary products is a relatively recent phenomenon, but the government has long intervened in the presentation of information about food to consumers. The 1990 Nutritional Labeling and Education Act required most foods to be labeled with clear information about ingredients, calories and other nutritional information. The act also required that health-related claims about food (e.g. "high in fiber") conform with Food and Drug Administration Standards. The act did not require restaurants to provide similar information, but there has been a steady increase in making its rules more widely applicable. For example, in 2008, New York City required fast food restaurants to make nutritional information easily available to consumers.

The other long-standing public intervention in this area is the dissemination of "public interest" messages" warning about the dangers of obesity and fast food. For example, in 1992, the U.S. Department of Agriculture started disseminating its food pyramid which warned that "fats, oils and sweets" should be used sparingly. The Surgeon General has regularly warned against the dangers of obesity and urged restraint in the consumption of high calorie foods. For example, in 2006, the Surgeon General compared the threat of obesity with the terrorist attacks of September 11, 2001.[10]

[8] http://www.cnn.com/2008/HEALTH/12/18/paterson.obesity/

[9] http://www.becker-posner-blog.com/archives/2009/05/a_soda_or_calor.html

[10] http://www.cbsnews.com/stories/2006/03/01/health/main1361849.shtml

3 Misperception about health, and welfare

We now turn to a simple model of misperceptions about health. The are n identical firms, who pay constant marginal costs (which we take to be 0 for simplicity), and compete Cournot-style in selling a product.[11] There are m individuals, and person i receives a net benefit of $(a \cdot i - c)$ if he consumes the product, where a and c are constants with $\alpha \equiv a - c > 0$, and the taste parameter i is uniformly distributed on the unit interval. The product could be a hamburger or a cigarette, which presumably have some negative health costs, or a medicine which has positive benefits. The value of the health cost c is not known, and we assume that all individuals believe that the health cost to them of consuming the product is $\hat{c}$, which is possibly erroneous. The perceived net benefit of consuming the product for consumer i is thus $(a \cdot i - \hat{c})$. We let $e \equiv c - \hat{c} \geq 0$ denote the error. We first ask about the welfare consequences of an exogenous error and then endogenize the error.

If the product is sold at price P, then demand equals $Q(P) = \frac{m}{a}(\alpha + e - P)$. Cournot behavior means that $q_j = q(e) = \frac{m(\alpha+e)}{a(n+1)}$, so that equilibrium sales, price and total profits are given by

$$Q(e) = \frac{nm(\alpha + e)}{a(n+1)} \tag{1}$$

$$P(e) = \frac{\alpha + e}{n+1} \tag{2}$$

$$\Pi(e) = nm\frac{(\alpha + e)^2}{a(n+1)^2} \tag{3}$$

Industry sales, price, and profits are all increasing in the error. Unsurprisingly, the producers would like consumers to think that their product is healthier. When there are more firms, the positive effect of the error on total production becomes larger ($Q_{en} > 0$), because more firms increase their output in response to a higher demand (although each individual firm responds less: $q_{en} < 0$). At the same time, the positive effect of e on price and profits becomes smaller as the market turns more competitive. The decreasing price effect is a consequence of $Q_{en} > 0$, since the direct effect of e on price $P(Q) = \alpha + e - \frac{a}{m}Q$ is independent of the number of firms. The decreasing effect of the error on profits is a consequence of the standard competitive externality that Cournot firms impose on each other. This externality is stronger when there are more firms, and therefore the error e increases profits by less in this case. Under perfect competition ($n \to \infty$), a small increase in the error has no first-order effect on either price or profits.

What is the impact of misinformation on welfare and consumer surplus? In general, when advertising affects preferences, the right measure of consumer surplus is not obvious (Dixit and Norman, 1978). Should the surplus reflect preferences before or after advertising? When advertising is misleading, it seems sensible to measure consumer surplus based on the true health costs of the

[11] Given our focus on investments in advertising, Cournot competition guarantees the profits necessary for such investment to take place, while under Bertrand competition profits would be 0. We discuss alternative market structures below.

product. This is the "ex post" utility experienced by a consumer after the product has been consumed and we denote it $CS(e)$. The corresponding welfare equals profits plus ex-post consumer surplus: $W(e) \equiv \Pi(e) + CS(e)$.[12] Proposition 1 follows (all proofs are in the Appendix).

Proposition 1 *Consumer surplus is decreasing in the error e. However, the welfare maximizing level of error is positive as long as the number of firms is finite.*

Misperception e increases the equilibrium price in (2) and causes existing as well as new consumers to pay more than their valuation. In Figure 1, as the inverse demand curve shifts out, area A is the reduction in consumer surplus of existing consumers, and area B represents the losses to new consumers. However, these losses are entirely offset by an increase in firm profits, and therefore do not reduce welfare. The area that drives welfare is C, which is the (true) utility that new consumers get from consuming the product. Even though the net surplus of these new consumers is negative because their expenditure is $B + C$, area C nevertheless represents a social gain: it is deadweight loss turned into profits. This gain will exist and welfare will increase with misinformation as long as there is any deadweight loss under the true preferences: until the error is so large that output reaches the intercept $Q_0 = \frac{m}{a}\alpha$, which is the competitive output level under the true preferences. Equivalently, welfare increases with misinformation as long as the equilibrium price is larger than the error: $P(e) > e$. The welfare maximizing (first best) level of misinformation,

$$e^*(n) = \frac{\alpha}{n}, \tag{4}$$

guarantees that output is equal to its competitive level. In less competitive markets, a larger error is necessary to reach this output level, hence $e^*(n)$ declines in n.

Since Cournot behavior implies that too little of the good is being consumed relative to the social optimum, misinformation that increases consumption offsets this underconsumption (Dixit and Norman, 1978).[13] The possibility that people are smoking too few Camels or not eating enough Big Macs may seem utterly implausible to public health advocates, and we are not claiming that this situation describes reality. Yet it is certainly possible that monopoly pricing leads to underconsumption even of unhealthy products as long as $a > c$, so that some people would choose to consume even under full information.

This result appears in many settings. For example, assume that a single representative consumer buys a vector of goods from competing producers who charge a price $P_l(e)$ for good l, which depends on the error. The consumer's utility is denoted $U(Y - PQ, Q)$, where P and Q are vectors and U represents the true ex post utility that is independent of the error term. The consumer purchases a

[12] We ignore all issues concerning non-comparability across individuals (or firms).

[13] If, following Fisher and McGowan (1979), "ex ante" consumer surplus (consumer surplus based on misinformed preferences) has any positive weight in welfare, a small amount of misinformation increases consumer surplus even under perfect competition. This is because misinformation has no first order effect on ex post consumer surplus, while its impact on the hedonic flow of utility included in ex ante surplus is positive.

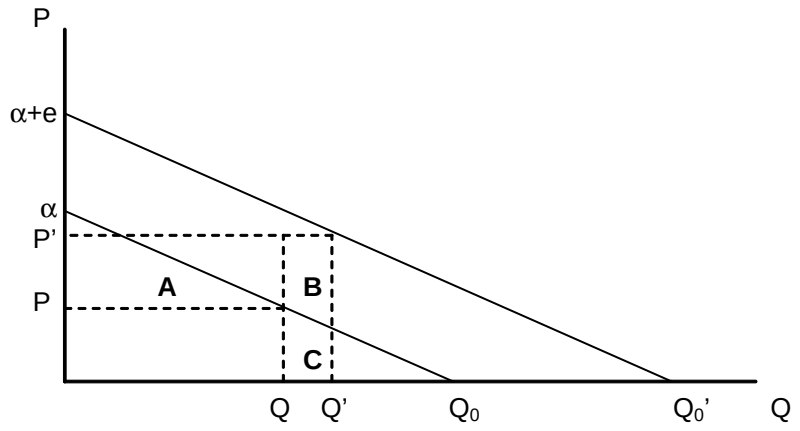

Figure 1: The welfare effect of misinformation

quantity $Q_l(P(e), e)$ of good l and the cost to each producer is $C_l(Q_l)$. If the consumer receives the profits earned by each firm, then welfare is increasing in the error term iff $\sum_l \frac{dQ_l}{de}(\frac{\partial U}{\partial Q_l} - C_l' \frac{\partial U}{\partial Y}) > 0$. As long as the error increases consumption of each product and marginal utilities are higher than marginal costs, then consumer error will be welfare-enhancing.

The welfare effects of misinformation become much more complicated if there are heterogeneous health consequences of consumption in the population. In that case, misinformation can create added welfare losses by inducing the "wrong" people to consume. Misperception might also have consequences in other areas of consumers' lives. For example, underestimating (or overestimating) the health consequences of a disease might lead to too much (or too little) of other forms of risky behavior beyond consuming the product.

4 Endogenous misinformation and welfare

4.1 Endogenous misinformation

The discussion above has taken the error as exogenous. In the remainder of the paper we assume that it is produced by the firms. We do not address the psychology of persuasion which is the topic of Mullainathan, Schwartzstein and Shleifer (2008). Instead, we assume that for a cost, firms can mislead consumers. Specifically, we assume that if each of the n identical firms spends Z_j dollars on misinforming the consumers, the error will be $e = e(\sum Z_j)$, where $e(\cdot)$ is an increasing function that is sufficiently concave for second order conditions to hold and $e(0) = 0$.

Advertising may be a public good among the firms because it is implausible to claim that one product is healthy without implying that other similar products are just as benign. For example, any cigarette ad showing vibrant outdoorsy people smoking suggests a connection between tobacco and health. Similarly, studies of brand-specific DTCA regularly find that these messages increase

product-class sales but not the sales of individual brands.[14] In some cases, like the cigarette industry in the 1950s, regulators have explicitly forbidden firms from making product specific claims. Section 7 discusses an extension in which misleading advertising is a private good.

We model advertising as a long-term investment decision made before production decisions, and assume that firms choose their spending Z_j simultaneously.[15] We focus on the symmetric equilibrium with $Z_j = Z$ for all j. The following proposition characterizes the equilibrium level of advertising and how it is affected by the parameters of the model.

Proposition 2 *The equilibrium advertising level Z solves*

$$\frac{2m}{a(n+1)^2}(\alpha + e(nZ))e'(nZ) - 1 = 0. \tag{5}$$

Total expenditure on misinformation increases with market-size ($\frac{\partial(nZ)}{\partial m} > 0$), decreases with the true health-cost ($\frac{\partial(nZ)}{\partial c} < 0$), and decreases with the number of firms ($\frac{\partial(nZ)}{\partial n} < 0$).

Larger markets will inspire more misinformation because the benefits of misinformation are proportional to market size but the costs are not.[16] As real health costs rise, the incentive to misinform declines, because the impact the error will have on demand and price will be smaller. As competition rises, misinformation falls. All firms benefit by confusing consumers about the costs of the product, but if there are many firms, they will fail to invest in this industry-level public good. This may be one explanation for why monopolistic chain restaurants and manufacturers of processed food are thought to mislead consumers more than regular restaurants operating in a more competitive environment.

These results are not particularly sensitive to our assumption about market structure. Consider any setting with multiple firms where the profits of a firm at the advertising stage can be written as $\Pi(e(\sum Z_j), X) - Z_j$, where X is any parameter of interest (e.g., the number of firms or market size). At the production stage, firms can engage in any price or quantity setting game. If firms are identical, then the equilibrium condition for advertising gives us that $\frac{\partial \Pi}{\partial e}e'(nZ) = 1$. Totally differentiating this equation with respect to X and using the second-order condition gives us that $\frac{\partial(nZ)}{\partial X} > 0$ if and only if $\frac{\partial^2 \Pi}{\partial e \partial X} > 0$. If increases in market size increase the returns to total consumer error, then larger markets will have more misinformation. If more competition reduces the return to misinformation for any given firm, which will be the case in many settings, then more competitive markets will have less misinformation.

[14] See Danzon and Keuffel (2007) for a survey.

[15] Given symmetry, the assumption of simultaneous moves only affects the distribution of profits among the firms. It has no impact on e or any of the other quantities of interest.

[16] If the costs of misinformation rose with market size, then this result could disappear.

4.2 Welfare effects

If we are concerned with ex post consumer surplus, then Proposition 2 should lead consumer advocates to fear monopoly both because of high prices and misinformation. Monopolists have stronger incentives to mislead consumers which further reduces ex post consumer surplus. As the market approaches perfect competition, (5) implies that equilibrium misinformation goes to zero.

We now include advertising costs in profits so that $\Pi(Z) = \Pi(e(nZ)) - nZ$, where $\Pi(e(nZ))$ is total profits defined under (3). Ex post welfare is then given by $W(Z) = CS(e(nZ)) + \Pi(Z)$. Propositions 1 and 2 suggest that misinformation will generate two opposing externalities. One firm's advertising will increase other firms' profits but reduce consumer surplus. The following proposition describes how these opposing forces play out in equilibrium (in the remainder of the paper we normalize $m = 1$).

Proposition 3 *A monopoly always produces too much misinformation. As the market becomes more competitive, the amount of misinformation can be excessive or suboptimal.*

In the case of a monopolist, there is no positive externality to other firms. Since the only externality from misinformation is negative, monopolists must advertise too much. More competition reduces the negative externality, and the equilibrium level of misinformation may become suboptimal due to the positive externality among firms. For example, taking $e(nZ) = \sqrt{nZ}$ in our model implies that a market with 4 or more firms produces too little misinformation.

The result that misinformation may be suboptimal, and more generally that monopolistic advertising is worse than competitive advertising, is in contrast to Dixit and Norman (1978). It follows from the twin assumptions that advertising is a public good and that advertising is a long-term investment which takes place before production.[17] Below, we consider regulatory responses to advertising in cases where misinformation is socially excessive.

5 Regulating misleading advertising

In this section, we study some of the commonly considered regulatory responses to misleading advertising: (i) a tax or a ban on advertising; (ii) product market regulations, including sales and profit taxes; (iii) government advertising or other changes in the firms' technology of misinformation. A direct tax (or, equivalently, a partial ban) on misinformation can implement the second-best. We then show that indirect instruments, such as product market regulations or government advertising, are generally inferior.

[17] It can be shown that if firms choose Z_j and q_j simultaneously, there is always too much misinformation. Intuitively, the public good problem is less severe in this case as firms do not have an incentive to limit their advertising in order to reduce their competitors' production.

5.1 Optimal policies

The second-best level of misinformation maximizes welfare taking into account the firms' equilibrium output choices and the costs of advertising. This second-best level of misinformation, e^{**}, can be implemented using either a tax (with a lump sum rebate) or a quantity restriction (partial ban) on misleading advertising Z. Simply set the policy such that the equilibrium condition (5) yields exactly $e(nZ^{**}) = e^{**}$. The equivalence of taxes and bans breaks down if we allow for entry or the possibility of targeting regulations to specific market segments (see Section 7).

In this model direct taxation of misleading advertising is equivalent to the taxation of profits gross of advertising costs. For example, in the UK, the Prescription Price Regulation Scheme (PPRS) for prescription medicine limits the promotional expenditures that firms can deduct as a cost in calculating the net rate of return (Danzon and Keuffel, 2007). If advertising costs may not be deducted from the tax base, firms' objective in the advertising game becomes

$$\pi(Z_j, \tau_\pi) = (1 - \tau_\pi)\frac{(\alpha + e)^2}{a(n+1)^2} - Z_j, \tag{6}$$

where τ_π is the profit tax. Assuming that tax revenues are rebated to consumers lump sum, the tax has no direct effect on welfare. Thus, the welfare effects work entirely through the firms' choice of advertising level Z, and under constant marginal costs of advertising, this profit tax is equivalent to a direct tax on misleading advertising. Dividing (6) by $(1-\tau_\pi)$ verifies that the tax τ_π is equivalent to a direct tax on misleading advertising $\tau_Z = \frac{1}{1-\tau_\pi} - 1$. Thus, without allowing for advertising cost deductions, a tax on profits can also implement the second best level of misinformation.

5.2 Government advertising and changes in the technology of persuasion

As discussed in Section 2, government advertising is a standard response to misleading information provided by firms. More generally, governments have used a variety of policies which limit the effectiveness of firms' advertising expenditures, including truth-content regulations and labeling requirements.

Assume that the government can take some action Z_g affecting the technology of persuasion, so that the error becomes $e(\sum Z_j, Z_g)$. We refer to Z_g as "government advertising" aimed at educating the consumers, and assume that higher levels of Z_g reduce the error ($e_2 < 0$). Let $e_1 > 0$ and $e_{11} < 0$ as before. We present four examples of how government advertising may change the technology of persuasion.

Example 1 *$e(\sum Z_j, Z_g) = e(\sum Z_j - Z_g)$, so that government advertising simply reduces the "stock" of advertising responsible for misinformation. For future reference, note that in this case the cross-partial e_{12} is equal to $\frac{e_2 e_{11}}{e_1}$.*

Example 2 *The reduction in the stock of misleading advertising that the government can achieve is inversely proportional to the stock itself: $\Delta Z = \frac{\mu_1 Z_g}{Z}$ and the relationship between the stock of*

advertising and misinformation is linear: $e(Z, Z_g) = \mu_2(Z - \Delta Z) = \mu_2(Z - \mu_1 \frac{Z_g}{Z})$ *(where* μ_1, μ_2 *are constants). In this case,* $e_{12} = \frac{\mu_1}{Z^2}$.

Example 3 *Consumers believe that a product is either "unhealthy", with health cost* c*, or "healthy", with health cost* $c - e_0$*, with probabilities* $(1 - r)$ *and* r*, respectively. Firms can influence these (subjective) probabilities by investing in advertising (for example, by increasing the number of ads claiming or suggesting that the product is "healthy"), so that* $r = r(Z)$*,* $r' > 0$*,* $r'' < 0$*. The government can influence consumers' perceptions of what "healthy" and "unhealthy" mean, i.e., it can affect the consumers' estimate of the difference in health costs between the two products.*[18] *Let* $e_0 = e_0(Z_g)$ *with* $e_0 < 0$*, so that the government can take actions to show that a claim of healthiness implies a lower difference in health costs than consumers would have thought. Then, the expected health cost is* $c - r(Z)e_0(Z_g)$*. Here,* $e_{12} = r'e_0' < 0$.

Example 4 *Misinformation only affects the beliefs of a fraction* u *of the population (the "uniformed"), while fraction* $(1 - u)$ *always holds correct beliefs. As long as the uninformed individuals have the same distribution of taste parameters* i *as the population, the model is equivalent to one where misinformation affects everyone, but the error that the firms can create is* $ue(nZ)$*. To see this, note that with* u *uninformed consumers, the demand function becomes* $Q(P) = \frac{u}{a}(\alpha + e - P) + \frac{1-u}{a}(\alpha - P) = \frac{1}{a}(\alpha + ue - P)$*, which is equivalent to a model with* $\hat{c} = c - ue$.[19] *If the government has the ability to reduce the fraction of uninformed individuals, so that* $u = u(Z_g)$*, we have* $\hat{c} = c - e(Z)u(Z_g)$ *(and* $e_{12} = u'e' < 0$*).*[20]

By affecting the error, government advertising changes the profitability of firms' advertising expenditures. Profitability in turn depends on how effective advertising is at creating misinformation (e_1), and the impact of the policy will therefore depend crucially on the cross partial e_{12}. Defining $\xi \doteq \frac{-e_2 e_1}{\alpha + e}$ and $\xi' \doteq \frac{e_2 e_{11}}{e_1}$ (where from second order conditions and the assumptions on e we know that $0 < \xi < \xi'$), we have the following.

Lemma 1 *An increase in government advertising* Z_g *(i) reduces both misleading advertising and the error if* $e_{12} < \xi$*; (ii) increases misleading advertising and reduces the error if* $\xi < e_{12} < \xi'$*; (iii) increases both if* $e_{12} > \xi'$.

When government advertising reduces the marginal effect of firm advertising, because $e_{12} \leq 0$, an increase in government advertising always reduces misinformation. However, when $e_{12} > 0$, the

[18] This is a simple way of modelling "truth-content" regulations which effectively define what certain words or phrases commonly used in advertisements have to mean. More generally, this assumption also captures the notion that firms usually provide information about the products they produce, while government campaigns might provide more generic information about the desirability of general classes of products, technologies, inputs/ingredients etc.

[19] With a more general demand function, this equivalence would not hold and the effect of government advertising would become harder to establish.

[20] For example, the government could send Z_g messages about true health-cost, which are received randomly in the population. Then the measure of uninformed agents changes from u_0 to $u(Z_g) = u_0(1 - \frac{Z_g}{m})$.

effect on deception is no longer unambiguous. If e_{12} is large enough so that $e_{12} > \xi'$, firms will react to government advertising by increasing their own advertising to such an extent that the amount of consumer error e actually rises. A different interpretation of this result is that *increasing* the effectiveness of firms' misinformation technology can be useful if that increase ends up reducing the amount of firms' investment in misinformation. In the above examples, Lemma 1 implies that government advertising has no impact on the equilibrium level of misinformation in Example 1, increases misinformation in Example 2, and reduces misinformation in Examples 3 and 4.

Turning to the welfare effects of government advertising, our first result is that since private advertising only enters consumer surplus through consumer error, by Proposition 1, ex post consumer surplus increases if and only if consumer error is reduced:

Corollary 1 *Ex post consumer surplus is increased by government advertising Z_g if and only if $e_{12} < \xi'$.*

Next, we consider total welfare, which includes consumer surplus, profits, and the cost of firm advertising. To make the best case for government advertising, we ignore its direct costs. The following proposition shows that, even if free, government advertising cannot improve upon the direct regulation of misinformation.

Proposition 4 *Once an optimal tax or quantity limit on misleading advertising is in place, advertising by the government cannot improve welfare.*

Of course, once a tax has been optimally set, firms advertise at the second best level Z^{**} and government advertising cannot improve welfare through Z. What the proposition shows is that government advertising cannot improve welfare even though it has a direct effect on the consumer error. Intuitively, since the second-best error is lower than the first best, lowering the error through government advertising can never help. Once an optimal tax or quantity limit on misleading advertising is in place, government advertising should be set equal to zero.

5.3 Taxing production

A policy of production or sales taxes is interesting both because it is often suggested as part of a policy mix to reduce misinformation (see Section 2), and because many products for which misleading advertising is a concern are already subject to taxation (e.g., tobacco).

Suppose that the government levies a tax τ on the product (with revenues rebated lump sum), so that each firm's objective function in the Cournot game becomes $(P(Q) - \tau)q_j$. As the following Proposition shows, such a tax always reduces misinformation. Nevertheless, its effect on consumer surplus may be negative, and such a policy is inferior to direct regulations of misleading advertising.

Proposition 5 *(i) An increase in the product tax always reduces the error e. However, it increases the price, and its effect on consumer surplus is negative whenever the equilibrium error satisfies*

$$\frac{e'[\alpha - \tau - (n+2)e]}{-[(e')^2 + (\alpha + e - \tau)e'']} < n(\alpha - \tau) - e. \tag{7}$$

(ii) Once an optimal tax or quantity limit on misleading advertising is in place, taxing production reduces welfare.

A tax on production makes misinformation less profitable, and the resulting decrease in misleading advertising raises consumer surplus. This effect is shown on the left hand side of (7), and depends on the responsiveness of consumer surplus to the error (the numerator) and on the effect of the tax on the equilibrium error (the denominator). At the same time, the tax leads to an increase in prices as firms reduce production for given e. The resulting decrease in consumer surplus is the right hand side of (7). This negative effect is larger the more firms there are, because each reduces its production slightly without internalizing the full effect of the resulting price increase. Whenever (7) holds, consumer surplus is reduced.

Because the product tax only affects consumer error through firms' advertising Z, once misleading advertising is optimally regulated, the tax has no first-order effect on misinformation. Only the price effect identified in part (i) of the Proposition remains, and welfare is reduced. In fact, part (ii) of the proposition implies that once misinformation is optimally regulated, *subsidizing* production would increase welfare by reducing the price (until the competitive quantity is reached).

6 Regulating misinformation in the presence of quality improving investments

We now turn to the more realistic assumption that firms engage in both misinformation and quality improving investments. For example, firms can make their products healthier, or engage in utility-increasing advertising, as in Becker and Murphy (1993). In particular, we now assume that people's utility from the product is $a_0 + a \cdot i$ with $i \sim U[0,1]$. Demand is $Q(P) = \frac{1}{a}(\alpha + a_0 + e - P)$. Firms now can invest in both misleading advertising Z_j and quality improvement. We let Y_j denote expenditure on quality improvement, and we assume that $a_0 = a_0(\sum Y_j)$, where a_0 is increasing and concave. For symmetry, we assume that both activities have the same public good aspect to them, and firms' profit in the investment stage is

$$\pi(Z,Y) = \frac{(\alpha + a_0(\sum Y_{j'}) + e(\sum Z_{j'}))^2}{a(n+1)^2} - Z_j - Y_j.$$

Because quality improvement raises demand, it increases the profitability of misinformation. Health improvement Y and misleading advertising Z are thus complements for the firms ($\pi_{YZ} > 0$).[21]

Proposition 1 implies that higher utility from the product (corresponding to a larger a_0) will make a given level of misperception more desirable because under-consumption in a noncompetitive market is more severe in this case. Because of complementarity, this effect is reinforced when investment levels are chosen by optimizing firms, since a larger error in turn implies a higher equilibrium level of quality improvement. Thus, the welfare maximizing level of misleading advertising, Z^{***}, is higher in the presence of quality improving investments: $Z^{***} > Z^{**}$.

Complementarity also implies that the effect of our various policies on Z will be magnified. For example, a small increase in an advertising tax on misleading advertising Z also reduces quality improvement Y, which in turn reduces Z further. Similarly, the presence of quality improving investments implies that relative to Lemma 1, the effect of government advertising will "more often" be negative.

The complementarity of misinformation and quality improvement implies that a tax (or quantity restriction) on misleading advertising reduces both the level of misinformative advertising and the level of quality improving investments. When quality improvements are possible, direct regulation of misleading advertising can no longer achieve the second-best level of misinformation e^{**}. The most a tax (or ban) can attain is the "third best" level of misinformation, $e^{***} = e(nZ^{***})$. This is the level of misinformation providing highest welfare taking into account the equilibrium relationship between misleading advertising and quality improving investments. To get closer to the second-best, the government would like to regulate misleading advertising while forcing firms to leave the level of quality improvement unchanged. While a regulator may be unable to achieve this directly, complementing the direct regulation of misinformation with other instruments can serve this purpose, as we show below.

Proposition 6 *Government advertising improves upon the optimal direct regulation of misleading advertising whenever the equilibrium error satisfies*

$$\frac{\frac{n}{a(n+1)^2}[(n+2)(\alpha+a_0)+e]a_0' - 1}{h_{22}} - \frac{1}{a(n+1)^2}(\alpha + a_0 - ne) > 0, \tag{8}$$

where $h_{22} = a_0' + (\alpha + a_0 + e)\frac{a_0''}{a_0'} < 0$ *is the second-order condition of firms' problem with respect to* Y.

Just as in the case with no quality improvement, once an optimal direct regulation of misinformation is in place, small changes in public advertising have no first-order effect on welfare through Z. However, this policy now has a negative effect on quality improving investments: Because of the

[21] Complementarity between the two forms of investment implies that the comparative statics of Proposition 2 continue to hold: a rising m and a declining c increase both Z and Y, and increasing the number of firms n reduces both total misleading advertising nZ and total quality improvement nY.

complementarity between consumer error and quality improvement, holding misleading advertising constant, public advertising reduces the level of quality improving investments. This is captured by the first term in (8). The second term in (8) represents the direct effect of government advertising on welfare through the consumer error. While in the absence of quality improvement this effect was always negative, things are different here. In this setting with two types of investment, optimal regulation of Z may allow the equilibrium output to be above the competitive level. Because of the complementarity with quality improvement, such a large degree of misinformation may be beneficial by producing equally large amounts of quality improving investments. When this is the case, government advertising will reduce the quantity produced, bringing it closer to the first-best competitive level. This effect of the policy is captured by the second term in (8). It is positive as long as the (optimally regulated) error is larger than e^*, the first-best level of misinformation in (4). Whenever the sum of these two effects is positive, government advertising improves welfare even under optimal direct regulation of misleading advertising.

Proposition 7 *Once an optimal tax or quantity limit on misleading advertising is in place, a tax on production improves welfare if and only if the equilibrium error satisfies*

$$\frac{\frac{n}{a(n+1)^2}[(n+2)(\alpha+a_0)+e-\tau]a_0'-1}{h_{22}^{\tau}}-\frac{1}{a(n+1)^2}(\alpha+a_0-ne+n\tau)>0, \tag{9}$$

where $h_{22}^{\tau}=a_0'+(\alpha+a_0+e-\tau)\frac{a_0''}{a_0'}<0$ *is the second-order condition with respect to* Y.

Similarly to government advertising, complementing direct regulation with a product tax may also be helpful. As above, small changes in the product tax have no first-order effect on welfare through consumer error, but they do have a negative effect on quality improving investments (the first term in (9)). Note that this negative effect tends to be larger with more firms because of the public good nature of quality improvement. The second term in (9) represents the direct effect of the tax on welfare through the price. Whenever optimal regulation of Z yields an equilibrium output above the competitive level, introducing a product tax will reduce the quantity produced, bringing it closer to the first-best. The second term in (9) is positive as long as the (optimally regulated) error is large enough. Whenever this second effect dominates the first one, a production tax improves upon direct regulation.[22]

We have assumed that the government can differentiate between misinformation and quality improving investments, and is able to directly regulate the former. In many cases, this is not problematic, but some activities, such as utility-increasing advertising, may be hard to distinguish. Additional difficulties arise when the two types of investments cannot be distinguished, since useful advertising will then be directly affected by the policy.[23]

[22] It is easy to see that an optimal direct policy cannot be improved upon with profit taxes. Because with a full rebate of the tax revenues a profit tax does not affect welfare directly, once misleading advertising is optimally regulated the only first-order effect of this policy is to reduce quality improving investments.

[23] This case corresponds more to cigarettes than to patent medicine. The Camel ads which show doctors smoking

7 Extensions

7.1 Market targeting

Some of the most contentious discussions of misleading information concerns advertising to children who are presumably more prone to believe misinformation. To address this, we assume there are two market segments and return to the case where all advertising is misinformation. The first one is the "high-valuation" segment, where the utility from the product is given by $a \cdot i_H$ with $i_H \sim U[\psi, 1]$, where $\psi < \frac{c}{a}$ is a constant. In the second, "low-valuation" segment, utility is $a \cdot i_L$, with $i_L \sim U[0, \psi]$. For simplicity, assume that the relative size of the two segments reflect their valuations, so that there are $(1 - \psi)$ and ψ individuals in each segment respectively.

Assume that firms can choose how much to invest in advertising in each of the two market segments (denoted by Z_L and Z_H respectively). Firms earn higher profits if they can target their ads to consumers who will respond to them more. Proposition 8 in the Appendix shows that in equilibrium, marginal consumers will always be located in exactly one of the segments, and firms will never choose positive levels of advertising in both. This implies that regulatory policies will only be effective at reducing misinformation if they encompass the market segment that firms are targeting. For example, a ban which only affects the high-valuation segment will be ineffective if firms optimally target the low valuation segment. If a ban has differential impact in the two segments, only its impact in the targeted segment matters.

The possibility of targeting regulation may affect regulatory costs (hence welfare). If targeted bans or taxes are feasible, the enforcement costs of such policies may be lower than attempting to regulate misinformation in the entire market. Similarly, counter-advertising targeted at the relevant market segment may be cheaper than also providing information to non-marginal consumers. The discussion above suggests that banning advertising to the young may be efficient even if the young think as clearly as adults. If firms target the young because they are new consumers who are particularly likely to respond to advertising, then it may make sense to particularly ban advertising against this group.

7.2 Private misinformation and entry

Consider now a version of the model in which misinformation is a private good. Write $e_j(Z_j)$, and assume that consumers have the same preferences as above. This implies that if $e_j(Z_j) < e_k(Z_k)$, everyone will buy from firm k and no-one buys from j. Assume $n = 2$ to simplify the discussion. One may check that if firms choose advertising levels simultaneously as before, no pure-strategy Nash equilibrium exists. Let us therefore assume that firm 1 chooses Z_1 first, and firm 2 responds by choosing Z_2.

Camels, and Marlboro advertisements showing healthy cowboys smoking are probably both utility enhancing and misleading.

For any advertising level Z_1, firm 2 will choose its advertising Z_2 slightly above it, unless that would yield negative profits, in which case he prefers not to advertise. Given this, the unique Subgame Perfect Nash Equilibrium is for Firm 1 to choose the advertising level yielding 0 profits, and Firm 2's best response is to choose no advertising.[24] Thus, firm 1 uses misinformation to deter entry. In the product market, Firm 1 acts as a monopoly, creates a deadweight loss, but earns 0 profits. The equilibrium level of total advertising is higher than any level observed in the case where misinformation was a public good, including the case of monopoly.

Because the threat of entry forces the incumbent to overinvest in misinformation, the case for regulatory intervention tends to be stronger than in the public goods case. For example, even a small regulatory restriction on misleading advertising raises welfare by increasing both consumer surplus and profits. The latter is possible because the restriction limits Firm 2's ability to increase its market share through advertising, which in turn allows Firm 1 to earn positive profits while still deterring entry. More generally, policies such as product taxes that create entry barriers may increase welfare by allowing the incumbent firm to reduce its advertising towards the monopoly level.

8 Conclusion

In this paper, we have examined the impact of misinformation on social welfare and the impacts of different governmental responses to misinformation. Our first result was that misinformation may not be socially inefficient. If a monopoly has high prices and then misleads people into consuming more, and if monopoly profits are distributed across the population, then misinformation can be welfare enhancing. Consumer error leads to more consumption which offsets the underconsumption due to monopoly prices. Misinformation is more likely to be welfare reducing when prices are closer to marginal costs than in a more monopolistic setting. When misleading advertising was endogenized, we found that monopolies will always produce too much misinformation. In a competitive market, this effect is limited because misinformation is a public good among firms.

When advertising only acts to misinform, then the second best outcome can be created by a tax on advertising or an equivalent quantity control. Counter-advertising by the government is inefficient both because it may have its own costs and because it can increase firm advertising. Taxes on sales also fail to replicate the second best outcome. These results suggest that quantity restrictions on false advertising in the spirit of the Pure Food and Drug Act of 1906 may have been an efficient response to the problem of misleading advertising of patent medicine.

When advertising is complemented by quality improving investments then the results are more nuanced. A simple tax on advertising cannot yield the second best outcome because the tax reduces both good and bad forms of investment even if the ban only applies to misinformation because the

[24] This result is analogous to that found in the theory of contestable markets, explaining why the threat of entry could force monopoly profits to 0.

two types of investment are complements. If an optimal tax is put in place, then it may still be desirable for the government to engage in counter advertising detailing the health costs of the product, or to implement a sales tax. This result suggests that the government policy towards cigarettes that both limited some forms of firm advertising and engaged in counter-advertising may have been efficient.

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A Appendix: Proofs

Proof of Proposition 1 Ex-post consumer surplus may be computed as the average utility of those individuals who chose to consume the product, $\frac{n\alpha-e(n+2)}{2(n+1)}$,[25] times the number of consumers,

[25] To find this, write the average utility as $E[ai|ai-\hat{c}-P>0]-c-P$. Using $P=\frac{\alpha+e}{n+1}$, this is $\frac{1}{2}(\frac{\alpha+e}{n+1}+a+c-e)-c-\frac{\alpha+e}{n+1}$. Rearranging gives the expression in the text.

$Q(e) = n\frac{m(\alpha+e)}{a(n+1)}$. This gives

$$CS(e) = nm\frac{\alpha^2 n - \alpha e - e^2(n+2)}{2a(n+1)^2}. \tag{10}$$

Ex-post welfare is $W(e) \equiv \Pi(e) + CS(e)$. Adding (3) and (10) and taking derivatives verifies that (4) is necessary and sufficient for $\frac{dW}{de} > 0$.

Proof of Proposition 2 Using (1) and (2), in the advertising game, firm j's profit is given by $\pi(Z_j) = \frac{m(\alpha+e(\sum Z_{j'}))^2}{a(n+1)^2} - Z_j$. The equilibrium average advertising level $Z \equiv \frac{1}{n}\sum Z_j$ is determined by the first order condition (5). The second-order condition is

$$\frac{2m}{a(n+1)^2}[(e')^2 + (\alpha+e)e''] < 0. \tag{11}$$

It will be convenient to use the notation $SOC \equiv (e')^2 + (\alpha+e)e''$, and $SOC^* \equiv \frac{SOC}{(\alpha+e)e'}$ (the latter is SOC around the equilibrium, obtained by substituting (5) into the left-hand side of (11)). Clearly, with constant symmetric marginal costs of advertising, any vector $(Z_1, ..., Z_n)$ such that $\frac{1}{n}\sum Z_j = Z^*$ is an equilibrium. We focus on the symmetric equilibrium with $Z_j = Z^*\ \forall\ j$. The comparative statics can be obtained directly from (5) and (11).

Proof of Proposition 3 Welfare is $CS(e) + \Pi(e) - nZ = \frac{nm}{2a(n+1)^2}(\alpha+e)((n+2)\alpha - ne) - nZ$. Taking the derivative, $\frac{\partial(CS+\Pi-nZ)}{\partial Z} = n\left[\frac{nm}{a(n+1)^2}(\alpha - ne)e' - 1\right]$. This equation implies that the socially optimal level of adverting is $\frac{nm}{a(n+1)^2}(\alpha - ne(nZ^{**}))e'(nZ^{**}) = 1$. To check whether the unregulated equilibrium produces too much or too little misinformation, substitute in the first-order condition 5 to get $\frac{\partial(CS+\Pi-nZ)}{\partial Z} = \frac{n}{2}\frac{\alpha(n-2)-e(n^2+2)}{a-c+e}$. For $n = 1$, this is always negative, and therefore a small reduction in misinformation would increase welfare. For n large, the sign is ambiguous. For example, if $e(nZ) = (nZ)^{\frac{1}{2}}$, the derivative is always positive for n large enough, and a small additional amount of misinformation would raise welfare.

Proof of Lemma 1 Comparative statics w.r.t. Z_g yield $\frac{\partial Z}{\partial Z_g} = \frac{-e_2 e_1 - (\alpha+e)e_{12}}{n((e_1)^2+(\alpha+e)e_{11})}$,which is negative iff $e_{12} < \xi$. Moreover, $\frac{de}{dZ_g} = ne_1\frac{\partial Z}{\partial Z_g} + e_2 = \frac{(\alpha+e)(e_2 e_{11} - e_1 e_{12})}{(e_1)^2+(\alpha+e)e_{11}}$, which is negative iff $e_{12} < \xi'$.

Proof of Proposition 4 We show that given any level of government advertising and a corresponding optimal advertising tax, reducing government advertising slightly always raises welfare. Write the derivative of welfare w.r.t. Z_g as $\frac{d(CS(e)+\Pi(e)-nZ)}{dZ_g} = \left[\frac{\partial(CS+\Pi)}{\partial e}e_1 - n\right]\frac{\partial Z}{\partial Z_g} + \frac{\partial(CS+\Pi)}{\partial e}e_2$. Under an optimal tax or quantity limit, the term in brackets is 0. Furthermore, the level of error is $e^{**}(Z_g) \equiv e(nZ^{**}(Z_g), Z_g)$, so the second term is $\frac{\partial(CS+\Pi)}{\partial e}e_2 = \frac{n}{a(n+1)^2}(\alpha - ne^{**}(Z_g))e_2$. Because $e^{**}(Z_g) < e^* = \frac{\alpha}{n}$, and $e_2 < 0$ by assumption, this expression is negative. Thus, given an optimal tax, government advertising should be set at its lowest possible level.

Proof of Proposition 5 Solving the Cournot game under taxes, we find $q(e,\tau) = \frac{\alpha+e-\tau}{a(n+1)}$, $P(e,\tau) =$

$\frac{\alpha+e+n\tau}{n+1}$, and the equilibrium profit is $\pi(e,\tau) = \frac{(\alpha+e-\tau)^2}{a(n+1)^2}$. Thus, price increases in the production tax. The first order condition of the advertising game is

$$\frac{2}{a(n+1)^2}(\alpha + e - \tau)e' - 1 = 0, \tag{12}$$

and write the corresponding second order condition as $SOC^*(\tau) = \frac{2}{a(n+1)^2}\left\{(e')^2 + (\alpha + e - \tau)e''\right\} < 0$. The comparative statics yield $\frac{\partial Z}{\partial \tau} = \frac{e'}{nSOC^*(\tau)} < 0$. Consumer surplus is $CS(e,\tau) = \frac{n}{2a(n+1)^2}[(\alpha - \tau)^2 n - 2(\alpha - \tau)e - e^2(n+2)]$. The derivative w.r.t. τ is proportional to $-[\alpha - \tau + (n+2)e]\frac{\partial e}{\partial \tau} - n(\alpha - \tau) + e$. Using (12) to find $\frac{\partial e}{\partial \tau} = \frac{e'}{-[(e')^2+(\alpha+e-\tau)e'']}$ and rearranging yields the condition in the text.

For the second part of the Proposition, we show that given an arbitrary level of product tax and a corresponding optimal advertising tax, reducing the product tax slightly always raises welfare. Let $Z^{**}(\tau)$ denote the second-best optimal level of misleading advertising given a product tax τ. The expression defining $Z^{**}(\tau)$ is

$$\frac{n}{2a(n+1)^2}(\alpha - ne(Z^{**}(\tau)) + n\tau)e'(Z^{**}(\tau)) = 1. \tag{13}$$

Write the derivative of welfare w.r.t. τ as $\frac{d(CS(e,\tau)+\Pi(e,\tau)-nZ)}{d\tau} = \left[\frac{\partial(CS+\Pi)}{\partial e}e_1 - n\right]\frac{\partial Z}{\partial \tau} + \frac{\partial(CS+\Pi)}{\partial \tau}$, where CS now includes the tax rebate $\tau n\frac{\alpha+e-\tau}{a(n+1)}$. Under an optimal tax or quantity limit, the term in brackets is 0, while the second term is $\frac{\partial(CS+\Pi)}{\partial \tau} = \frac{-n}{a(n+1)^2}(\alpha - ne(Z^{**}(\tau)) + n\tau)$. From (13), this expression is negative: given an optimal advertising tax, taxing production can only reduce welfare.

Proof of Proposition 6 In a symmetric equilibrium, Z and Y solve the first-order conditions

$$\frac{2(\alpha + a_0 + e)e'}{a(n+1)^2} = 1 \tag{14}$$

$$\frac{2(\alpha + a_0 + e)a_0'}{a(n+1)^2} = 1. \tag{15}$$

Write the second-order condition corresponding to (14)-(15) as the requirement that the Hessian $\mathbf{H} = [h_{ij}]$ be negative semi-definite, where $h_{11} = \frac{2}{a(n+1)^2}[(e')^2 + (\alpha + a_0 + e)e'']$, $h_{12} = h_{21} = \frac{2}{a(n+1)^2}e'a_0'$, and $h_{22} = \frac{2}{a(n+1)^2}[(a_0')^2 + (\alpha + a_0 + e)a_0'']$. Write $Y(Z, Z_g)$ as the equilibrium level of quality improvement as a function of Z and Z_g, and write the derivative of welfare with respect to Z_g as $\frac{dW(Z,Y,Z_g)}{dZ_g} = \left[\frac{\partial W}{\partial Z} + \frac{\partial W}{\partial Y}\frac{\partial Y}{\partial Z}\right]\frac{dZ}{dZ_g} + \frac{\partial W}{\partial Y}\frac{\partial Y}{\partial Z_g} + \frac{\partial W}{\partial Z_g}$. When the direct regulation of misleading advertising Z is optimally set, the term in brackets is equal to 0. Therefore, we get $\frac{dW}{dZ_g} = \frac{\partial W}{\partial Y}\frac{\partial Y}{\partial Z_g} + \frac{\partial W}{\partial Z_g}$. Using the first order condition (15), we find $\frac{\partial Y}{\partial Z_g} = \frac{-e_2 a_0'}{(a_0')^2+(\alpha+a_0+e)a_0''}$. Finally, since the sum of consumer surplus and profits is $\frac{n}{2a(n+1)^2}[(2+n)(\alpha + a_0)^2 + 2(\alpha + a_0)e - ne^2]$, we get

$$\frac{dW}{dZ_g} = ne_2\left[\frac{1 - \frac{n}{a(n+1)^2}[(n+2)(\alpha + a_0) + e]a_0'}{a_0' + (\alpha + a_0 + e)\frac{a_0''}{a_0'}} + \frac{1}{a(n+1)^2}(\alpha + a_0 - ne)\right].$$

Using the fact that $e_2 < 0$, the condition in the proposition follows.

Proof of Proposition 7 Write $\frac{dW}{d\tau} = \left[\frac{\partial W}{\partial Z} + \frac{\partial W}{\partial Y}\frac{\partial Y}{\partial Z}\right]\frac{dZ}{d\tau} + \frac{\partial W}{\partial Y}\frac{\partial Y}{\partial \tau} + \frac{\partial W}{\partial \tau}$, and note that under direct regulation of misleading advertising Z, the term in brackets is equal to 0. Therefore, we have $\frac{dW}{d\tau} = \frac{\partial W}{\partial Y}\frac{\partial Y}{\partial \tau} + \frac{\partial W}{\partial \tau}$. Using the first order condition (15), we find $\frac{\partial Y}{\partial \tau} = \frac{a_0'}{(a_0')^2 + (\alpha + a_0 + e - \tau)a_0''}$. Finally, we get

$$\frac{dW}{d\tau} = n\left[\frac{\frac{n}{a(n+1)^2}[(n+2)(\alpha + a_0) + e - \tau]a_0' - 1}{a_0' + (\alpha + a_0 + e - \tau)\frac{a_0''}{a_0'}} - \frac{1}{a(n+1)^2}(\alpha + a_0 - ne + n\tau)\right].$$

Market Targeting

Proposition 8 *Assume that an equilibrium exists. There is positive advertising in at most one market segment.*

Proof. Denote $e(\sum Z_L) = e_L$ and $e(\sum Z_H) = e_H$. Given the distribution of tastes, the demand function is given by the following expression

$$Q(P) = \min\left[1, \frac{\alpha + e_H - P}{(1-\psi)a}\right](1-\psi) + \max\left[0, \frac{\psi a - c + e_L - P}{\psi a}\right]\psi. \tag{16}$$

There are four cases to consider. When $\frac{\alpha + e_H - P}{(1-\psi)a} \geq 1$ and $0 < \frac{\psi a - c + e_L - P}{\psi a}$, all type-$H$ and some type-L individuals consume. Eq. (16) then becomes $Q(P) = \frac{1}{a}(a - c + e_L - P)$. Since on the margin Z_H does not affect demand, $Z_H = 0$, while the equilibrium value of Z_L is given in (5).

When $\frac{\alpha + e_H - P}{(1-\psi)a} < 1$ and $0 \geq \frac{\psi a - c + e_L - P}{\psi a}$, some type-$H$ consume but no type-L do. Demand is $Q(P) = \frac{1}{a}(a - c + e_H - P)$ so that in equilibrium $Z_L = 0$, and Z_H is given in (5).

When $\frac{\alpha + e_H - P}{(1-\psi)a} \geq 1$ and $0 \geq \frac{\psi a - c + e_L - P}{\psi a}$, all type-$H$ individuals consume but none of the type-L do. In this case, $Q(P) = 1 - \psi$ and therefore there is no advertising in either segment.

What is left to show is that there is no equilibrium in which $\frac{\alpha + e_H - P}{(1-\psi)a} < 1$ and $0 < \frac{\psi a - c + e_L - P}{\psi a}$. If this was the case, demand would be $Q(P) = \frac{1}{a}((1+\psi)a - 2c + e_H + e_L - 2P)$. Because the two errors enter symmetrically, concavity implies that $e'(nZ_H^*) = e'(nZ_L^*)$ in equilibrium, so that firms advertising in both segments would do so at the same level. Denoting the resulting error $\bar{e}$, we get $P = \frac{\frac{1+\psi}{2}a - c + \bar{e}}{n+1}$. But then $\frac{\alpha + e_H - P}{(1-\psi)a} < 1$ is $\bar{e} < a\frac{1}{n}(\frac{1+\psi}{2} - (n+1)\psi) + c$ while $0 < \frac{\psi a - c + e_L - P}{\psi a}$ is $\bar{e} > a\frac{1}{n}(\frac{1+\psi}{2} - (n+1)\psi) + c$: a contradiction.[26]

[26] One may show that the necessary conditions for the first three cases are mutually exclusive. In particular, $Z_L > 0$ requires that $n > \frac{a(1-\psi)}{a\psi - c}$, $Z_H > 0$ requires that $n < \frac{a(1-\psi)}{a\psi - c}$, and $Z_L = Z_H = 0$ occurs in the knife-edge case when $n = \frac{a(1-\psi)}{a\psi - c}$.