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Balancing the Public Interest-Defense in Cartel Offenses

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Abstract

In some jurisdictions, horizontal agreements may be exempted from the cartel law if they advance certain public interests, such as public health or the environment, enough to compensate the consumers damaged by their anti-competitive effects. We formalize the balancing of cartel unit price overcharges on a private good against the willingness of its consumers to pay for an accompanying public good, using a standard model of public good provision with voluntary private contributions. A cartel may improve upon the under-provision in competitive equilibrium, even though it crowds out private contributions. Contrary to the Samuelson condition, the compensating public good level required decreases in consumers' willingness to pay. A public interest-cartel is not sustainable beyond a small critical mass of consumers who combine a preference for private consumption with a low willingness to pay for the public good. Orthogonal to Lindahl-pricing, by self-selection the policy targets exactly those consumers. The information requirements for a competition agency to identify a genuine public interest-defense seem prohibitively large by all standards.

JEL-codes: H41, K21, L40, Q01
Keywords: cartel, public interest, public good, overcharge, exemption

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1 Introduction

A concern that certain public interests, such as environmental protection, public health, animal well-being or sustainability, may not be well served by competition has directed several antitrust agencies to weigh in their decisions other public interests as well. The idea is to exempt agreements among competitors with an anti-competitive nature that claim to promote such wider public interests from the competition laws. The US antitrust authorities and courts have resisted calls to consider wider public policy arguments on welfare merits against combinations in restraint of trade.[1] Yet the European Treaty provides that the prohibition of all agreements between firms which have as their object or effect the prevention, restriction or distortion of competition within the internal market, may be declared inapplicable if such an agreement: "...contributes to improving the production or distribution of goods or to promoting technical or economic progress, while allowing consumers a fair share of the resulting benefit."[2] The efficiency gains here intended by the drafters have recently been stretched to include the advance of wider public interest such as more sustainable production.

In *CECED*, a landmark decision from 1999, the European Commission exempted horizontal agreements between manufacturers of washing machines to discontinue the production of their least energy-efficient models from the European cartel law, on the conclusion that the agreements would on balance bring about energy and water bill savings, as well as environmental benefits for society in excess of their negative effects from reduced competition. The Commission has since been reluctant to grant such cartel exemptions.[3] Whereas the 2001 Guidelines on Horizontal Agreements contained a separate chapter on assessing environmental agreements for exemption under 81(3), the revised 2011 Guidelines no longer even mentions this possibility.[4] In the same year, the Commission fined the *Washing Powder* cartel case, which allegedly was a trade association initiative to improve the environmental performance of detergent products.[5]

The Dutch Authority for Consumers and Markets (ACM) became recently receptive to claims of anti-competitive horizontal agreements promoting sustainability. North Sea shrimp fishermen, who were fined in 2003 for colluding to restrict shrimp catches, argued on appeal that their cartel made

[1] Werden (2014). In *National Society of Professional Engineers v. United States* 435 U.S. 679 (1978), the U.S. Supreme Court rejected justification of a suppression of price competition in violation of Section 1 of the Sherman Act on the argument that competition would produce inferior engineering work endangering public safety. The Supreme Court held that even if competition would conflict with professional standards, that would be a matter of regulation, and "... not a reason, cognizable under the Sherman Act, for doing away with competition."

[2] Article 101 TFEU.

[3] Commission Decision, Case IV.F.1/36.718, *CECED*, 24 January 1999. The exemption was given under paragraph 3 of Article 101 TFEU. It was shortly after stretched to include dishwashers and water heaters as well. See European Commission, "Commission approves agreements to reduce energy consumption of dishwashers and water heaters," IP/01/1659, Brussels, 26 November 2001.

[4] Several legal scholars, including Townley (2009) and Kingston (2011), nevertheless argue that the EU Treaties and case-law of the European courts allow, or even demand consideration of wider public interests. Note that although legally a horizontal agreement that is exempted under Article 101(3) is not a cartel, to be concise we refer in this paper to a horizontal agreement with anti-competitive effects in the meaning of Article 101(1) as a 'cartel', 'cartel agreement' or 'collusion'.

[5] Commission Decision, Case COMP/39579, *Consumer Detergents*, 13 April 2011.

sustainable fishing methods possible that were less damaging to the seabed.[6] The Dutch Royal association 'The Frisian Horses Pedigree' in 2008 asserted that its stallions breeding quotum system was exempted from the cartel law, for it served the public interest of conserving the Frisian pedigree by preventing inbreeding.[7] Pig farmers in 2009 alleged they needed a sector-wide agreement to ban the widespread practice of castrating piglets without anesthetics.[8] Even though the Dutch competition agency initially was dismissive to these claims, public pressure followed by an obligation by the Dutch Ministry of Economic Affairs in 2014 to weigh any claim made of countervailing "sustainability benefits" under the Dutch equivalent of Article 101(3) induced it to pioneer the exempting of cartel agreements aimed at improving sustainability.[9]

A first case concerned an agreement between Dutch energy companies to close down five coal burning power plants, as part of the Dutch Energy Agreement for Sustainable Growth, a nation-wide contract to switch to green energy, initiated by the Ministry.[10] The ACM gave an informal view that the closure of these plants, which accounted for approximately 10% of the Dutch generating capacity, would harm consumers by leading to higher energy prices. The environmental benefits for the Dutch consumers were deemed insufficient to compensate their harm from increased energy prices, in particular because the lower CO2 emissions in the Netherlands would be offset by higher emissions by plants in neighboring countries acquiring the surplus emission allowances through the EU system of emissions trading (ETS) and using them, which would still affect the Dutch.[11]

Another informal view, the agency gave in the 'Chicken of Tomorrow' case. It involved poultry farmers, broiler meat processors and Dutch supermarkets, who responded to a public outcry against the poor living conditions of chicken in factory farms - referred to by an animal rights organization as 'exploding chicken' ("plofkip") - by making arrangements to sell chicken meat produced under enhanced animal welfare-friendly conditions. Among other things, supermarkets agreed to remove regular chicken meat from their shelves. The ACM concluded from questionnaires that although

[6] NMa (2011). While the Netherlands Competition Authority (NMa), the ACM's predecessor before 1 April 2013, took a positive view towards the sustainability claims, the argument was unsuccessful.

[7] NMa (2009), page 45. The authority asked the association to find less restrictive means to control inbreeding.

[8] NMa (2009). The NMa allowed this agreement on animal welfare grounds, provided that painless castration would not be obligatory.

[9] Besluit van de Minister van Economische Zaken van 6 mei 2014, nr. WJZ / 14052830, houdende beleidsregel inzake de toepassing door de Autoriteit Consument en Markt van artikel 6, derde lid, van de Mededingingswet bij mededingingsbeperkende afspraken die zijn gemaakt ten behoeve van duurzaamheid (in Dutch). In Article 2 (our translation): "[T]he ACM considers in its assessment of the conditions whether [...] in agreements that restrict competition made in order to promote sustainability, a fair share of the improvements benefits 'users' in the long run." In response to the policy rule, the agency published a vision document on how it would make such assessments, ACM (2014). In keeping with the conditions in paragraph 3, the Dutch competition authority clarified the following conditions to qualify for a cartel exemption on public interest grounds: (i) the benefits must be objective and clearly visible; (ii) consumers must receive a fair share of the resulting benefits, i.e. minimally be compensated by them for the anti-competitive harm resulting from allowing the horizontal agreement, (iii) the restrictions must be indispensable to obtain the benefits, and (iv) sufficient residual competition must remain in the market in question. To mount a successful public interest defense, in principle all four conditions would need to be fulfilled.

[10] See SER (2013).

[11] See ACM (2013) and Kloosterhuis & Mulder (2015).

consumers' willingness to pay for more sustainable chicken meat was 0.82 euro/kilo on average, on balance with a 1.46 euro/kilo price rise consumers would not benefit from the initiative.[12]

Cartel coordination may in theory reduce negative externalities and improve upon the classic under-provision of public goods in unregulated economies that results from free-riding. In fact, a reduction in output alone may take away negative externalities, such as industrial pollution, or ease a commons problem, like over-fishing.[13] Arguably also the industries concerned will have superior knowledge and special skills to actively promote public interests in their sectors through self-regulation. They would know best air pollution control systems, cradle-to-cradle designs or humane farm animal care, as well as any latent willingness to pay with consumers for more socially responsible and sustainable production, such as green energy or fair trade products. Private companies may therefore be the most efficient producers also of certain public interests.[14]

However, allowing a public interest-defense for cartel offenses raises some immediate concerns. While corporations may want to be seen taking social responsibility, the actual effects thereof need not exceed what suffices for self-promotion.[15] Also, only certain general interests are tied to private consumption. It is by no means clear that allowing collusion indeed creates private incentive to promote sustainability sufficiently, even when consumers do have a willingness to pay for it.[16] Furthermore, consumers cannot be expected to appraise in their private consumption all wider possible public interest benefits, such improvements in public health from a reduced use of antibiotics in meat production that slow down the build-up of resistance against antibiotics, and so may easily be satisfied with just greenwashing.

Moreover, horizontal agreements are known to carry direct and indirect risks of collusion, including

[12] See ACM (2015). Formally, an individual's willingness to pay for a public good is defined as the amount of expenditures the individual is willing to give up for one additional unit of the public good, keeping utility constant, see Batina (1990). The ACM asked consumers to compare two discretely different market situations, one with and one without the exploding chicken on offer in supermarkets, thus including a collective switch to more animal friendly chicken meat production for the Dutch market. In this paper, we will also use the term 'willingness to pay' in a more loose manner.

[13] Adler (2004) argues that antitrust interventions in the California sardine fishery led to over-fishing and environmental damage. Crane (2005) suggests that United States Tobacco's monopolization attempts of the snuff tobacco market increased welfare through health improvements and health-care costs savings from lower tobacco consumption.

[14] Coase (1974) claimed that lighthouses, which Paul Samuelson had made a textbook example of services that could only be provided by the government, were in fact in late 19th century Britain efficiently built and operated by private individuals that were granted the right by the government to levy tolls on passing ships calling at British ports. While Coase's lighthouse case has been criticized as a pure example of efficient private production of a public good because of the government backing, a cartel exemption would be like that. However, as Bertrand (2006) documents, the statutory authority at the time, Trinity House, also imposed strict quality requirements for the building, maintenance and operation of lighthouses, while excludability from port services enforced the levying of the tolls. Also, several privately owned lighthouses needed to be taken over by Trinity House when their service was neglected.

[15] See Delmas & Montes-Sancho (2010).

[16] Schinkel & Spiegel (2016) shows that when consumers value sustainable products and firms choose investments in sustainability before choosing output or prices, coordination of output choices or prices boosts investments in sustainability and may even enhance consumer surplus, whereas coordination of investments in sustainability directly hinders investments and harms consumers. A production cartel can improve consumer welfare only when products are sufficiently close substitutes and the marginal cost of sustainability investment is relatively low, or the sustainability benefits will be lower than the harm from reduced output. If a production cartel must be made to compensate consumers, investments in sustainability are reduced below the competitive level.

higher prices and lower quality of product and variety.[17] Many public interest benefits are hard to quantify as a mitigating factor. Sustainability appears to be sufficiently widely interpretable a concept to invite overly rosy contribution claims. Objectionable cartels may misuse the policy in an attempt to get away with hard core collusion under the guise of green. The policy burdens antitrust agencies with a complex monitoring and balancing task. Agencies will find it difficult to assess cartel contribution claims on their merits, in ex ante notifications such as the coal and chicken cases that the Dutch authority considered, as well as ex post, after the discovery of a cartel in operation, when the defense would also be available for obtaining an exemption - or possibly as a mitigating factor in determining the fine. As a result, opening up the public interest-defense can undermine deterrence.

In this paper, we formalize the antitrust balancing of cartel damages against public interest benefits that can somehow only be had by a horizontal industry-wide agreement. We restrict public interests to public goods, in conformity with the cartel benefits in our leading examples, which are non-excludable and non-rivalrous. No individual can be excluded from feeling better about an improved seabed, biodiversity in horses, public health or animal well-being, nor does anyone's enjoyment thereof take away from someone else's. The policy then amounts to government mandating an industry to collude to impose a unit tax on the private consumption good(s) it produces, provided that part of the proceeds are contributed to one or more public goods that compensate the consumers of the private good(s) for the harm caused by the cartel price overcharge.[18]

Samuelson (1954) determined that the efficient level of public good provision is where sum of the marginal rates of substitution of all individuals is equal to the economy's marginal rate of transformation between the public good and any private good. Lindahl (1958) suggested individuals be taxed personalized prices, so as to contribute their marginal utility from the consumption of the optimal level of the public good, times that level, for a government to provide. Without coordination, public goods will be under-provided and Olson (1965) designated the provision of public goods in larger economies a government task. In practice, it is complex to implement optimal public goods production, as it requires private information about preferences that people would have an incentive not to reveal. Optimal taxation theory seeks to design tax-subsidy schemes for financing public goods that achieve efficiency without specific knowledge about the individual preferences, including by targeting revealed consumption patterns.[19] Even though incentive-compatible implementation schemes do exist,

[17] Fonseca & Normann (2012) reports experimental evidence that talking helps collusion, which is continued after communication is disabled. Duso *et al.* (2013) establishes empirically that networks between competitors participating in R&D joint ventures in the US are conducive to collusion. Awaya & Krishna (2016) models how cheap talk within a cartel makes equilibria possible with near-perfect collusion by improving monitoring.

[18] Note that, while we focus on horizontal agreements, the basic trade-off analysis applies equally to abuse of dominance and merger control with public interest gains. In merger cases, there is a longer tradition in weighing in public interests, in particular also in developing countries, see Capobianco & Nagy (2016) and Reader (2016). The South African competition agency dealt with general interests in a number of abuse of dominance cases, see Buthelezi & Njisane (2016).

[19] See Boadway & Keen (1993) on the use of observables, including revealed preferences and self-selection, to determine who to tax what for which type of public good.

government policy can only be second-best.[20]

We examine the trade-off between the cartel's public interest benefits against a unit price overcharge, using a standard public economics model with private consumption and voluntary public goods contributions. Heterogeneous individuals spend their endowment on a private good, a public good, and a composite commodity. Depending on relative preferences and the wealth distribution, no, some or all consumers of the private good also contribute to the public good. The cartel price rise has various substitution and income effects. The public interest-cartel's compensating contribution crowds out private contributions, as individuals free-ride on the public good contributions by others. For example can improvements in the energy efficiency of appliances be offset by lax morals in their use. In response to a substantial reduction by industry in emissions, households may reduce their own efforts. In Chicken of Tomorrow, with improved living conditions for chicken overall, some consumers would switch from buying high-end free range chicken to a generic biological brand.

The European Commission's guidelines explain that allowing 'consumers a fair share' is the pass-on of benefits, so that: "the net effect of the agreement must at least be neutral from the point of view of those consumers directly or indirectly affected by the agreement."[21] In the cases about animal well-being, this rules out animals as direct beneficiaries of the cartel. On the basis of case law, it is further clarified that: "the overall impact on consumers of the products within the relevant market and not the impact on individual members of this group of consumers."[22] More particularly, "the average consumer" is to be compensated.[23] Excluding the Pareto-criterion that each and every individual consumer in the relevant market would minimally need to be compensated widens the space for the policy, as it avoids that a single individual can block any public interest-cartel. Yet, it implies interpersonal utility comparisons, which require a cardinal utility measure. This means that there is no unambiguous welfare measure to implement the policy.

We show that, contrary to the Samuelson condition for efficient public good supply, the public good level a cartel is required to produce in compensation decreases in consumers' willingness to pay for the public good. A public interest-cartel is sustainable only if it can pay for the compensating public good level from its price overcharge proceeds. Using the sum of generally weighted utility functions as a welfare function, we find that a public interest-cartel is not sustainable beyond a critical mass of consumers who combine a preference for private consumption with a low willingness to pay for the

[20] See Diamond & Mirrlees (1971), Stiglitz & Dasgupta (1971) and Walker (1981).

[21] European Commission (2004), recital 85.

[22] European Commission (2004), recital 87. The grounds for excluding the Pareto-criterion are in Case T-131/99, *Shaw*, 21 March 2002, in which the Court of First Instance ruled that compensation (of a group of tied lessees) has to be assessed: "within the same analytical framework, that of the effect of the notified agreements on the functioning of the market, and hence on the situation of the tied lessees taken as a whole, not on each lessee considered in isolation." That not every individual consumer needs to be compensated individually was confirmed by the European Court of Justice in Case C-238/05, *Asnef-Equifax*, 23 November 2006, recitals 68-70.

[23] In *Shaw*, recital 163 the Court of First Instance explained that: "it is not material that the benefits produced by the notified agreements do not entirely compensate the price differential suffered by a particular tied lessee if *the average lessee* does enjoy that compensation and it is therefore such as to produce an effect on the market generally."

public good. The size of this mass depends on the utility measure. The individuals that will be the hardest to compensate are those who consume of a lot of the private good and also value the public good little. Their exposure to damage from even a small cartel price increase is large, and they require a lot of public good contribution by the industry to offset it. Also, any contributors among them will respond with relatively large reductions, possibly to zero, and so crowed out the cartel provision.

The public interest-defense policy in essence asks exactly those individuals who have self-selected themselves, through their private good consumption, as types with a relatively low willingness to pay for the public good, to pay most for the provision of a compensating public good that they value least, which is orthogonal to Lindahl-pricing. As a result, in most economies the industry cannot afford the required compensation from the cartel proceeds. Only in quite special circumstances, in which sufficiently many consumers have a relative willingness to pay for the private and the public good that stays constant within narrow bounds, may a sustainable public interest-defense exist. In addition, the information requirements for a competition agency to identify a genuine public interest-defense seem prohibitively large, even if the Pareto-criterion for compensation would apply.

Our analysis builds on a literature that studies government provision of the public good in economies with voluntary private contributions. Pareto improvements can be obtained through commodity taxation in such economies, and efficiency in public good provision via lump-sum taxation. However, if consumers anticipate that the government will use the tax revenue to finance purchases of the public good, they adjust their own public good spendings. Bergstrom *et al.* (1986) show that for income redistributions smaller than the initial individual voluntary contributions to the public good, crowding out of government spending on the public good by lump sum taxation is full. Bernheim (1986) establishes a similar neutrality result for 'distortionary' commodity taxation as well, provided consumption bundles do not change. The latter is obtained by marginal taxation, allowing negative private contributions to two public goods and varying government spending on the one to which consumers are all contributors. With larger taxes and subsidies, and therefore certainly by taxing non-contributors, can government improve welfare by levying taxes to finance public goods in these models.

Andreoni & Bergstrom (1996) point out that local neutrality crucially depends also on the structure of the game. If the government commits to no change in taxes and balances the budget by adjusting its contribution to the public good, consumers can keep their private consumption constant, no matter what the other consumers do, and so offset the policy. In different setups, including one-shot games of the kind we model, government can unambiguously increase total contributions.[24] Note also that we do not impose a balanced budget, as not all cartel profits need to be contributed to the public good. Our model furthermore has only one public good and includes a third, composite commodity, so that consumers can substitute away from the cartellized product and mitigate the damage.

Closest to our application, the public goods model with private contributions has been used to study the extent to which corporate social responsibility may contribute to public interests. Bagnoli

[24] See Boadway *et al.* (1989).

& Watts (2003) show that firm contributions to a public good when consumers are socially responsible vary across market structures. Besley & Ghatak (2007) find that corporate social responsibility does not improve upon private voluntary contributions. Kotchen (2006) confirms that in 'green markets', which offer bundled private and public goods, company contributions to more sustainable production are often neutralized by reduced consumer donations. In sufficiently large economies can green technology increase the general level of provision, despite crowding out all private provision of the associated environmental public good.

The remainder of the paper is organized as follows. In Section 2, we formalize the trade-off involved in compensating consumers for price increases in the private good industry by firm-provided public goods. In Section 3, we examine the scope for welfare-enhancing policies for constant elasticity of substitution utility functions. In Section 4 we discuss alternative welfare measures to the policy. In Section 5 we conclude on some policy implications and extensions. Derivations are provided in an appendix.

2 Public Goods Provision by a Private Cartel

2.1 A Model of Private Consumption and Public Good Contributions

Consider an economy with n individuals. Each individual i spends its income between consuming a private good x_i that is produced by an industry that is considered for a public interest-cartel exemption, a composite commodity y_i, representing all other consumption of goods supplied on markets that are unchanged, and making a private contribution g_i to the total public good spend

$$G = \sum_{i=1}^{n} g_i + g_N + g_F,$$

in which $g_N \geq 0$ is the initial provision of the public good and $g_F \geq 0$ is the joint contribution by the firms that are allowed to collude. Public interest contributions are objectively and measurable. If the public good is clean air, private contributions can be investments in the installation of solar panels, for example, soot filters on cars or a more sustainable consumption pattern. In the following, we denote by G_{-i} the amount of public good contributions by other individuals than individual i. We abstract from simple direct volume reduction effects from collusive price increases of consumption goods that generate negative (production) externalities, so that the public interest is measured entirely by G and volume effects from the cartel price increase do not themselves serve a public interest.[25]

Individual i's preferences are represented by utility function $U_i(x_i, y_i, G)$, which satisfies standard conditions: U_i is twice continuously differentiable and increasing in each argument, and marginal

[25] Note that it may as well be that the production of substitutes to the cartellized good, i.e. of products in y_i, has offsetting negative externalities that we also ignore with this assumption.

utilities of consumption are positive and decreasing in each argument, so that all individuals consume a positive amount of all goods.[26] We assume linear commodity pricing. Normalizing the price of the composite commodity to one, prices are $(p_x, 1, p_g)$, in which p_g can be thought of as the cost of producing the public good from contributions. Individual i decides on how to optimally allocate his wealth endowment w_i over private consumption and contributing to the public good as follows:

$$max_{g_i, x_i y_i} U_i(x_i, y_i, G),$$

$$s.t. \, p_x x_i + y_i + p_g g_i \leq w_i,$$

$$g_i \geq 0.$$

Note that, if left unconstrained, the optimal individual contribution to the public good may well be zero or negative, in particular when there is already a high initial provision of the public good by nature. If the air was pure and pollution-free, it would be unlikely that people invested into making it even cleaner. Similarly, low wealth endowments or a low preference for the public good can prevent individuals from spending their own resources on it. However, substantial individual diminutions of the public good are not natural to our concerns. While, for example, individual consumers may, in the knowledge that others invest in clean air, relax their own emissions, such compensations do not convert obviously into cash. It is fitting therefore to constrain individual contributions to be non-negative.

The main effects at play in allowing the public interest-defense are captured in a partial equilibrium comparative statics analysis. With respect to the composite commodity and the cost of producing the public good, ignoring general equilibrium price effects can be interpreted as the market for the private good being small relative to the rest of the economy. For the relevant market of the private good, this simplification is less innocuous. In particular would the decrease in the demand for the private good resulting from the cartel price increase in general equilibrium decrease p_x, so that it depends on the model specifications whether the net effect on the price of the private good will indeed be positive, and compensation be required. This demand effect is second-order, however, and counteracted by the crowding-out effect. Typically, a cartel will raise prices above competitive levels and the various effects identified below apply. As we seek to characterize a consumer welfare status quo, we need not account for any surplus cartel profit net of compensation.

[26] For analytical convenience, it is assumed that U_i satisfies: $lim_{z \to 0^+} \frac{\partial U_i}{\partial z_i} = \infty$ and $lim_{z \to \infty} \frac{\partial U_i}{\partial z_i} = 0$ for all $z \in \{G, x, y\}$. Note that while these assumptions on preferences ensure that $x_i > 0$ and $y_i > 0$ in the optimum, it may still be optimal for the consumer to want to purchase negative amounts of the public good if his total public goods consumption remains positive thanks to contributions from other sources. For this reason, it is assumed that $g_i \geq 0$. It is often binding amounting to important corner solutions.

2.2 Competitive Equilibrium

In the competition benchmark equilibrium, a large number of identical firms produce the private good x at zero economic profits. Naturally $g_F = 0$, as the firm's provision is zero. Rewriting individual utility as

$$U_i(x_i, y_i, G) = U_i(\frac{w_i - y_i - p_g g_i}{p_x}, y_i, g_i + G_{-i} + g_N),$$

the first-order conditions readily become

$$\frac{\partial U_i(.)}{\partial G}(1 + \frac{dG^e_{-i}}{dg_i}) - \frac{\partial U_i(.)}{\partial x_i}\frac{p_g}{p_x} = 0, \tag{1}$$

$$-\frac{1}{p_x}\frac{\partial U_i(.)}{\partial x_i} + \frac{\partial U_i(.)}{\partial y_i} = 0, \tag{2}$$

in which conjectural variation $\frac{dG^e_{-i}}{dg_i}$ is individual i's expectation about the change in the contribution to the public good purchases by other sources as a consequence of the change in the size of his own contribution.

Conditions (1) and (2) determine individual i 's optimal purchase bundle (x_i^*, y_i^*, g_i^*), and so jointly $G^* = \sum_{i=1}^{n} g_i^* + g_N$. While individuals are price takers, they react to each others' behaviors because of the presence of the public good. Note that condition (1) is relevant only for non-binding levels of the public good $g_i > 0$, in which case individual i is a contributor to the public good. Should the resulting purchase bundle include negative levels of g_i^*, the relevant condition is (2) together with $g_i^* = 0$, and the individual is a non-contributor. An individual is more likely to be a contributor if his wealth is sufficiently high, public good contributions from other sources are low, if he values more the public good as compared to the other goods, or if the prices of the other goods are high. Some combination of these conditions is required to overcome his incentive to fully free-ride on the public good provided by others.

Assume that everybody takes the contributions of others as given when optimizing, i.e. conjectural variations $\frac{dG^e_{-i}}{dg_i} = 0$ for all i, that all the goods are normal goods and that there is a single-valued demand function for the public good. Then there exists a competitive Nash equilibrium with a unique quantity of the public good and unique sets of contributors and non-contributors.[27] The structure of

[27] The equilibrium existence and uniqueness proof is analogous to that in Bergstrom *et al.* (1986), with the only additional aspect being the composite commodity y_i, which does not affect the proof materially. Apart from the inequality constraint for private contributions to the public good, each consumer's optimization problem is a standard demand problem with income $w_i + G_{-i}$. Denoting $f_i(w)$ individual i 's demand function for the public good and assuming it is single-valued, individual i 's contribution becomes $g_i = max\{f_i(w_i + G_{-i}) - G_i, 0\}$, by the inequality constraint. This is a continuous function from a compact and convex set on itself, so that existence of a Nash equilibrium follows from Brouwer's Fixed Point Theorem. The proof of uniqueness is more complex and follows Bergstrom *et al.* (1986) verbatim, with an additional sufficient assumption that the marginal propensity to consume the public good is a differentiable function of wealth satisfying $0 < f_i'(w) < 1$ for all $i = 1, .., n$. In the model in Section 3, existence and uniqueness of equilibrium is proven by construction directly, allowing also for a higher marginal propensity to consume

the utility functions assures that if $g_N = 0$ and there is no provision by firms either, at least some consumers will purchase the public good. In fact, if $G = 0$, every consumer has an incentive to contribute. For positive initial levels of public good ($g_N > 0$), it can be that no individual privately contributes. In any event, in the competitive equilibrium there is under-provision of the public good.[28]

In equilibrium, individual i's indirect utility is given by

$$V_i^*(p_x, p_g, W, g_N) = U_i\left(\frac{w_i - y_i^*(.) - p_g g_i^*(.)}{p_x}, y_i^*(.), g_i^*(.) + G_{-i}^*(.) + g_N\right), \tag{3}$$

in which W is a vector of the wealths of all consumers, which are all relevant through the determination of G^*.

2.3 Collusive Provision of the Public Good

The public-interest justification for a cartel offense here amounts to allowing the industry a price increase $p_x^c > p_x$, in exchange for the industry contributing to the public good, $g_F > 0$.[29] The price increase may just cover the cost of the public good contribution, but can also fall short of that or exceed it. The comparative statics is of two unique Nash equilibria to the two policy options: $(p_x, g_F = 0)$ versus $(p_x^c > p_x, g_F > 0)$.[30] The public good is sufficiently widely appreciated so that at least all consumers in the cartellized market have it as an argument in their utility functions. Since we are considering cartel agreements that would be legal if exempted, we can ignore issues of cartel stability by assuming the agreements are contractable if necessary.

In principle, cartel provision of the public good has the potential to improve upon the under-provision in competitive equilibrium and therefore compensate the price increase. The extent to which it can depends on the interplay of several effects. In response to the cartel price increase of x_i, three things will happen. First, consumers will substitute away from the cartellized private good, either to the composite commodity or by making a larger public good donation, or both. These substitution effects mitigate their individual harm from the price increase directly, and larger contributions to the public good also benefit others. Second, the increase in p_x has negative real income effects, which reduce the

the public good.

[28] See Bergstrom *et al.* (1986).

[29] Note that if the cartel would apply nonlinear pricing, the fixed price components would be comparable to lump sum taxation, while also demanding compensation as a cartel damage. Since the neutrality result of Bergstrom *et al.* (1986) applies to the fixed fee part, so that compensation is ever more expensive, it is unlikely that a cartel would opt for non-linear pricing in the context of a public interest-defense.

[30] With respect to the composite commodity and the cost of producing the public good, ignoring general equilibrium price effects can be interpreted as the market for the private good being small relative to the rest of the economy. With respect to the relevant market for the private good, it is less innocuous. In particular would the decrease in the demand for the private good resulting from the cartel price increase in general equilibrium decrease p_x, so that it depends on the model specifications whether the net effect on the price of the private good will indeed be positive, and compensation be required. This demand effect is second-order, however, and counteracted by the crowding-out effect. Typically, a cartel will raise prices above competitive levels and the various effects identified in the text apply. As we seek to characterize a consumer welfare status quo, we need not account for any surplus cartel profit net of compensation.

consumption of x_i, y_i and g_i, which are all assumed to be normal goods. Third, there may be crowding out effects with contributors, as increases in G_{-i} may induce lower own contributions, including to stop contributing at all. Non-contributors enjoy the increased level of public good provided, and in border cases can be induced by the increase in p_x to start purchasing the public good. Generally, however, the substitution effect towards the public good are at least partially offset by the income and crowding out effects. In addition, the industry's compensation contribution $g_F > 0$ will further crowd out private contributions to the public good and increase the demand for the private and composite commodity in the collusive equilibrium.

On balance, the net utility change for individual i from allowing a public-interest cartel is

$$\triangle U_i = V_i^*(p_x^c, p_g, W, g_N + g_F) - V_i^*(p_x, p_g, W, g_N),$$

which increases in g_F. Interpreting the compensation requirement to mean that the consumers of the private good are to be compensated on average, assuming a cardinal comparison possible by the weighted sum of individual utilities, using weight α_i for the utility of individual i - or its type - as a welfare function, in linear approximation it is

$$\frac{-(p_x^c - p_x)}{\sum_{i=1}^n \alpha_i} \sum_{i=1}^n \alpha_i \frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial p_x} \leq \frac{g_F}{\sum_{i=1}^n \alpha_i} \sum_{i=1}^n \alpha_i \frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial g_F}, \tag{4}$$

since all consumers consume a positive amount of the cartellized good.[31] The competition authority's task would be to identify the level of public good $\hat{g}_F$ such that condition (4) is satisfied as an equality, and only accept the public interest-defense if the level of the public good actually provided by the firms is at least $\hat{g}_F$. As firms have no incentive to contribute more than minimally required, compensation condition (4) will be binding with equality.

Even with a welfare function assumed, the information requirements for a competition agency to assess whether or not to approve the anti-competitive conduct on the public interest grounds seem prohibitively large, as they include perfect information of all individuals' preference structures. Note also that the individuals that are hardest to compensate, i.e. that need the highest cartel contribution to the public good to offset their utility loss from the cartel price increase, need not be those who have suffered the most harm by the price increase. There may well be a group of consumers in the economy that derive too little utility from G to be compensated effectively, even if they have not suffered much damage from the price increase at all. In this respect, public good compensation is very different from monetary compensation, which will never need to go above making the old bundle affordable. In compensations via public interests, that is, there is no effective upper limit on how much of the public good is needed to compensate everyone, individually or on average. The choice set of each individual

[31] Note that while the term $\frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial p_x}$ in (4) generally will be negative, it may be positive for individuals who care little for the private consumption good, yet benefit from other people's substitution effects toward the public good.

is affected, as no one can choose to consume less public good than $G^*_{-i} + g_N$. The public interest compensation scheme thus proves to be both cumbersome and potentially costly, quite possibly too costly to be financed from the cartel price overcharge on the private good.

In the following, we examine the implicit definition of $\hat{g}_F$ in more detail to see what space for a public interest-defense may be. With n individuals in the economy, there are 4^n combinations of each of them contributing or not contributing to the public good before and after allowing a public interest-cartel, all with different consumer harms and benefits. We restrict attention to analyses of an economy with no contributors to the public good in Section 2.3.1, and the case where some (possibly all) individuals are contributors in Section 2.3.2. In Section 2.4 we turn to the issue of the cost of compensating.

2.3.1 An Economy with No Private Contributions

If g_N is high enough, no individual contributes to the public good in either of the periods and $g_i^*(.) = \frac{\partial g_i^*(.)}{\partial p_x} = \frac{\partial G^*_{-i}(.)}{\partial p_x} = 0$. The equilibrium purchases of each consumer depend only on own wealth and prices of the private good and the composite commodity. The indirect utility function becomes $V_i^*(p_x, p_g, w_i, g_N + g_F)$, since only the firms and nature provide the public good. The increase in p_x then causes a simpler marginal harm of

$$\frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial p_x} = \frac{\partial U_i(x_i, y_i, G)}{\partial x_i} \frac{-1}{p_x^2} \left(\frac{\partial y_i^*(.)}{\partial p_x} p_x + w_i - y_i^*(.) \right) + \frac{\partial U_i(x_i, y_i, G)}{\partial y_i} \frac{\partial y_i^*(.)}{\partial p_x}. \quad (5)$$

From accompanying increases in g_F, individual i gains a straightforward marginal benefit of

$$\frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial g_F} = \frac{\partial U_i(x_i, y_i, G)}{\partial G}.$$

The utility losses will be distributed unevenly. Unsurprisingly, those who like the private good the most will suffer the highest utility decline. Moreover, wealthy consumers are damaged more. This damage is, however, partially mitigated by the possibility to substitute towards the composite commodity.

Compensation condition (4) for a discrete price change for which all individuals remain non-contributors becomes

$$-(p_x^c - p_x) \sum_{i=1}^{n} \left(\frac{\partial U_i(x_i, y_i, G)}{\partial x_i} \frac{-1}{p_x^2} \left(\frac{\partial y_i^*(.)}{\partial p_x} p_x + w_i - y_i^*(.) \right) + \frac{\partial U_i(x_i, y_i, G)}{\partial y_i} \frac{\partial y_i^*(.)}{\partial p_x} \right) =$$

$$g_F \sum_{i=1}^{n} \frac{\partial U_i(x_i, y_i, G)}{\partial G}, \quad (6)$$

which implicitly defines $\hat{g}_F > 0$.

Note that while it may appear at first glance that in an economy with only non-contributors apparently there is no willingness to pay for more public good than the status quo, and so that by revealed preference it would be impossible to compensate an increase of the price of the private good, this is not necessarily so. There may well be under-provision of the public good in the competitive non-contributors equilibrium that coordination can improve upon. If a sufficiently large proportion of individuals has a high enough willingness to pay for the public good, even though apparently too low to contribute, it can still be possible to compensate consumers on average. For a discrete rise in the price of the private good, in fact some consumers may substitute towards contributing, raising the well-being of everybody.

2.3.2 An Economy with Contributors

In an economy with contributors, a willingness to pay for the public good is revealed. The change in a contributing consumer i 's equilibrium utility brought about by a small increment in p_x then becomes[32]

$$\frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial p_x} = \frac{\partial U_i(x_i, y_i, G)}{\partial x_i} \frac{-1}{p_x^2} \left(\left(\frac{\partial y_i^*(.)}{\partial p_x} + p_g \frac{\partial g_i^*(.)}{\partial p_x} \right) p_x + w_i - y_i^*(.) - p_g g_i^*(.) \right) +$$

$$\frac{\partial U_i(x_i, y_i, G)}{\partial y_i} * \frac{\partial y_i^*(.)}{\partial p_x} + \frac{\partial U_i(x_i, y_i, G)}{\partial G} \left(\frac{\partial g_i^*(.)}{\partial p_x} + \frac{\partial G_{-i}^*(.)}{\partial p_x} \right). \tag{7}$$

Individual i 's marginal equilibrium utility gain from firm provision of the public good is

$$\frac{\partial U_i(x_i^*(.), y_i^*(.), G^*(.))}{\partial g_F} = \frac{\partial U_i(x_i, y_i, G)}{\partial G} \left(\frac{\partial g_i^*(.)}{\partial g_F} + \frac{\partial G_{-i}^*(.)}{\partial g_F} \right) +$$

$$+ \frac{\partial U_i(x_i, y_i, G)}{\partial x_i} \frac{1}{p_x} \left(- \frac{\partial y_i^*(.)}{\partial g_F} - p_g \frac{\partial g_i^*(.)}{\partial g_F} \right) + \frac{\partial U_i(x_i, y_i, G)}{\partial y_i} * \frac{\partial y_i^*(.)}{\partial g_F}, \tag{8}$$

where the set of arguments (.) are the terms exogenous to the individual, i.e. $(p_x, p_g, W, g_N + g_F)$. Substituting (7) and (8) into (4) holding with equality yields an implicit function of $\hat{g}_F > 0$ that is long and unwieldy.

It should be more easy to compensate individuals that are already contributing to the public good. In fact, some individuals may actually gain utility if the price of the private good increases, from increases in the public good contributions by others as they substitute away from the private good. This is reflected in the term $\frac{\partial G_{-i}^*(.)}{\partial p_x}$ in (7), which is non-negative and effectively represents a

[32] Recall that $U_i(x_i^*, y_i^*, G^*) = U_i(\frac{w_i - y_i^*(p_x, p_g, W, g_N) - p_g g_i^*(p_x, p_g, W, g_N)}{p_x}, y_i^*(p_x, p_g, W, g_N), g_i^*(p_x, p_g, W, g_N) + G_{-i}^*(p_x, p_g, W, g_N))$.

mitigation of consumers' harm. With changes in the price of the private good, there can also be new contributors emerging. Since the private good price increase and the industry's compensating public good provision occur simultaneously, some individuals may benefit from both. However, there will always be contributing consumers in the economy harmed by the price increase as well. In addition, among contributors the term $\frac{\partial G^*_{-i}(.)}{\partial g_F}$ in (8) is non-positive, so that there is crowding out of their private contributions by the cartel provision. Some contributors may even become non-contributors in response to the cartel's contribution. The crowding out need not be complete, however, and the marginal benefit from the cartel's public good provision is always positive.

2.4 Sustainability of a Compensating Cartel

While it is possible to compensate consumers for a cartel price rise through the public good, it is not obvious that the required compensation can be paid for out of the cartel proceeds. The individuals that will be the hardest to compensate consume of a lot of the private good, have a small substitution and income effect for it towards the rest of the economy, and also value the public good little. Their exposure to damage from even a small cartel price increase is large, and they require a lot of public good contribution by the industry to offset it. Also, to the extent that they did contribute to the public good in the competitive equilibrium, they will respond with relatively large reductions, possibly to zero. Naturally, a relative preference for the private good over the public good manifests itself in a lot of private good consumption and little private contribution to the public good. Hence, the public interest-defense policy in fact asks exactly those individuals who have self-selected themselves, through their private good consumption, as relatively low willingness to pay for the public good types, to pay most for the provision of a compensating public good that they value least. The industry may therefore not be able to afford the required compensation: if the cartel attempted to increase revenues in order to pay for its compensation requirement with higher prices, an even larger compensating contribution would be required.

In order for the compensation scheme to be incentive compatible for the cartel, each firm's costs of contributing to the public good cannot exceed the extra profits it yields by the higher price. Assuming that the colluding firms have efficient means of splitting the cost of producing $\hat{g}_F$, the industry's incentive compatibility condition is

$$p_g \hat{g}_F \leq \Pi(p_x^c, p_y, W, g_N + \hat{g}_F) - \Pi(p_x, p_y, W, g_N), \tag{9}$$

where $\Pi(.)$ are the joint profits of firms engaged in the collusive agreement and paying for the public good.[33] Note that condition (9) will not generally hold with equality, for the cartel whenever possible

[33] Alternatively, we may ask if the cartel is able to pay for the required public good provision out of its price overcharge, that is whether $p_g \hat{g}_F \leq (p_x^c - p_x) \sum_{i=1}^{n} x_i^c$, in which x_i^c is the level of consumption of the private good under the cartel

will raise profits more than the cost of producing the compensating level of public good. Any surplus cartel profits net of compensation will increase welfare in an unspecified way, due to the partial equilibrium nature of the model. Note that sufficient residual competition in the market remaining, which formally is a requirement for obtaining a cartel exemption, may imply that condition (9) holds with equality, provided it is strong enough. However, in practice residual competition appears not to have been required directly on the cartellized product market and an exempted cartel may earn a surplus.

For a public interest defense to pass, conditions(4) and (9) need to be satisfied simultaneously. Without further specification of the market structures generating p_x and p_x^c, very little can be said about the circumstances under which they are satisfied. The next section analyses specific preferences and shows that while there exist economies in which sustainable public interest defenses exist, they are a small and special subset of all economies.

3 Sustainable Public Interest-Defenses

Suppose preferences can be represented by well-behaved constant elasticity of substitution utility functions, that is, let the preferences of individual i be represented by

$$U_i = a_i \frac{G^{1-\theta}}{1-\theta} + b_i \frac{x_i^{1-\theta}}{1-\theta} + c_i \frac{y_i^{1-\theta}}{1-\theta},$$

in which (a_i, b_i, c_i) are positive parameters expressing the relative strength of preferences for the public good, the private good x_i and the composite commodity y_i , and $\theta = 1/\rho \in (0,1)$, satisfying the general conditions imposed in the previous section. All individuals are consumers in the relevant market. The optimal private contribution to the public good is

$$g_i = \frac{w_i - (p_x(\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho)(G_{-i} + g_N)}{p_g + p_x(\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho},$$

so that consumer i is a contributor if and only if

$$w_i > \left(p_x(\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho \right) (G_{-i} + g_N), \tag{10}$$

and $g_i = 0$ otherwise. A wealthy enough individual will contribute to the public good, and at lower wealth levels if a_i is high and g_N is low.

Firms produce good x at constant marginal costs c, so that $p_x = c$. Denoting market demand for good x at price p_x as $D_x(p_x)$, under the weighted average compensation requirement to produce $\hat{g}_F$, collusion is profitable for the industry only if

regime. Holding with equality, this formulation is analogous to the balanced budget requirement in the taxation literature. It is equivalent to condition (9) in the case of perfect competition at constant marginal costs considered in Section 4.

$$\Pi = (p_x^c - c)D_x(p_x^c, \hat{g}_F) - p_g \hat{g}_F(p_x^c, c) \geq 0, \tag{11}$$

where the demand at price p_x^c naturally depends also on the level of the industry-financed public good as it enters the consumer's optimization problem. The cartel should be able to afford the public good requirement from its price overcharge or it would not form.

Figure 1 illustrates the problem of sustainability with the public interest-defense policy when there are two types of individuals.[34] On the horizontal axis increases the cartel price from the competitive level $p_x = c = 1$. The vertical axis displays public good contributions, as well as cartel profits. The triangulated lines show both individuals' private contributions to the public good in the absence of compensation, the circled lines when the cartel compensates. The upper two lines belong to individual 1, who values both the private and the public good more than individual type 2 does, with a relatively larger increased valuation of the private good. When the price of the private good increases, individual 1 substitutes towards public good contributions to such an extent that he induces individual 2 to lower his contributions somewhat.

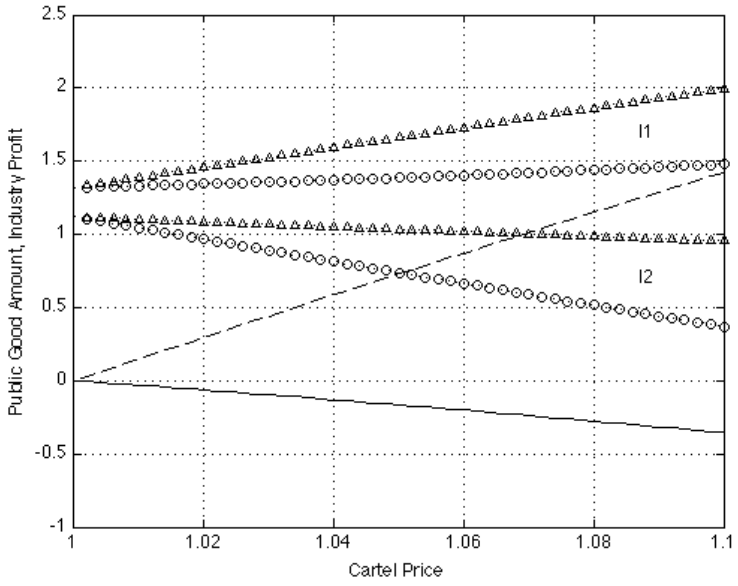

Figure 1: No sustainable public interest-defense.

The dashed line shows $\hat{g}_F$ for each cartel price increase. Allowing a cartel with a compensation requirement leads both consumers to reduce their own voluntary contributions in response, on the

[34] Parameter values are: $\alpha_1 = \alpha_2 = 1$; $(a_1, b_1, c_1) = (8, 10, 1)$; $(a_2, b_2, c_2) = (1, 1, 1)$; $\theta = \frac{1}{3}$; $(w_1, w_2) = (10, 10)$; $g_N = 2$; $(p_x = c, p_y, p_g) = (1, 1, 1)$.

balance of a substitution effect from the private good to the public good and the composite commodity, and a negative income effect from the cartel price rise, plus a crowing out effect from the cartel provided public good contribution. While both consumers just remain net contributors for the cartel prices displayed, they reduce their private contributions steeply, in particular individual 2 who likes the private good more. Eventually, individual 2 will become a non-contributor. Industry profit is given by the lower solid line: no price rise exists for which the cartel can actually afford the compensating public good level required. Even though both consumers have a revealed willingness to pay for the public good, no sustainable public interest-defense can be mounted.

The example captures that the policy targets consumers with a high consumption of the private good, whom are damaged a lot by the cartel price rise, to pay for the public good, for which they have a relatively low willingness to pay, while the cartel provision crowds out private contributions in addition. Yet, there are specifications for which the cartel profit is positive for some price range and identifies, since Π is concave for constant elasticity of substitution-type demands, a unique viable optimal cartel strategy under the compensation requirement.[35] In the following, we study the set of parameters for which a sustainable public interest-defense is possible. Section 3.1 considers the case without private contributions to the public good, while in Section 3.2 there are private contributions.

In order to determine analytically whether $\hat{g}_F$ can be sustainably contributed by the cartel, we investigate for a marginal cartel overcharge the sign of $\frac{\partial \Pi}{\partial p_x^c}\Big|_{p_x^c=c}$, since if a positive deviation from the cost-price $p_x = c$ yields a positive profit, there naturally exists a price $p_x^c > p_x$ at which firms make profit and consumers are compensated, while if it does not, no sustainable compensation exists due to the concavity of the profit function. At $p_x = p_x^c = c$

$$\frac{\partial \Pi}{\partial p_x^c}\bigg|_{p_x^c=c} = \frac{\partial (p_x^c - p_x) \times D_x(p_x^c, \hat{g}_F)}{\partial p_x^c}\bigg|_{p_x^c=p_x} - \frac{\partial p_g \hat{g}_F}{\partial p_x^c}\bigg|_{p_x^c=p_x} = D(p_x, \hat{g}_F) - \frac{\partial p_g \hat{g}_F}{\partial p_x^c}\bigg|_{p_x^c=p_x},$$

since

$$\frac{\partial (p_x^c - p_x) \times D_x(p_x^c, \hat{g}_F)}{\partial p_x^c}\bigg|_{p_x^c=p_x} =$$

$$\left(\frac{\partial (p_x^c - p_x)}{\partial p_x^c}\bigg|_{p_x^c=p_x}\right) D(p_x, \hat{g}_F) + (p_x - p_x)\left(\frac{\partial D_x(p_x^c, \hat{g}_F)}{\partial p_x^c}\bigg|_{p_x^c=p_x}\right) = D_x(p_x, \hat{g}_F) + 0.$$

Even though in actual cases price increases will be discrete rather than infinitesimal, the approach allows for identifying where there is possibility for a sustainable public interest-defense at all. It also provides a full structure for the challenge to an agency to determine the necessary compensation under the price increase that actually occurred.

[35] In the example in Figure 1, if we lower $g_N = 0.2$ and $b_1 = 8.5$, there is just a positive profit maximum at price $p_x = 1.034$ - while both consumers stay contributors.

3.1 No-contributors Economy

Suppose condition (10) is not satisfied for any individual i, so that $g_i = 0$ for all i and only $G = g_N + g_F$ enters into every individual's utility. The compensating amount of public good then is

$$\hat{g}_F = \left(g_N^{1-\theta} + \frac{Z(c) - Z(p_x^c)}{\sum_{i=1}^{n} \alpha_i a_i} \right)^{\frac{1}{1-\theta}} - g_N,$$

in which

$$Z(p) = \sum_{i=1}^{n} \alpha_i \left(b_i \left(\frac{w_i}{(p + (\frac{c_i p}{b_i})^\rho)} \right)^{1-\theta} + c_i \left(\frac{w_i}{(1 + (\frac{b_i}{c_i p})^\rho p)} \right)^{1-\theta} \right),$$

for $p = c$ and $p = p_x^c$, respectively.

Note that $\hat{g}_F$ decreases in consumers' willingness to pay for the public good (a_i), reflecting that a cartel will only produce the bare minimum of compensation required. This is contrary to the industry's optimal contribution according to the Samuelson condition for this economy, which expressed relative to the private good is

$$g_F^S = \left(\frac{p_x^c}{p_g} \sum_{i=1}^{n} \frac{a_i}{b_i} \left(\frac{w_i}{p_x^c + (\frac{c_i p_x^c}{b_i})^\rho} \right)^{\theta} \right)^{\rho} - g_N,$$

and increases in a_i.

With both $D_x(p_x^c, \hat{g}_F)$ and $p_g \hat{g}_F$ fully characterized, using the fact that locally $p_g \hat{g}_F|_{p_x^c = p_x} = 0$, we find that $\left. \frac{\partial \Pi}{\partial p_x^c} \right|_{p_x^c = c} \geq 0$ for infinitesimal cartel price rises if and only if

$$\sum_{i=1}^{n} \alpha_i a_i \sum_{i=1}^{n} \frac{w_i}{c + (\frac{c_i c}{b_i})^\rho} \geq \frac{p_g g_N^\theta}{c} \sum_{i=1}^{n} \alpha_i b_i \left(\frac{w_i}{c + (\frac{c_i c}{b_i})^\rho} \right)^{1-\theta}. \tag{12}$$

This sustainability condition provides some insights. If a large proportion of consumers has a high willingness to pay for the public good, that is if a_i is large for sufficiently many (or heavily weighted) individuals, its left hand-side increases, making compensation more sustainable. The right hand-side increases analogously in b_i. Note also that the right hand-side of (12) increases in both p_g, as producing the public good is more expensive, and g_N, reflecting that the willingness to pay for additional public goods provision decreases in the existing public good level. In fact, if g_N is low enough, it will become possible to sustainably collude and compensate - yet it will also induce individuals to contribute privately for lower wealth levels by contribution condition (10). In addition, the closer θ is to 0, the less constraining condition (12) is, reflecting that utility becomes near linear in all goods.

Figure 2 show the space for a sustainable public-interest defense for a no-contributors economy

with two types.[36] Type 1's preferences for the public and the private good are varied, relative to a fixed non-contributing type 2, at I2. The cartel marginally increases the price from $p_x = c$. The dashed line marks the preferences for which type 1 will remain a non-contributor too. The solid line depicts sustainability condition (12). Together, the two lines mark a bandwidth in which the ratio of a_1 to b_1 should stay for a public-interest defense to be sustainable in this economy. That is, type 1's preference weights for the public and the private good should jointly increase and not diverge much. While possibilities for compensation requires a sufficiently high value of a_1, relative to b_1, a_1 should not become too high, or type 1 becomes a contributor. If, on the other hand, b_1 increases above the solid line, type 1 likes the private good so much, the cartel cannot profitably compensate him.

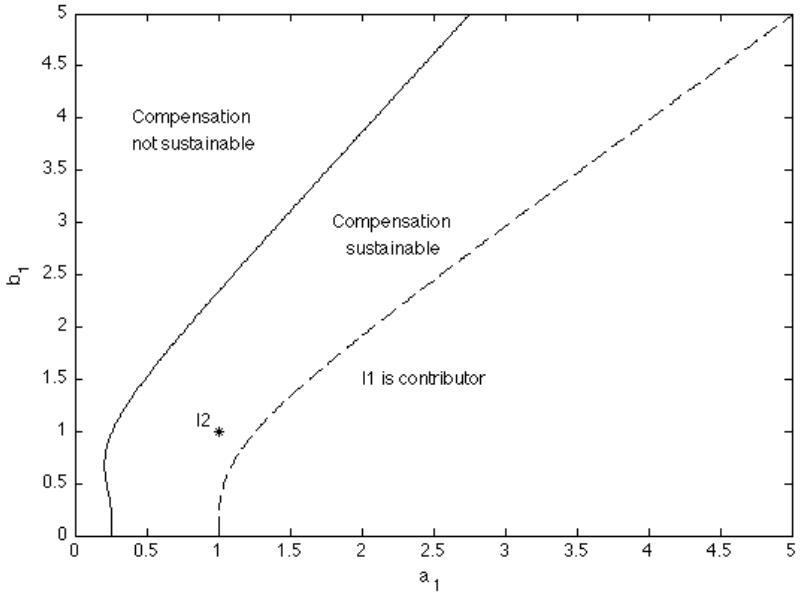

Figure 2: Sustainable public interest-defense space in a no-contributors economy.

The specific shape and location of the space of $\frac{a_1}{b_1}$ values for which a public interest-defense is sustainable depends on all other parameters of the economy, yet the example is non-specific: generally the relative willingnesses to pay for the private and public good should stay within narrow bounds.

3.2 Contributor Economies

In an economy in which at least some individuals are private contributors to the public good, the crowding out effect comes into play. Suppose condition (10) is satisfied for all individuals, which is the

[36] Parameter values are: $\alpha_1 = \alpha_2$; $c_1 = 1$; $(a_2, b_2, c_2) = (1, 1, 1)$; $\theta = \frac{1}{3}$; $(w_1, w_2) = (10, 10)$; $g_N = 10$; $(p_x, p_y, p_g) = (1, 1, 1)$.

case if they all have high enough wealth endowments. The level of public good in equilibrium then is

$$G = \left(\frac{p_g(g_N + g_F) + \sum_{i=1}^{n} w_i}{p_g + \sum_{i=1}^{n} \left(p_x (\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho \right)} \right), \tag{13}$$

in which the numerator is the total value of the endowment in the economy. Note that indeed, consistent with Bergstrom *et al.* (1986), lump-sum reallocations of wealth have no effect on the total level of public goods in equilibrium. Allowing the cartel overcharge changes consumption bundles through substitution and income effects, so that crowing out in a contributor economy is not full, as it is in Bernheim (1986).

The compensating cartel contribution$\hat{g}_F$ is contrary to the Samuelson condition and sustainable in an all-contributor economy for an infinitesimal cartel price rise if and only if

$$\sum_{i,j}^{i \neq j} \left(\alpha_j a_j \left(\frac{b_i}{a_i} \right)^\rho + \alpha_i a_i \left(\frac{b_j}{a_j} \right)^\rho \right) \geq p_g^{\rho - 1} \sum_{i,j}^{i \neq j} \frac{\alpha_j a_j - \alpha_i a_i}{a_i^\rho a_j^\rho} \left((b_j c_i)^\rho - (b_i c_j)^\rho \right), \tag{14}$$

in which $\sum_{i,j}^{i \neq j}$ is the sum over all unique pairs of two different individuals (i, j) in the total n.

Sustainability depends critically on the relationships between the willingness of individuals to pay for the private, the public and the composite commodity. Note that it does not depend on prices, apart from p_g, the price of the public good, for which, since $\rho > 1$, it naturally holds that the more expensive it is to compensate consumers, the harder it is to do so from the cartel proceeds. Given welfare weights, since the left-hand side is positive and the right-hand side is a subtraction, note that condition (14) can be satisfied for a wide variety of parameter values. What matters is the 'distance' in preferences between pairs of individuals, in all three goods. Certainly, supposing all individuals receive the same weight (i.e. if $\alpha_i = \alpha_j$ for all (i, j)), if everybody values the public good equally (i.e. if $a_i = a_j$ for all (i, j)), it will always be possible to compensate all consumers in a contributor economy profitably. The same is true if all individuals value both the public good and the composite commodity equally (i.e. if $b_i = b_j$ and$c_i = c_j$ for all (i, j)). In both cases, the right-hand side of (14) is zero.

Around these limit identity cases is a range of different preference structures for which compensation is possible as well, as long as consumers are sufficiently homogeneous in their valuation of the three goods in society. If the private willingnesses to pay for the public good a_i are far apart between pairs of individuals, the right-hand side of (14) will be larger and compensation not sustainable, unless the combined willingnesses to pay for the private goods x and y are very close, so that the last part of the right hand-side of the condition goes to zero. The cross-multiplications of b_i and c_j reflect the fact that cartel damage is mitigated by substitution towards the composite commodity when p_x rises.

Figure 3 is an all-contributors economy with two types, induced by a lower level of g_N in otherwise the same example as above.[37] In the region in which both types contribute, between the dashed lines, the ratio $\frac{a_1}{b_1}$ stays relatively constant. Given that $\frac{a_2}{b_2} = 1$, if individuals are more different than quite alike in their preferences, it will not be possible to mount a sustainable public interest-defense. In the upper-left region, type 1 has insufficient liking of the public good to contribute, whereas in the lower-right region his contribution is so large that it crowds out type 2's. Compensation is sustainable within the region between the solid lines, by which (a_1, b_1) are bounded away from zero and cannot be too high. Compensation is in principle possible close to the vertical axis, as long as type 1 is sufficiently wealthy, where the cartel would make sufficient profit on his large consumption of the private good. To the lower-right, type 1 likes the public good enough to be easy to compensate. The upper-limit on sustainability bounds the parameter space in which compensation is sustainable in an all-contributors economy, relative to the importance of the rest of the economy.

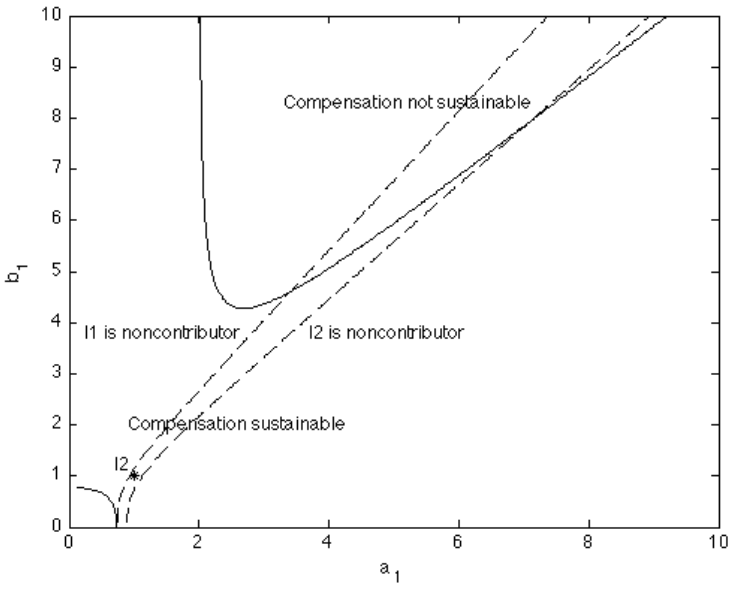

Figure 3: Sustainable public interest-defense space in an all-contributors economy.

The location of the sustainability upper-bound depends on the relative importance of the composite commodity in individual preferences: if the c_i's are sizable, compared to the private-public good trade-off, the parameter space is bounded as in Figure 3. Certain higher (a_1, b_1) combinations then cannot benefit from mitigating substitution to the composite commodity enough. If the preference for the

[37] Parameter values are: $\alpha_1 = \alpha_2$; $c_1 = 1$; $(a_2, b_2, c_2) = (1, 1, 1)$; $\theta = \frac{1}{3}$; $(w_1, w_2) = (10, 10)$; $g_N = 2$; $(p_x, p_y, p_g) = (1, 1, 1)$.

composite commodity is small to begin with, the sustainability condition need not restrict the absolute values of (a_1, b_1), as long as their ratio remains within bounds. Even though in an all-contributors economy, compensations tend to be cheaper, still in most circumstances no sustainable compensation exists.

For intermediate economies with contributors and non-contributors, conditions are more complex and less clean, yet the main intuitions hold. Cartel provision of the public good can alleviate the problem of under-provision in competitive equilibrium and so bring an economy closer to efficient public good levels. This is the case even though consumers decrease their contributions in response to the policy. Hybrid economies in fact combine the presence of a high willingness to pay for the public good in some portion of the population, with non-contributors that aggravate the problem of under-provision. In addition, individual contributions to the public good in an economy in competition are further discouraged by free-riding when the number of individuals is larger. Together with the fact that the cartel provision benefits more people over which the cost of producing the public good can be spread, this widens the space for improvement by the policy. The exact composition of preferences and wealth endowments, however, remains crucial for the possibilities to mount a sustainable and effective public-interest defense. Also, the cartel provision, the accompanying increase in the price of the private good, and all responses to it will potentially turn consumers from contributor to non-contributor and vice versa. The finding remains that the existence of a critical mass of consumers who combine a low marginal utility for the public good with high purchases of the private good can easily make an effective public-interest cartel impossible.

4 Alternative Welfare Measures

The construction of a welfare function to comply with the case law that consumers in the same relevant market are compensated is cardinal, as noted. As a result, the policy does not offer an unambiguous welfare standard to guide the agency's balancing exercise. In conditions (12) and (14), the choice of weights in the welfare function α_i directly affects the sustainability condition: it is always possible to weigh certain individuals in such a way that it will not be possible for a cartel to compensate the consumers profitably - and vice versa.[38] Alternative norms may allow for a more practical approach. Consumer surplus may seem an empirically viable measure, yet even as an approximation of welfare it is not well-defined, as demand for the public good does not integrate even for standard preferences. Also, while aggregate demand for the private goods is observable, that for the public good is not.

The Pareto criterion certainly is more strict, as a single individual with zero willingness to pay for the public good would hold up any possibilities for a public-interest defense. At the same time, it

[38] The example of an unsustainable public interest-defense in Figure 1, in which both types have equal weight, becomes sustainable if individual 2 receives a weight in the welfare function that is at least three times higher than the weight of individual 1.

may be easier to assess for a competition agency. Consider an all-contributors economy in which one individual h is the hardest to compensate. The linear approximation of minimal individual-specific level of public good required with general utility functions is

$$(p_x^c - p_x)\frac{-\partial U_h(x_h^*(.), y_h^*(.), G^*(.))}{\partial p_x} = \hat{g}_{F,h}\frac{\partial U_h(x_h^*(.), y_h^*(.), G^*(.))}{\partial g_F}.$$

In the case of constant elasticity of substitution utility functions, the cartel can afford the implied $\hat{g}_{F,h}$ if and only if

$$a_h^\rho \geq p_g^{\rho-1}\left(b_h^\rho \frac{\sum_i^{i\neq h}\left[\left(\frac{c_i}{a_i}\right)^\rho\right]}{\sum_i^{i\neq h}\left[\left(\frac{b_i}{a_i}\right)^\rho\right]} - c_h^\rho\right),$$

in which $\sum_i^{i\neq h}$ is the sum over all individuals other than h. While this condition is considerably simpler than condition (14), and requires no welfare function, still information is needed about the preferences of all consumers to implement it, since all individuals interact through the public good contributions.

Also note that asking for potential Pareto improvements, for which those who are better off could compensate those who are worse off, as proposed in the Kaldor-Hicks-criteria, is not obvious either. This criterion is less stringent than the Pareto-criterion, but it still requires a full comparative statics analysis. Moreover, in economies with contributors any redistribution of wealth among contributors does not change individual utilities by the neutrality result in Bergstrom *et al.* (1986), and so Kaldor-Hicks compensation offers no solution. In the non-contributor economy, the information required to establish whether potential compensations exist remains staggering. In addition, the relevant case law would probably extend to exclude the potential Pareto criterion as well.

Finally, a more practical approach, applied by the Dutch competition agency in the coal and chicken cases, may be to try to measure the willingness to pay for the promised cartel public good contribution by consumers of the private good and compare it to the projected cartel price increase. In principle, if the average willingness to pay for the new equilibrium public goods level is larger than the price increase, the public-interest defense would be allowed and otherwise not. For small increases in an all-contributors economy, the approach seems straightforward: for an increase in the public good provision the average willingness to pay is equal to the current price of the public good p_g.[39] However, such a test is generally not strict enough, since the price increase of the private good will lead to substitution towards private contributions to the public good, which will lower the willingness to pay for further contributions by the cartel. In addition, once some compensation is given, consumer's willingness to pay for the public good will be lowered further. Therefore, even if the (average) willingness to pay

[39] For the non-contributors economy, we obtain the overall willingness to pay at a point $G = g_N$ as $p_g^{g_N} = \left(\frac{\sum_{i=1}^n w_i}{g_N \sum_{i=1}^n \left(p_x(\frac{b_i}{a_i p_x})^\rho + (\frac{c_i}{a_i})^\rho\right)}\right)^{\frac{1}{\rho}}$, which is not obvious to establish empirically.

for the public good would be found to be higher than the cartel price increase, i.e. $p_x^c - p_x$, it is still very well possible that consumers are damaged on average. Asking consumers to compare discretely different regimes in questionnaires allows for including the cartel's coordination benefits as well as consumer demand substitutions, yet is potentially unreliable.

5 Concluding Remarks

A public interest cartel is not generally sustainable beyond a critical mass of consumers who combine a preference for private consumption with a low willingness to pay for the public good. The individuals that will be the hardest to compensate are those who consume of a lot of the private good and also value the public good little. Their exposure to damage from even a small cartel price increase is large, and they require a lot of public good contribution by the industry to offset it. Also will contributors to the public good in the competitive equilibrium respond with a relatively large reductions, possibly to zero. The policy is orthogonal to Lindahl-pricing, as it targets those individuals who have self-selected themselves, through their private good consumption, as relatively low willingness to pay for the public good types, to pay most for the provision of a compensating public good that they value least. In Chicken of Tomorrow, it is the vegetarians who are most likely to have the highest willingness to pay for more animal friendly broiling, not the consumers of cheap chicken meat. In the coal burning electricity plants, it is those who already buy wind or solar power. Therefore the cartel cannot balance the budget to produce the required compensation. Only when sufficiently many consumers have a relative willingness to pay for the cartellized private commodity and the public good that stays constant within narrow bounds, may a sustainable public interest-defense exist. The space for sustainable compensation is particularly small if the market for the cartellized private good is not too large relative to the rest of the economy.

Our model has wider application in competition policy context. It applies to price rises from various forms of (partial) cartels that face remaining fringe competition - which they would in the strict interpretation of the Treaty requirement that a cartel exemption should not afford the companies concerned: "the possibility of eliminating competition in respect of a substantial part of the products in question."[40] Likewise does our analysis extend to companies in a position of dominance that are allowed to price excessively in return for promoting a public interest, or mergers that are cleared with public interest remedies, such as avoiding job losses to preserve social stability.[41] In the latter case, the merging firms' ability to raise prices and profits post-merger will be limited, likely leaving an even narrower space for sustainable public interest mergers than under collusion.

These policies saddle competition authorities with a conflict of public interests. A cartel's compensation public good requirement is contrary to the Samuelson condition for efficient public good

[40] Article 101(3)b TFEU.

[41] These are expressed concerns in the South-African competition law. See Buthelezi & Njisane (2016).

supply. The conditions for sufficient compensation prove complex and the information requirements on a competition agency that is to practically implement the policy seem prohibitively large. Even if an unambiguous welfare assessment were possible, or when the Pareto criterion would be applied, to identify whether a given market satisfies the compensation condition, perfect information is needed in principle of all consumers' preferences. While the market activities of consumers reveal some information about their valuation of public goods, it is partial, in particular for non-contributors, of limited use and insufficient. Given the narrow set of economies and the precise sizes of compensating public good contributions required, a false assessment is quite probable. In addition, the exemption suggests to allow future benefits as well, possibly including benefits for future generations - which would require a highly complex analysis of bequest motives to stay within the principle of consumer sovereignty.

The same is true for companies that would want to self-assess whether their intended agreement would qualify for an exemption if it would ever become a concern. Even if corporations had the best intentions to meet the criteria set forth, the difficulty to self-assess the policy may leave too much legal uncertainty, or firms would require an ex ante exemption by notification, as in the Dutch cases discussed in the introduction. Industries would have an incentive to exaggerate their contribution or, if they would have bad intentions, possibility to deliberately abuse the policy. With the capacity of the competition agency to effectively check whether the firm contributions match the collusive harm lacking, government cannot reasonably be expected to guarantee that firms do not just take advantage of the policy and provide some cosmetic public good in exchange for a free pass to collude. A cartel exempted has all the incentives to raise prices by as much as it possibly can, doing as little for the public interest as it can get away with.

We have abstracted from public interest benefits that result directly from a reduction in the consumption of private commodities that generate negative externalities, such as smoking or polluting production, that may result from a cartel price increase. Such effects can however be thought of as compensating cartel benefits, without changing our qualitative findings. In particular do we note that arguably those individuals who consume most of products that harm the public interest will generally care less for the public benefits, or they wouldn't generate the externalities. A cartel price overcharge in this context can be seen as a uniform Pigovian tax on those individuals that cause the negative externality by consumption. Constrained by competition case law, the cartel price rise can, however, not exceed the average of Lindahl prices in the subgroup of individuals with the lowest willingnesses to pay.

Also, we model all public interests in the form of a single public good that enters independently into preferences, as a substitute for spending on private consumption. In many cases, for example cars and road safety, private and public goods may be complementary, so that the demand for the private good increases as the provision of the public good rises.[42] When the cartel produces the

[42]See, for example, Bradford & Hildebrandt (1977). Complementarity is noted in the commodity taxation literature as reducing the social costs of the second-best policy.

complementary public good in compensation, it can benefit from an increased demand effect that would relax the sustainability constraint. Finally, we note that public goods often have a local character. For the provision that consumers in the same relevant market are compensated, it is necessary that the cartel contributes to a compensating public good in that market, or otherwise possibly to various different local public goods that together span all consumers affected by the cartel price overcharge for compensation. The latter case would complicate enforcement accordingly. While public interest benefits may (far) exceed the relevant market, they must cover it by the European Treaty provisions.

The case law requirement that consumers are to be compensated on average, rather than all, introduces a fundamental equity matter as well. The compensating public good provision that will preserve utility on average will still harm consumers with a low marginal valuation of the public good. Consumers with a low preference for the private good and a relatively high willingness to pay for the public good are effectively paying less, in terms of damage suffered by the price increase, than the consumers targeted by the policy: those who buy substantial volumes of the private good. This heterogeneity in impacts is much more pronounced than it would be in a system of (capped) monetary compensations. The Pareto criterion does not suffer from these problems, yet if it cannot apply, the trade-offs seem for political, rather than bureaucratic decision making.

The policy has the potential to tap into superior corporate knowledge and capabilities to promote public interests most efficiently. Whether to mandate an industry to produce public goods by private collusion is the best way to do this is quite questionable, given all conceptual and practical implementation problems discussed. Moreover, neither the taxes levied, nor the public goods provided by a cartel will generally be second-best. Government would have better means of raising public good funds and optimize taxing and spending over a spectrum of public goods - certainly if it had the information required to assess the public-interest cartel defense. A cartel instead has incentives contrary to balancing the budget. It appears to remains therefore with Olson (1965) that public interests call for government provision paid for by taxation, rather than private production financed through cartel pricing.

Regulation seems the obvious better alternative. While sector knowledge may still be involved in its drafting, regulation would vertically impose more sustainable production conditions, without the need for horizontal agreements. This may raise the cost of production, yet would do so symmetrically across all firm in the industry, and thus increase consumer prices in competition by no more than necessary. In some cases, jurisdictional or political barriers, effective lobbies and stubborn creative compliance may render regulation problematic. Yet, allowing a public interest-cartel seems hardly an effective workaround for a well meaning agency operating in a intergovernmental vacuum. In the cases so far seen, the more traditional government interventions were perfectly available. Energy inefficient household appliances and coal burning electricity plants can simply be phased out by law, as cruelty to animals can be made illegal by putting minimum living conditions for chicken and pigs in place. Horizontal anti-competitive restrictions do not appear to be indispensable for fixing public interests.

More than a conviction that competition agencies are best placed to balance different public interests, the introduction of the public interest-defense seems to reflect a lack of political will to regulate, or, more concerning even, a politicking of antitrust.

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Appendix - Derivations of the Model in Sections 3 and 4

Consumer $i \in \{1, .., N\}$ has a wealth endowment w_i and a utility function

$$U_i = a_i \frac{G^{1-\theta}}{1-\theta} + b_i \frac{x_i^{1-\theta}}{1-\theta} + c_i \frac{y_i^{1-\theta}}{1-\theta},$$

where

$$G = \sum_{i=1}^{n} g_i + g_F + g_N.$$

For consumer i the budget constraint is (normalizing $p_y = 1$)

$$w_i + p_g G_{-i} - p_g G - p_x x_i - y_i = 0,$$

together with a natural condition $g_i \geq 0$. First-order-conditions for consumer i with no bounds for g_i are

$$x_i = \left(\frac{b_i p_g}{a_i p_x}\right)^{\rho} G,$$

$$y_i = \left(\frac{c_i p_g}{a_i}\right)^{\rho} G,$$

$$g_i = \frac{w_i - \left(p_x (\frac{b_i p_g}{a_i p_x})^{\rho} + (\frac{c_i p_g}{a_i})^{\rho}\right)(G_{-i} + g_N)}{p_g + p_x (\frac{b_i p_g}{a_i p_x})^{\rho} + (\frac{c_i p_g}{a_i})^{\rho}},$$

so that $g_i > 0$ iff

$$w_i > \left(p_x (\frac{b_i p_g}{a_i p_x})^{\rho} + (\frac{c_i p_g}{a_i})^{\rho}\right)(G_{-i} + g_N).$$

No-contributors Economy

If each consumer's voluntary contribution is negative both under competition and collusion, $g_1 = ... = g_N = 0$ in both states. The public good does not enter the utility maximization, so that demands are

$$x_i = \frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^{\rho}},$$

$$y_i = \frac{w_i}{1 + (\frac{b_i}{c_i p_x})^{\rho} p_x}.$$

Equilibrium utility is

$$U_i^* = \frac{1}{1-\theta}\left(a_i G^{1-\theta} + b_i\left(\frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^{\rho}}\right)^{1-\theta} + c_1\left(\frac{w_i}{1 + (\frac{b_i}{c_i p_x})^{\rho} p_x}\right)^{1-\theta}\right),$$

where $G = g_N$, as no consumer contributes to the public good. Equilibrium utility under collusion is the same, with the higher price p_x^c and $G = g_N + g_F$, including the industry's compensation. Giving consumer i a weight α_i in a welfare function, total welfare becomes

$$W = \sum_{i=1}^{n} \alpha_i U_i^* = \sum_{i=1}^{n} \frac{\alpha_i}{1-\theta}\left(a_i G^{1-\theta} + b_i\left(\frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^{\rho}}\right)^{1-\theta} + c_1\left(\frac{w_i}{1 + (\frac{b_i}{c_i p_x})^{\rho} p_x}\right)^{1-\theta}\right).$$

Equating welfare in the two equilibria $(p_x, G = g_N)$ and $(p_x^c, G = g_N + g_F)$,

$$\sum_{i=1}^{n} \frac{\alpha_i}{1-\theta}\left(a_i g_N^{1-\theta} + b_i\left(\frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^{\rho}}\right)^{1-\theta} + c_1\left(\frac{w_i}{1 + (\frac{b_i}{c_i p_x})^{\rho} p_x}\right)^{1-\theta}\right) =$$

$$\sum_{i=1}^{n} \frac{\alpha_i}{1-\theta}\left(a_i (g_N + g_F)^{1-\theta} + b_i\left(\frac{w_i}{p_x^c + (\frac{c_i p_x^c}{b_i})^{\rho}}\right)^{1-\theta} + c_1\left(\frac{w_i}{1 + (\frac{b_i}{c_i p_x^c})^{\rho} p_x^c}\right)^{1-\theta}\right),$$

which is equivalent to

$$\sum_{i=1}^{n} \alpha_i a_i g_N^{1-\theta} + \sum_{i=1}^{n} \alpha_i\left(b_i\left(\frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^{\rho}}\right)^{1-\theta} + c_1\left(\frac{w_i}{1 + (\frac{b_i}{c_i p_x})^{\rho} p_x}\right)^{1-\theta}\right) =$$

$$\sum_{i=1}^{n} \alpha_i a_i (g_N + g_F)^{1-\theta} + \sum_{i=1}^{n} \alpha_i\left(b_i\left(\frac{w_i}{p_x^c + (\frac{c_i p_x^c}{b_i})^{\rho}}\right)^{1-\theta} + c_1\left(\frac{w_i}{1 + (\frac{b_i}{c_i p_x^c})^{\rho} p_x^c}\right)^{1-\theta}\right).$$

This condition yields the minimally required compensation level to keep total welfare constant

$$\hat{g}_F = \left(g_N^{1-\theta} + \frac{1}{\sum_{i=1}^{n} \alpha_i a_i} \left[Z(p_x) - Z(p_x^c) \right] \right)^{\frac{1}{1-\theta}} - g_N,$$

where

$$Z(p) = \sum_{i=1}^{n} \alpha_i \left(b_i \left(\frac{w_i}{p + (\frac{c_i p}{b_i})^{\rho}} \right)^{1-\theta} + c_i \left(\frac{w_i}{1 + (\frac{b_i}{c_i p})^{\rho} p} \right)^{1-\theta} \right),$$

for $p = p_x$ and $p = p_x^c$, respectively.

The Samuelson condition, $\sum_{i=1}^{n} MRS_i = MRT$, for an economy after the price increase, expressed relative to the private good x_i, is

$$\sum_{i=1}^{n} \frac{a_i G^{-\theta}}{b_i x_i^{-\theta}} = \frac{p_g}{p_x^c}.$$

Substituting $x_i = \frac{w_i}{p_x^c + (\frac{c_i p_x^c}{b_i})^{\rho}}$ and $G = g_N + g_F$ for the no-contributors economy yields

$$g_F^S = \left(\frac{p_x^c}{p_g} \sum_{i=1}^{n} \frac{a_i}{b_i} \left(\frac{w_i}{p_x^c + (\frac{c_i p_x^c}{b_i})^{\rho}} \right)^{\theta} \right)^{\rho} - g_N,$$

as the industry contribution that achieves efficient provision of the public good.

Total industry profits in perfect competition are $\Pi = (p_x - c) \times D_x(p_x) = 0$, at $p_x = c$. After raising the price to p_x^c and paying compensation $\hat{g}_F$ industry profits become

$$\Pi = (p_x^c - p_x) \times D_x(p_x^c) - p_g \times \hat{g}_F(p_x^c, p_x).$$

Demand $D_x(p_x^c)$ has the form

$$D_x(p_x^c) = \sum_{i=1}^{n} x_i = \sum_{i=1}^{n} \frac{w_i}{p_x^c + (\frac{c_i p_x^c}{b_i})^{\rho}}.$$

The derivative of industry income evaluated at point $p_x^c = p_x (= c)$ is

$$\left. \frac{(p_x^c - p_x) \times D_x(p_x^c)}{\partial p_x^c} \right|_{p_x^c = p_x} = \left. \left[\frac{\partial (p_x^c - p_x)}{\partial p_x^c} \times D_x(p_x^c) + (p_x^c - p_x) \times \frac{\partial D_x(p_x^c)}{\partial p_x^c} \right] \right|_{p_x^c = p_x} = D_x(p_x) + 0.$$

The derivative of the costs of compensation evaluated at point $p_x^c = p_x (= c)$, using the fact that $[Z(p_x) - Z(p_x^c)]|_{p_x^c = p_x} = 0$, becomes

$$\left.\frac{\partial p_g \hat{g}_F(p_x^c, p_x)}{\partial p_x^c}\right|_{p_x^c=p_x} = \frac{p_g g_N^\theta}{(1-\theta)\sum_{i=1}^n \alpha_i a_i}\left[-\left.\frac{\partial Z(p_x^c)}{\partial p_x^c}\right|_{p_x^c=p_x}\right],$$

where

$$-\left.\frac{\partial Z(p_x^c)}{\partial p_x^c}\right|_{p_x^c=p_x} = \frac{(1-\theta)}{p_x}\sum_{i=1}^n \alpha_i b_i \left(\frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^\rho}\right)^{1-\theta}.$$

We thus finally get

$$\left.\frac{\partial p_g \hat{g}_F(p_x^c, p_x)}{\partial p_x^c}\right|_{p_x^c=p_x} = \frac{p_g g_N^\theta}{p_x \sum_{i=1}^n \alpha_i a_i}\sum_{i=1}^n \alpha_i b_i \left(\frac{w_i}{p_x + (\frac{c_i p_x}{b_i})^\rho}\right)^{1-\theta},$$

so that the sustainability condition (the sign of $\left.\frac{\partial \Pi}{\partial p_x^c}\right|_{p_x^c=p_x}$) is as in equation (12) in the text.

Contributors Economies

Assuming the contributor condition is satisfied for every consumer in both states of the economy, $g_i = \frac{w_i - \left(p_x(\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho\right)(G_{-i}+g_N)}{p_g + p_x(\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho}$ and thus

$$G = \sum_{i=1}^n g_i + g_N + g_F = \left(\frac{p_g(g_N + g_F) + \sum_{i=1}^n w_i}{p_g + \sum_{i=1}^n \left(p_x(\frac{b_i p_g}{a_i p_x})^\rho + (\frac{c_i p_g}{a_i})^\rho\right)}\right),$$

with $g_F = 0$ before the price increase and $p_x = p_x^c$ after. Using $x_i = \left(\frac{b_i p_g}{a_i p_x}\right)^\rho G$ and $y_i = \left(\frac{c_i p_g}{a_i}\right)^\rho G$, equilibrium utility is

$$U_i = \frac{G^{1-\theta}}{1-\theta}\left(a_i + b_i\left(\frac{b_i p_g}{a_i p_x}\right)^{\rho(1-\theta)} + c_i\left(\frac{c_i p_g}{a_i}\right)^{\rho(1-\theta)}\right).$$

Giving consumer i a weight α_i in a welfare function, total welfare becomes

$$W = \sum_{i=1}^n \alpha_i U_i^* = \frac{G^{1-\theta}}{1-\theta}\sum_{i=1}^n \alpha_i\left(a_i + b_i\left(\frac{b_i p_g}{a_i p_x}\right)^{\rho(1-\theta)} + c_i\left(\frac{c_i p_g}{a_i}\right)^{\rho(1-\theta)}\right).$$

Welfare in the two equilibria equal,

$$\frac{\left(g_N+\sum_{i=1}^n g_i\right)^{1-\theta}}{1-\theta}\sum_{i=1}^n \alpha_i\left(a_i+b_i\left(\frac{b_i p_g}{a_i p_x}\right)^{\rho(1-\theta)}+c_i\left(\frac{c_i p_g}{a_i}\right)^{\rho(1-\theta)}\right)=$$

$$\frac{\left(g_N+g_F+\sum_{i=1}^n g_i\right)^{1-\theta}}{1-\theta}\sum_{i=1}^n \alpha_i\left(a_i+b_i\left(\frac{b_i p_g}{a_i p_x^c}\right)^{\rho(1-\theta)}+c_i\left(\frac{c_i p_g}{a_i}\right)^{\rho(1-\theta)}\right),$$

after expressing the equilibrium level of the public good yields the minimally required compensation

$$\hat{g}_F=\frac{\sum_{i=1}^n w_i+p_g g_N}{p_g}\times$$

$$\left\{\left(\frac{p_g+\sum_{i=1}^n\left(p_x^c(\frac{b_i p_g}{a_i q_x})^\rho+(\frac{c_i p_g}{a_i})^\rho\right)}{p_g+\sum_{i=1}^n\left(p_x(\frac{b_i p_g}{a_i p_x})^\rho+(\frac{c_i p_g}{a_i})^\rho\right)}\right)\left(\frac{\sum_{i=1}^n\alpha_i\left(a_i+b_i(\frac{b_i p_g}{a_i p_x})^{\rho(1-\theta)}+c_i(\frac{c_i p_g}{a_i})^{\rho(1-\theta)}\right)}{\sum_{i=1}^n\alpha_i\left(a_i+b_i(\frac{b_i p_g}{a_i p_x^c})^{\rho(1-\theta)}+c_i(\frac{c_i p_g}{a_i})^{\rho(1-\theta)}\right)}\right)^{\frac{1}{1-\theta}}-1\right\}.$$

Industry profits after raising the price to p_x^c and paying compensation $\hat{g}_F$ are $\Pi=(p_x^c-p_x)\times D_x(p_x^c)-p_g\times\hat{g}_F(p_x^c,p_x)$ and analogically to the no-contributors case we have that $\left.\frac{(p_x^c-p_x)\times D_x(p_x^c)}{\partial p_x^c}\right|_{p_x^c=p_x}=D_x(p_x)$ where

$$D_x(p_x)=\sum_{i=1}^n x_i=G\sum_{i=1}^n\left(\frac{b_i p_g}{a_i p_x}\right)^\rho=\left(\frac{p_g g_N+\sum_{i=1}^n w_i}{p_g+\sum_{i=1}^n\left(p_x(\frac{b_i p_g}{a_i p_x})^\rho+(\frac{c_i p_g}{a_i})^\rho\right)}\right)\sum_{i=1}^n\left(\frac{b_i p_g}{a_i p_x}\right).$$

The derivative of the costs of compensation evaluated at point $p_x^c=p_x(=c)$ is

$$\left.\frac{\partial p_g\hat{g}_F}{\partial p_x^c}\right|_{p_x^c=p_x}=\left(p_g g_N+\sum_{i=1}^n w_i\right)\times$$

$$\left(\frac{(1-\rho)p_x^{-\rho}\left(\sum_{i=1}^n(\frac{b_i p_g}{a_i})^\rho\right)}{p_g+\sum_{i=1}^n\left(p_x(\frac{b_i p_g}{a_i p_x})^\rho+(\frac{c_i p_g}{a_i})^\rho\right)}+\frac{\rho p_x^{-\rho}\left(\sum_{i=1}^n b_i(\frac{b_i p_g}{a_i})^{\rho-1}\right)}{\sum_{i=1}^n\left(a_i+p_x^{1-\rho}b_i(\frac{b_i p_g}{a_i})^{\rho-1}+c_i(\frac{c_i p_g}{a_i p_y})^{\rho-1}\right)}\right).$$

Some algebra reveals that the sustainability condition $\left.\frac{(p_x^c-p_x)\times D_x(p_x^c)}{\partial p_x^c}\right|_{p_x^c=p_x}\geq\left.\frac{\partial p_g\hat{g}_F}{\partial p_x^c}\right|_{p_x^c=p_x}$ becomes

$$\sum_{i,j}^{i\neq j}\left(\alpha_j a_j\left(\frac{b_i}{a_i}\right)^{\rho}+\alpha_i a_i\left(\frac{b_j}{a_j}\right)^{\rho}\right)\geq p_g^{\rho-1}\sum_{i,j}^{i\neq j}\frac{\alpha_j a_j-\alpha_i a_i}{a_i^{\rho}a_j^{\rho}}\left((b_j c_i)^{\rho}-(b_i c_j)^{\rho}\right),$$

as (14) in the text, in which $\sum_{i,j}^{i\neq j}$ is the sum over all unique pairs of two different individuals (i,j).[43]

The Pareto Criterion

Assume consumer h is the most difficult to compensate individual in society. In the all-contributor economy, the required compensation for consumer h is

$$\hat{g}_{F,h}=\frac{\sum_{i=1}^{n}w_i+p_g g_N}{p_g}\times$$

$$\left[\frac{p_g+\sum_{i=1}^{n}\left(p_x^c(\frac{b_i p_g}{a_i p_x^c})^{\rho}+(\frac{c_i p_g}{a_i})^{\rho}\right)}{p_g+\sum_{i=1}^{n}\left(p_x(\frac{b_i p_g}{a_i p_x})^{\rho}+(\frac{c_i p_g}{a_i})^{\rho}\right)}\left(\frac{a_h+b_h(\frac{b_h p_g}{a_h p_x})^{\rho(1-\theta)}+c_h(\frac{c_h p_g}{a_h})^{\rho(1-\theta)}}{a_h+b_h(\frac{b_h p_g}{a_h p_x^c})^{\rho(1-\theta)}+c_h(\frac{c_h p_g}{a_h})^{\rho(1-\theta)}}\right)^{\frac{1}{1-\theta}}-1\right].$$

By similar algebra as above, $\left.\frac{\partial\Pi}{\partial p_x^c}\right|_{p_x^c=p_x}\geq 0$ iff

$$a_h^{\rho}\geq p_g^{\rho-1}\left(b_h^{\rho}\frac{\sum_i^{i\neq h}\left[\left(\frac{c_i}{a_i}\right)^{\rho}\right]}{\sum_i^{i\neq h}\left[\left(\frac{b_i}{a_i}\right)^{\rho}\right]}-c_h^{\rho}\right).$$

[43] For instance in the case of three consumers, the sum is over $(1,2)$, $(1,3)$ and $(2,3)$.