



The distribution of harm in price-fixing cases

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ABSTRACT

We consider a vertically related industry and analyze how the total harm due to a price increase upstream is distributed over downstream firms and final consumers. For this purpose, we develop a general model without making specific assumptions regarding demand, costs, or the mode of competition. We consider both the case of homogeneous and differentiated goods markets, and illustrate how basic intuition from the tax incidence literature carries over to the distribution of harm. Furthermore, we discuss data requirements and suggest explicit formulas and regression specifications that can be used to estimate the relevant terms in the harm distribution in practice.

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1. Introduction

In this paper we consider a simple vertical industry structure as shown in Fig. 1. There is an upstream sector with firms producing an input for the downstream sector which uses the input to produce a final good that is sold to consumers. We assume that due to cartelization or the abuse of a dominant position, the upstream sector is able to raise the wholesale price of the intermediate good. This will most likely have a negative effect on direct purchasers as the elevated wholesale price leads to a cost increase for direct purchasers. However, the direct purchasers might be able to pass on some or all of the harm they suffer to final consumers by increasing their price. The question we want to answer is how the total harm due to the increased upstream price is distributed over downstream firms and final consumers.

This analysis is motivated by recent and, perhaps more importantly, likely future developments of the legal framework of antitrust policy with respect to the issues of *pass-on defence* and the *legal standing of indirect purchasers* or class actions for consumers. In the setup considered in this paper, in which an upstream firm illegally raises the wholesale price, *pass-on defence* refers to the possibility that the upstream firm (defendant) can have a downstream firm's (plaintiff)

claim reduced by the amount that the latter passes on to consumers by means of a higher consumer price. The legal standing of indirect purchasers concerns the question whether or not indirect purchasers (in the context of our paper: consumers) who do not directly deal with the defendant are allowed to bring an action before a court. We will review the development of the relevant antitrust law and policy in the U.S. and in the E.U. in some detail in Section 2 below. What emerges from this review is that in both of these jurisdictions, some form of *pass-on defence* and legal standing of indirect purchasers is in place or is very likely to be established in the near future. The establishment of these two pieces of legislation can be predicted to lead to an increase of court cases in which the correct distribution or "apportionment" of antitrust harm down the production or supply chain needs to be determined.

Clearly, given the recent developments of the legal framework of antitrust policy there will be two main challenges: first, the determination of total harm and, second, its correct apportionment. In this paper, we do not concentrate on the first task as it has already received considerable attention in the literature; most recently by Hellwig (2007), Verboven and Van Dijk (2009), Basso and Ross (2010), Han et al. (2008).¹ Instead we concentrate on the second task, as so far

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¹ Earlier contributions are due to, e.g., Brander and Ross (2006), Kosicki and Cahill (2006), Baker and Rubinfeld (1999), Basmann and Boisso (1999), Connor (2001), Connor (2007), Finkelstein and Levenbach (1983), Fisher (1980), Harrison (1980), Page (1996), Rubinfeld (1985), Rubinfeld and Steiner (1984), and White (2001).

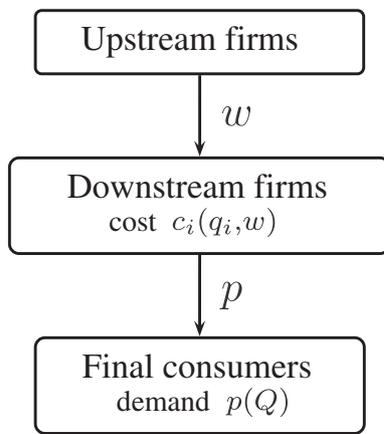


Fig. 1. The simple vertical industry structure considered in this paper.

there is no general framework comprising the full range of competitive models (from perfect competition to monopoly) and incorporating several modes of competition (e.g., price or quantity competition in a homogeneous or heterogeneous market), in which this apportionment can be analyzed. With this paper we contribute towards filling this gap.²

We do not model the upstream sector and simply assume that due to cartelization or the abuse of a dominant position, the wholesale price, w , has been inflated. Taking the total harm as given,³ we determine the distribution of this total harm in proportion to actual losses suffered in the downstream sector and, due to pass-on, by final consumers. For this purpose, we first determine the change of downstream industry profits and consumer welfare in response to an increase in w , and then consider the share of the total actual harm (loss in downstream industry profits plus loss in consumer welfare) borne by consumers. We refer to this share as the consumer harm share (CHS).

In Section 3 we determine the CHS both for the case of homogeneous and heterogeneous products. We show that (ceteris paribus) the CHS is smaller, (i) the larger the industry aggregate price cost margin, (ii) the larger the elasticity of a firm's output level with respect to the wholesale price w , (iii) the smaller the pass-through elasticity, and (iv) the higher the revenue share of the input whose price, w , has been illegally raised. Furthermore, the CHS turns out to be independent of the number of downstream firms affected by the upstream cartel. Finally, we illustrate how basic intuition from the tax incidence literature carries over to the distribution of harm.

The usefulness of the framework put forward in this paper hinges on whether it can be applied in actual antitrust cases at reasonable cost. Hence, in Section 4 we suggest procedures to estimate the relevant terms in the CHS. For this purpose we discuss data requirements and suggest explicit formulas and regression specifications that can be used to estimate the building blocks of the CHS. We furthermore discuss several potential problems of the estimation process such as endogeneity issues.

The main contributions of our paper are as follows: first, we concentrate on determining the distribution of harm over downstream firms and final consumers rather than on determining the (correct) level of total harm. Second, we use a very general model with only mild assumptions on demand and cost. Third, we discuss data requirements and suggest explicit formulas and regression specifications that can be used to estimate the relevant terms in the harm

distribution in practice. As a consequence of our general modeling approach and the derived results (especially Proposition 1 and Corollary 1), these specifications can be used irrespective of whether the analyst knows the form of conduct in the industry or which firms are affected by the increase of the upstream price.

We believe that our focus on the distribution of harm has useful practical implications as the determination of total harm and its distribution can now be separated. One can first determine some measure of total harm and then decide how this is distributed over direct and indirect purchasers. Assuming that courts (continue to) have a preference for a simple (but perhaps incorrect) measure of total harm such as the overcharge (observed output times the increase in the input price), our CHS could then be used to determine how this measure of total harm, however incorrect it may be, is to be shared between downstream firms and final consumers. To the extent that the measure of total harm is reasonable, this procedure would avoid double liability (if passing-on defence is not permitted and indirect purchasers have legal standing) or insufficient liability (in the converse case).⁴

Clearly, we are not the first to attempt to determine the distribution of harm over a production or supply chain (or the determination of total harm). We further highlight the contributions and the distinctiveness of our paper relative to others in the context of discussing the related literature.

1.1. Related literature

First, our analysis is related to the literature on tax incidence, especially in the case of a unit tax that directly affects costs, which is similar to facing higher upstream prices. An important stream of papers has clarified the effect of excise and ad valorem taxation under imperfect competition focusing either on homogeneous markets with Cournot competition (e.g., Seade (1985), Stern (1987), Besley (1989), Delipalla and Keen (1992), Skeath and Trandel (1994), Hamilton (1999)) or on differentiated-goods markets with Bertrand competition (e.g., Anderson et al. (2001a,b)).⁵ Two of these papers are closely related to the setup considered in this paper. Partly generalizing the work of Seade (1985) and Stern (1987), Delipalla and Keen (1992) consider the effect of ad valorem and specific taxation on prices and profits (and their relative efficiency) in the short and the long run in homogeneous good markets, but do so only for symmetric costs across firms. Anderson et al. (2001b) perform a similar analysis as Delipalla and Keen (1992) for the case of price competition in differentiated-good markets, but do so only for symmetric constant unit costs. Note that next to differences in modeling assumptions (such as the mode of competition or the cost structure), in contrast to this literature we focus on the apportionment of harm over the various links in a production/supply chain.

Second, there is also an extensive literature on the pass-through rate of price increases in (vertical) industry structures. See for instance Kosicki and Cahill (2006) and the references therein. Instead of concentrating on pass-through rates of prices, we determine the distribution of harm with respect to lost profits and lost consumer welfare.

Third, there is a recent literature that deals with the correct determination of harm in a vertically related industry. The common starting point of these papers is criticism of the overcharge as a measure of harm in price-fixing cases. The overcharge is the difference between the anticompetitively elevated upstream price and the upstream price under competitive circumstances multiplied by the number of units purchased by downstream firms at the elevated price. Hellwig (2007) determines the change in profits of a downstream firm affected by an illegally raised input price. In particular, he decomposes the overall change of profits into three different

² We view the relevant previous literature on this issue below.

³ As in Basso and Ross (2010), we will distinguish between "harm" which refers to losses in economic surplus of downstream producers and consumers and "damages" as being the legal term used to denote payments to be made by defendants. For instance, in the U.S. firms can sue for damages which are three times the harm inflicted.

⁴ We thank an anonymous referee for emphasizing this interpretation.

⁵ An overview of this literature is given in Fullerton and Metcalf (2002).

effects (a per-unit revenue effect, a business-loss effect, and a cost effect). Verboven and Van Dijk (2009) suggest a general and elegant framework to determine discounts on the overcharge as a measure of harm to downstream firms in price-fixing cases. As in Hellwig (2007), Verboven and Van Dijk (2009) also show that the overall change in downstream firms' profits can be decomposed into three effects (direct cost effect, pass-on effect, and output effect). Whereas Verboven and Van Dijk (2009) focus on the harm suffered by direct purchasers, we concentrate on the distribution of total harm over direct and indirect purchasers. Furthermore, while the range of models of imperfect competition in their and our paper is similar, Verboven and Van Dijk (2009) assume constant returns-to-scale cost functions whereas we work with completely general cost functions.⁶ Perhaps the most closely related paper is Basso and Ross (2010). These authors not only determine correct measures of total harm when the price of a downstream input is raised upstream, but also provide measures of the distribution of harm between direct and indirect purchasers. For their main results (Propositions 1 and 2), however, Basso and Ross (2010) rely on specific linear parametrizations of demand and costs while our approach is completely general. As a result of their specific modeling assumptions, Basso and Ross (2010)'s "error" term and harm distribution variable, never depend on the cartelized input price. In the examples illustrating our CHS, we demonstrate that this may cease to be the case once one allows, for example, for nonlinear costs. Moreover, whereas Basso and Ross (2010) use a discrete-change approach (accounting for a possibly large change in the upstream price), as Verboven and Van Dijk (2009) we use a differential approach, studying the effect of a small change in the upstream price. Finally, Han et al. (2008) consider a vertical industry structure with an arbitrary number of layers and assess the accuracy of the use of the overcharge as a correct measure of antitrust damages. Moreover, they assess damages of suppliers of a cartel in case the latter is located further down the supply or production chain.

2. Pass-on defence and indirect-purchaser standing in the U.S. and in the E.U.

In this section we review the evolution of antitrust law regarding pass-on defence and legal standing of indirect purchasers both in the U.S. and the E.U. Note that below we do not argue in favor or against a legal system that allows pass-on defence or legal standing of indirect consumers. We just wish to establish that currently in some legal systems (and more will follow in the future) there is room for pass-on defence and legal standing of indirect purchasers, so that an analysis as the one carried out in this paper is useful.

Regarding the development in the U.S., the starting point is the 1968 Supreme Court decision in *Hanover Shoe, Inc. v United Shoe Machinery Corp.*⁷ in which it was ruled that the defendant could not use a pass-on defence to avoid liability. Roughly, the reasoning behind this ruling was that the task of showing the extent of pass-on "would normally prove insurmountable." An additional reason was that indirect purchasers might be too dispersed and their claims likely to be small, so that they "would have only a tiny stake in a lawsuit and little interest in attempting a class action." In this case, "those who violate the antitrust laws by price fixing or monopolizing would retain the fruits of their illegality because no one was available who would bring suit against them."

In 1977, in *Illinois Brick Co. v Illinois*⁸ the Supreme Court ruled that only direct but not indirect purchasers would be allowed to sue for antitrust harms. This can be viewed as a logical implication of the

earlier ruling in the *Hanover Shoe* case: if a pass-on defence is not allowed, there is no room for indirect purchaser claims. In other words, if indirect purchasers were given legal standing, the extent of pass-on would have to be determined which would contradict the earlier ruling in *Hanover Shoe*.

With these two rulings in place (no pass-on defence and no standing for indirect purchasers), our analysis sketched above would hardly be necessary or relevant. But these two rulings constitute various problems. First, the *Hanover Shoe* ruling opened the doors for direct purchasers to claim the entire overcharge that occurred even if they passed on some or all of this overcharge to their customers. This would imply unjustified windfall profits for direct purchasers.⁹ Second, the *Illinois Brick* case implies that there is no compensation for other parties that suffered damages (e.g. indirect purchasers or final consumers). Accordingly, the two rulings have been criticized from the beginning and in response things have changed. In 1989 the Supreme Court ruled in *California v ARC America Corp*¹⁰ that indirect purchasers may sue for treble damages under state law although damages suffered by direct purchasers may have been assessed by federal law. Kosicki and Cahill (2006) report that currently 23 states and the District of Columbia have so-called *Illinois Brick* repealer statutes that give indirect purchasers standing under state law. Finally, the Antitrust Modernization Committee (2007), henceforth AMC, rigorously assessing the U.S. antitrust law, gives the following advice to Congress:

"Direct and indirect purchaser litigation would be more efficient and more fair if it took place in one federal court for all purposes, including trial, and did not result in duplicative recoveries, denial of recoveries to persons who suffered injury, and windfall recoveries to persons who did not suffer injury. To facilitate this, Congress should enact a comprehensive statute with the following elements: Overrule *Illinois Brick* and *Hanover Shoe* to the extent necessary to allow both direct and indirect purchasers to sue to recover for actual damages from violations of federal antitrust law. [...] Damages should be apportioned among all purchaser plaintiffs—both direct and indirect — in full satisfaction of their claims in accordance with the evidence as to the extent of the actual damages they suffered." (AMC, p. 267).¹¹

All these developments and facts (together with consumer class actions which are common in the U.S.) suggest that efficient methods are needed to determine how damages due to unlawful price increases are distributed (or apportioned) over the production chain.

With regard to the E.U., it seems fair to say that the (case) law is at a less advanced state especially with respect to the passing-on defence in antitrust cases. The annex to the Commission's Green Paper on "Damages actions for breach of the EC antitrust rules" summarizes the situation regarding the issue of a passing-on defence as follows: "It can be said that there is no passing on defence in Community law; rather, there is an unjust enrichment defence [...]" (Commission (2005), Annex p. 48), henceforth Annex. This assessment seems to have emerged from relatively recent court cases in which firms claimed compensation for illegal duties and levies imposed by individual member states. Indeed, in *Comateb*¹² the European Court of Justice (ECJ) states: "Accordingly, a Member State may resist repayment to the trader of a charge levied in breach of Community law only where it is established that the charge has been borne in its entirety by someone other than the trader and that reimbursement of the latter would constitute

⁶ Relating their approach to our paper, these authors also briefly discuss the determination of total harm and its distribution over direct and indirect purchasers.

⁷ *Hanover Shoe, Inc. v. United Shoe Machinery Corp.*, 392 U.S. 481 (1968).

⁸ *Illinois Brick Co. v. Illinois*, 431 U.S. 720 at 730–31 (1977).

⁹ This is called "unjustified enrichment" in European Court rulings. More on this below.

¹⁰ *California v. ARC America Corp.*, 490 U.S. 93 (1989).

¹¹ http://www.amc.gov/report_recommendation/amc_final_report.pdf.

¹² C-192/95 *Comateb* and others v Directeur général des douanes et droits indirects [1997] ECR I-165.

unjust enrichment.” Furthermore, the ECJ states in its ruling in *Courage*¹³: “[T]he Court has held that Community law does not prevent national courts from taking steps to ensure that the protection of the rights guaranteed by Community law does not entail the unjust enrichment of those who enjoy them [...]”¹⁴ This statement is considered by some observers as a positive stance towards a pass-on defence. Others, however, contradict this interpretation (see *Norberg* (2005, p. 16ff)).

Yet also in the E.U. a pass-on defence is met with considerable scepticism due to the view that necessary computations are potentially very difficult. In fact, the Commission states that “It does not appear possible to construct a model which accurately identifies, at reasonable cost, the harm suffered by players at different levels of the supply chain.” (Annex, p. 46). Nevertheless, the Commission also acknowledges that: “The door to apportionment is opened by the Court’s recognition of partial passing-on in *Comateb* and *Michailidis*.”¹⁵ It is one of the purposes of this paper to show that such an analysis can be accomplished and to show how the apportionment works.

With regard to the legal standing of indirect purchasers, the situation in the E.U. seems to be clearer. In the *Courage* case, the ECJ states in Section 26: “The full effectiveness of Article 85 [until recently 81 and Article 101 in the Lisbon Treaty] of the Treaty and, in particular, the practical effect of the prohibition laid down in Article 85(1) [now 81(1)] would be put at risk if it were not open to any individual to claim damages for loss caused to him by a contract or by conduct liable to restrict or distort competition.” (See also the *Manfredi* case.¹⁶) This statement is interpreted by most observers to say that both direct and indirect purchasers can claim damages.

In any case, with the recent publication of the White Paper on “Damages actions for breach of the EC antitrust rules”, the Commission emphasizes that damage actions are a high priority in the E.U. In fact, in its White Paper the Commission clearly argues in favor of allowing pass-on defence and legal standing of indirect purchasers. With respect to the first issue, the Commission states “defendants should be entitled to invoke the passing-on defence against a claim for compensation of the overcharge” (White Paper, p. 8), and with respect to the latter: “In the context of legal standing to bring an action, the Commission welcomes the confirmation by the Court of Justice that “any individual” who has suffered harm caused by an antitrust infringement must be allowed to claim damages before national courts. This principle also applies to indirect purchasers, i.e. purchasers who had no direct dealings with the infringer, but who nonetheless may have suffered considerable harm because an illegal overcharge was passed on to them along the distribution chain.” (White Paper, p. 4, original emphasis). Furthermore, the White Paper also suggests policy measures regarding collective redress of “scattered and relatively low-value damage” of individual consumers and small businesses that would allow the “aggregation of the individual claims of victims of antitrust infringements.” (For details see White Paper, p. 4).

Taken together, the development in Europe also hints at the importance of developing methods to determine not only the exact amount of damage caused by antitrust law infringement but also its distribution among direct and indirect purchasers – a task that we set out to do in this paper.

3. Basic model

In this section, we first derive the Consumer Harm Share (CHS) for the case of homogeneous goods and differentiated products. Then we

¹³ C-453/99 *Courage Ltd v. Bernhard Crehan and Bernhard Crehan v. Courage Ltd*, [2001] E.C.R. I-6297.

¹⁴ Note also that *Waelbroeck et al.* (2004), p. 6, state that “passing-on defence was considered possible in Denmark, Germany (by some courts) and Italy where the question had arisen.”

¹⁵ C-442/98 *Michailidis* [2000] ECR I-7145.

¹⁶ Joined Cases C-295-298/04, *Manfredi*, [2006] ECR I-6619.

illustrate the relation between our approach to apportionment and the tax incidence literature in oligopoly markets. All proofs are presented in the [Appendix A](#).

3.1. Homogeneous products

Consider a simple vertical industry structure as shown in [Fig. 1](#). There is an upstream sector with firms producing an input for the downstream sector. We do not model the upstream sector. We just assume that due to cartelization or abuse of a dominant position, the upstream firms are able to raise the price w of the input to $w + dw > w$. The downstream firms have a cost function $c_i(q_i, w)$ which is strictly increasing and convex in q_i and increasing in w . That is, we assume that $\partial c_i(q_i, w)/\partial q_i > 0$, $\partial^2 c_i(q_i, w)/\partial q_i^2 \geq 0$, and $\partial c_i(q_i, w)/\partial w \geq 0$. Furthermore, we assume $\partial^2 c_i(q_i, w)/\partial q_i \partial w \geq 0$ where the inequality is strict for at least one firm i (otherwise $dw > 0$ does not affect the industry in the short run).¹⁷ We allow different downstream firms to have different cost functions. Some firms may simply be more efficient than others or some firms may be more dependent on the upstream firms than others. For example, some firms may have a more flexible technology that allows them to substitute away from the upstream input if w is raised. Moreover, we explicitly allow some firms not to be affected at all by the increase in w , that is we allow $\partial c_i(q_i, w)/\partial w = 0$ for some firms i . These firms may source their input outside the cartel or they may be vertically integrated with an upstream firm and therefore not directly affected by the cartel.

To start, we assume that goods produced by the downstream firms are homogeneous. Hence we can write total output as $Q = \sum_{i=1}^n q_i$ where q_i is firm i ’s output level and n is the number of firms producing in the market. Downstream firms face an inverse demand function $p(Q)$, such that $p'(Q) < 0$, and $p''(Q)Q + p'(Q) < 0$ to ensure that the profit maximization problem of the firms is well defined.¹⁸ In order to derive an expression for CHS, we first look at the effect of an increase in w on consumer surplus and then on downstream firms’ profits.

To find the effect of the wholesale price w on consumer surplus $CS = \int_0^Q p(t)dt - pQ$, we differentiate CS with respect to w :

$$\frac{dCS}{dw} = -Qp'(Q) \frac{dQ}{dw}, \quad (1)$$

where we use the shorthand notation $dQ/dw = \sum_{j=1}^n (dq_j/dw)$. The sign of dCS/dw is determined by the sign of dQ/dw which we determine in [Lemma 1](#) below.

We use here the differential approach of calculating the change in CS (and below also profits) due to a small change in w . [Verboven and Van Dijk](#) (2009) do the same in calculating the cartel damages, while [Basso and Ross](#) (2010) consider a discrete change in w .¹⁹ If CS does not depend on w , clearly our results generalize to discrete changes in w . If the expression for CHS does depend on w , our results can be viewed as a linear approximation of CHS when considering a discrete change in w . Interestingly, as [Examples 3](#) and [5](#) below show, even with non-linear demand and cost specifications, the CHS can be independent of w .

Turning to the downstream firms, we write the profit of firm i as

$$\pi_i = p(Q)q_i - c_i(q_i, w).$$

We do not want to make assumptions on the mode of competition between downstream firms. Hence we assume that firm i chooses

¹⁷ We focus here on cases where $dw > 0$ affects marginal costs and not only fixed costs. If $dw > 0$ raises firms’ fixed costs, there is no price effect (for indirect purchasers) in the short run. Exit by firms can lead to higher prices in the long run. We do not analyze this case here.

¹⁸ See [Farrel and Shapiro](#) (1990) for a discussion of this assumption.

¹⁹ Compare the differential approach adopted here with the similar approach of analyzing infinitesimal merger in [Farrel and Shapiro](#) (1990).

action a_i which we normalize such that higher a_i implies higher q_i . A Nash equilibrium in actions a_i implies that firm i , when considering a deviation, assumes that each of its competitors $j \neq i$ keeps a_j constant.

The first order condition w.r.t. a_i is given by

$$p'(Q) \frac{\partial Q}{\partial a_i} q_i + p(Q) \frac{\partial q_i}{\partial a_i} - \frac{\partial c_i(q_i, w)}{\partial q_i} \frac{\partial q_i}{\partial a_i} = 0.$$

Let

$$\theta = \frac{\partial Q}{\partial a_i} \bigg/ \frac{dq_i}{da_i}, \tag{2}$$

such that θ measures the (conjectured) effect of firm i 's action on total output Q relative to i 's output.²⁰ Hence we can write the first order condition as

$$p - \frac{\partial c_i(q_i, w)}{\partial q_i} + p'(Q)\theta q_i = 0. \tag{3}$$

As is well-known, different modes of competition are nested in this framework, including Cournot competition ($a_i = q_i$) with $\theta = 1$, Bertrand or perfect competition ($a_i = p_i$) with $\theta = 0$ and the collusive outcome with $\theta = n$. However, as the next example illustrates, the framework also encompasses cases that are less often used.

Example 1. As argued by Grant and Quiggin (1994), managers are trained to think in terms of price cost margins. Consequently, an interesting case to consider is where firms compete in price cost margins. To illustrate this, assume linear demand, $p(Q) = 1 - \beta Q$ and quadratic costs, $c(q, w) = wq + \frac{1}{2} \gamma q^2$. We write the price cost margin as $PCM_i = p - c_q = 1 - \beta Q - w - \gamma q_i$. As we normalized actions such that higher a_i implies higher q_i , we define $a_i = -PCM_i = \beta Q + w + \gamma q_i - 1$. Then it is routine to verify that $\theta = \gamma / (\gamma + \beta(n - 1))$ is equivalent to $da_j/dq_i = 0$ ($j \neq i$). Clearly, with linear costs ($\gamma = 0$), competing in price cost margins is equivalent to Bertrand competition.

From now on we work directly with Eq. (3) without mentioning the underlying actions a_i .

We assume that $0 \leq \theta q_i \leq Q$ for all i . The first inequality implies that firm i does not expect total output Q to fall in response to an increase in its own action. The second inequality implies that firm i does not produce less than a monopolist (who owns all the n firms) would let firm i produce.²¹ Now we can prove the following result.

Lemma 1. Assume that $\frac{\partial^2 c_i(q_i, w)}{\partial w \partial q_i} > 0$ for all i . Then an increase in w leads to a fall in total output Q . That is,

$$\frac{dQ}{dw} < 0.$$

The intuition for this result is simple: as firms' marginal cost curves shift upward (due to an increase in w), firms reduce their output to equate marginal costs and marginal revenues again. Note that Lemma 1 means that the effect of raising the wholesale price on consumer surplus, given in Eq. (1), is unambiguously negative. That is, Lemma 1

implies $\frac{dCS}{dw} < 0$.²² This means that in the model considered in this section consumers are always harmed to some degree if the wholesale price increases. In other words, if the downstream market produces a homogeneous good, downstream firms will always pass on some of the harm independent of the number of competitors, the form of the demand and cost functions, and the mode of competition.

Next, we are interested in the effect of w on downstream industry profits $\Pi = \sum_{i=1}^n \pi_i$. We can write

$$\begin{aligned} \frac{d\pi_i}{dw} &= p'(Q)q_i \frac{dQ}{dw} + \left(p - \frac{\partial c_i}{\partial q_i} \right) \frac{dq_i}{dw} - \frac{\partial c_i}{\partial w} \\ &= p'(Q)q_i \left[\frac{dQ}{dw} - \theta \frac{dq_i}{dw} \right] - \frac{\partial c_i}{\partial w}. \end{aligned} \tag{4}$$

Note that the second equality follows from Eq. (3).

If $\left[\frac{dQ}{dw} - \theta \frac{dq_i}{dw} \right] \geq 0$, we find that firms' profits fall with w (as $-\frac{\partial c_i}{\partial w} < 0$).

However, if $\left[\frac{dQ}{dw} - \theta \frac{dq_i}{dw} \right] < 0$ it is possible that an increase in w which reduces both Q and q_i tends to raise downstream firms' profits. See, e.g., Dixit (1986), Quirmbach (1988), Seade (1985) and Examples 2 and 3 below for some conditions where the latter effect dominates the former effect such that $d\pi_i/dw > 0$. In this case, the fall in Q raises p and therefore harms consumers. If indirect purchasers (here the final consumers) have no standing before a court, there is no incentive to sue for damages. Hence this is an example demonstrating that giving standing to indirect purchasers is important. As shown by Schinkel et al. (2008), even if $d\pi_i/dw < 0$, the upstream firms may be able to profitably compensate the downstream firms such that the latter have no incentive to sue for damages. That further makes the case that indirect purchasers should get standing.

To prepare for the first main result of this paper, we list a few well-known terms.

- $e_w^p = \frac{dlnp}{dlnw}$ is the cost pass-through elasticity: percentage increase in output price p in response to a 1% increase in input price w ;
- $H = \sum_{i=1}^n \left(\frac{q_i}{Q} \right)^2$ is the Herfindahl-Hirschmann index of industry concentration;
- $PCM = \sum \frac{p - \partial c_i / \partial q_i}{p} \frac{q_i}{Q}$ is the industry aggregate price cost margin;
- $e_w^{q_i} = \frac{dlnq_i}{dlnw}$ is the elasticity of firm i 's output level with respect to the wholesale price w ; and
- z_i is the amount of the input used by firm i . Note that by Shepard's lemma we have $z_i(q_i, w) = \frac{\partial c_i(q_i, w)}{\partial w}$.

With these definitions in place we can state the first main result of this paper regarding the CHS, which we define as the ratio of the change in consumer surplus to the change in the sum of consumer and producer surplus.

Proposition 1. For the industry structure defined above, the consumer harm share is given by

$$CHS = \frac{e_w^p}{PCM \left(\frac{1}{H} \right) \sum_{i=1}^n \left[\left(\frac{q_i}{Q} \right)^2 |e_w^{q_i}| \right] + \frac{\sum w z_i(q_i, w)}{pQ}}. \tag{5}$$

Note that Eq. (5) is written in terms of variables that are observable or can be estimated. That is, we have substituted away the parameters θ and $\partial c_i / \partial w$ which are not readily observable.

To get some intuition for Eq. (5) we start by considering some special cases. First, assume that the input produced by the upstream firms is the only input used and that there is perfect competition in the downstream market such that $PCM = 0$. If it is further the case that $c(q, w) =$

²⁰ Implicitly, we assume here that firms entertain symmetric conjectures. In principle, we could allow for asymmetric conjectures θ_i . However, this leads to more complicated notation while not adding much insight. For the use of symmetric conjectures in related contexts, see, e.g., Hamilton (1999), Basso and Ross (2010) or Han et al. (2008).

²¹ To see this, suppose in contrast that $\theta q_i > Q$. Then Eq. (3) becomes

$$p - \frac{\partial c_i}{\partial q_i}(q_i, w) + p'(Q)\theta q_i < p - \frac{\partial c_i}{\partial q_i}(q_i, w) + p'(Q)Q = 0,$$

where the right hand side of the inequality is a monopolist's first order condition for q_i .

²² If, instead, $\frac{\partial^2 c_i(q_i, w)}{\partial w \partial q_i} = 0$ for some i , the result becomes $dCS/dw \leq 0$. Consider for example the case of Bertrand competition with homogeneous goods and constant marginal costs. If the second most efficient firm's marginal costs (determining the price) are unaffected by w , then $dCS/dw = 0$.

wq, we know that $p = w$ and $z = q$. Hence downstream firms make no profits and consumers face all the harm due to $dw > 0$. This follows immediately from Eq. (5) as in this case $PCM = 0$, $e_w^p = 1$ and the income share of upstream firms $\frac{\sum w_i z_i(q_i, w)}{pQ}$ equals 1 and thus $CHS = 1$.

Now assume that the elasticities satisfy $e_w^{q_i} = 1$ for all i . That is, for simplicity, normalize the elasticity of w on q_i to 1 for each firm. In this case the CHS given by (5) can be written as

$$CHS = \frac{e_w^p}{PCM + \frac{\sum w_i z_i(q_i, w)}{pQ}} \tag{6}$$

The numerator shows that a high pass-through leads to a high CHS as p increases with w . In the denominator there are two effects on the downstream firms' profits. First, as PCM is higher, the same fall in output (due to the increase in w) leads to a bigger fall in profits. Hence CHS is lower. The second term in the denominator of Eq. (6) shows that the higher the income share of the input (ceteris paribus the pass-on), the more harmful an increase in w for the downstream firms. Clearly, if the input is only 1% of total revenue, the price increase $dw > 0$ (ceteris paribus the pass-through) hardly raises costs and is not going to hurt downstream firms much.

Finally, going back to Eq. (5) there is one effect that has not yet been discussed. The term

$$\frac{\sum_{i=1}^n \left(\frac{q_i}{Q}\right)^2 |e_w^{q_i}|}{H} \tag{7}$$

can be seen as a weighted average of $|e_w^{q_i}|$ where the weights equal firm's squared market shares (since $H = \sum_{i=1}^n \left(\frac{q_i}{Q}\right)^2$). If big firms are relatively more responsive to a change in w than small firms, the expression in Eq. (7) is relatively big and consumers tend to bear less of the total harm due to $dw > 0$. The intuition is the following. Firms that are big (in equilibrium) are relatively efficient firms. Hence these firms have a high price cost margin and contribute a lot to industry profits. If their output falls relatively more than the output of small firms (for given fall in total output; determined by e_w^p), industry profits are reduced substantially. Consequently, CHS is low. If, on the other hand, the fall in Q is mainly due to a fall in output at small inefficient firms, industry profits do not fall by much and consumers bear a bigger share of the total harm.

Note that Eq. (1) can be written as

$$\frac{dCS}{dw} = -\frac{pQ}{w} e_w^p$$

In Section 4, we show how the pass-through elasticity e_w^p can be estimated. Hence, if one can find an estimate of pQ/w , it is possible to determine (the level of) the harm done to consumers. Together with an estimate of CHS (see Section 4), one can then also calculate the harm done to downstream firms ($d\pi/dw$). However, as mentioned in the introduction, we focus in this paper on the distribution of harm, not the level of total harm.

When faced with the task of determining the distribution of harm, the practitioner can in general proceed in two different ways. First, one can use Eq. (5) and directly estimate all necessary terms given in this equation. This is what we illustrate in Section 4. Second, one can make specific parametric assumptions on demand and costs and see whether this reduces the number of terms that need to be estimated. The latter approach is what we illustrate next. To stress the generality of our approach (compared to previous work by, e.g., Anderson et al. (2001b), Verboven and Van Dijk (2009) or Basso and Ross (2010)), we also consider examples with non-linear specifications for demand and cost functions. Note that with the linear cost function in

the examples below, an increase in w is equivalent to an increase in an excise tax, which ceases to be the case when costs are quadratic.

Example 2. (Linear demand) Let inverse demand be given by $P(Q) = a - bQ$.

- (i) If costs are given by $C_i(q_i, w) = (c_i + w)q_i$ we get $CHS = \frac{n}{n+2\theta}$. Note that CHS is independent of the size of the market (a), marginal production costs (c_i), and the wholesale price (w). The only item to be estimated is the conjectural variation θ which can be determined using Eq. (A.3) in the Appendix A. Note furthermore that $CHS = 1$ if either $n \rightarrow \infty$ or $\theta = 0$ (Bertrand). In these cases all harm is completely passed on to consumers. Further, $CHS = 1/3$ when $\theta = 1$ and $n = 1$ (Monopoly)²³ or when $\theta = n$ (Collusion). In general, it holds that $1/3 \leq CHS \leq 1$.
- (ii) If costs are given by $C_i(q_i, w) = \frac{1}{2}(c + w)q_i^2$ we get $CHS = \frac{2bn}{c+w+b(n+3\theta)}$. In this case CHS does also depend on the cost parameter c and the wholesale price w . The higher either c or w the lower CHS . Furthermore, $CHS > 1$ for n sufficiently large. Note that both of the facts just mentioned do not occur for the specific linear demand and cost functions used in (Basso and Ross, 2010).

Example 3. (Constant-elasticity demand) Let inverse demand be given by $P(Q) = a^{(1/b)}Q^{-(1/b)}$ ($Q(P) = aP^{-b}$).

- (i) If costs are given by $C_i(q_i, w) = (c + w)q_i$ we get $CHS = \frac{bn}{bn-\theta+b\theta}$. Thus, $CHS = 1$ if either $n \rightarrow \infty$ or $\theta = 0$ (Bertrand), and $CHS = b/(2b - 1)$ when $\theta = 1$ and $n = 1$ (Monopoly) or when $\theta = n$ (Collusion). Furthermore, we can have $CHS > 1$ if $b < 1$ and $\theta > 0$. This result is due to the fact that in this case firms' profits increase rather than decrease with a rising wholesale price w over this range of the demand elasticity b (see e.g. Seade (1985)).
- (ii) If costs are given by $C_i(q_i, w) = \frac{1}{2}(c + w)q_i^2$ we get $CHS = \frac{2bn}{nb^2-\theta+b(n+\theta)}$. We find $CHS = 2/(b + 1)$ if either $n \rightarrow \infty$ or $\theta = 0$ (Bertrand). Further, $CHS = 2b/(b^2 + 2b - 1)$ when $\theta = 1$ and $n = 1$ (Monopoly) or when $\theta = n$ (Collusion). Again, $CHS > 1$ is possible.

Note that in some of these examples CHS is independent of the wholesale price w implying that for the determination of CHS the "but for" price is not needed.

In these two examples we assume that all firms are affected. But actually this is not necessary for Eq. (5) to hold. Even if only a subset of firms is affected by the increase in w , the distribution of harm is still given by Eq. (5). We illustrate this by considering the case where all firms face the same cost function $c(q, w)$. In particular, out of the n firms, $m \in \{1, \dots, n - 1\}$ face a price increase $dw > 0$. Although, it follows directly from Proposition 1 that CHS is not affected, we also provide a direct proof to illustrate this result.

Corollary 1. In the case where firms produce homogeneous goods and where $n-m$ firms have a cost function $c(q, w)$ while m firms have a cost function $c(q, w + dw)$ it holds that

$$\frac{dCHS}{dm} = 0.$$

To gain some understanding for how this result comes about we note that the proof in the Appendix A shows that dQ/dw is linear in m which, as it turns out, implies that dCS/dw and $d\pi/dw$ are also linear in m such that m cancels out in $CHS = \frac{dCS/dw}{d(CS+\pi)/dw}$.

²³ This can be viewed as the harm counterpart to the known result that the price pass-through rate (that is, the change in the price charged to consumers relative to the change in marginal costs stemming e.g. from the imposition of a unit tax) is exactly 50% if a monopolist faces linear demand and constant marginal costs. See, e.g., Kosicki and Cahill (2006), p. 612.

This corollary follows from the generality of our model and has clear implications. When applying CHS in an actual case, it is not necessary to determine how many firms were affected by the cartel. One only needs to show that at least one downstream firm was affected by the overcharge and then Eq. (5) can be applied to determine the distribution of harm.

3.2. Differentiated products

Instead of assuming homogeneous goods as above, here we allow goods to be differentiated. In particular, we assume the utility function of a representative consumer takes the form $u(q_1, \dots, q_n) + x$ with some outside good x (sold at a normalized price equal to 1). By maximizing consumer surplus $u(q_1, \dots, q_n) + y - \sum_{i=1}^n p_i q_i$ (where y denotes the amount of money the consumer wants to spend this period), the inverse demand curve for firm i is given by

$$p_i(q_i, q_{-i}) = \frac{\partial u}{\partial q_i}.$$

Firm i 's own demand elasticity is defined as

$$e_{p_i}^{q_i} = \frac{\partial q_i}{\partial p_i} \frac{p_i}{q_i}. \tag{8}$$

We focus here on the symmetric case where firms have the same cost functions $c(q, w)$, face symmetric demand functions and play a symmetric equilibrium.²⁴ We define the (market) demand elasticity e_p^q as follows. Differentiating the (inverse) demand function for firm i we can write:

$$d \ln p_i = \sum_{j=1}^n \frac{\partial p_i}{\partial q_j} \frac{q_j}{p_i} d \ln q_j.$$

We consider a symmetric equilibrium where all prices p_i increase with the same percentage $d \ln p$. As a consequence all output levels change with the same percentage as well, denoted by $d \ln q$. Then we define the market elasticity, e_p^q , as the percentage change in output as the result of a 1% increase in all prices:

$$e_p^q = \frac{d \ln q}{d \ln p} = \frac{1}{\sum_{j=1}^n \frac{\partial p_i}{\partial q_j} \frac{q_j}{p_i}}. \tag{9}$$

Note that e_p^q is the elasticity of Chamberlin's DD curve that traces out the quantity demanded from firm i when all firms' prices change. Consumer surplus is defined as

$$CS = u(q_1, \dots, q_n) + y - \sum_{j=1}^n p_j q_j.$$

²⁴ This symmetry assumption is necessary to get a straightforward definition of the market demand elasticity. We do not know how to meaningfully define a market demand elasticity (or any other elasticity involving output at the market level) in case firms charge different prices and produce different output levels. Then a one percent increase in each firm's price can lead to different percentage changes in firms' output levels. Since goods are differentiated we cannot simply add these output levels (adding "apples and oranges"). If in a particular case, the symmetry assumption is clearly violated, Eq. (5) can be applied by assuming that each firm acts as a (local) monopolist on the market of its own (differentiated) product. This is, of course, always possible but is more demanding on the time-series dimension of the data as firm specific variables cannot be estimated on the cross section of firms (unless one is willing to make additional assumptions).

Hence we find

$$\frac{dCS}{dw} = - \sum_{i=1}^n q_i \sum_{j=1}^n \frac{\partial p_i}{\partial q_j} \frac{dq_j}{dw}.$$

In a symmetric equilibrium, we can write this as

$$\frac{dCS}{dw} = np \frac{1}{|e_p^q|} \frac{dq}{dw} < 0. \tag{10}$$

Profits of firm i are defined as

$$\pi_i = p(q_i, q_{-i})q_i - c(q_i, w).$$

The first order condition can be written as

$$\frac{\partial p_i}{\partial q_i} q_i p_i (1-\theta) + \sum_{j=1}^n \frac{\partial p_i}{\partial q_j} \frac{q_j}{p_i} p_i \theta q_i + p_i - \frac{\partial c}{\partial q_i} = 0,$$

where $\theta = dq_j/dq_i$ for $i \neq j$.²⁵ In a symmetric equilibrium this can be written as

$$\frac{p(1-\theta)}{|e_{p_i}^{q_i}|} + \frac{p\theta}{|e_p^q|} = p - \frac{\partial c}{\partial q}. \tag{11}$$

To see the effect of w on industry profits, write first

$$\frac{d\pi_i}{dw} = \sum_{j=1}^n \frac{\partial p}{\partial q_j} \frac{dq_j}{dw} + \frac{dq_i}{dw} p - \frac{\partial c}{\partial q_i} \frac{dq_i}{dw} - \frac{\partial c}{\partial w}. \tag{12}$$

Using Eq. (11), we can write

$$\frac{d\pi}{dw} = n \left[p(1-\theta) \frac{dq}{dw} \left(\frac{1}{|e_{p_i}^{q_i}|} - \frac{1}{|e_p^q|} \right) - \frac{\partial c}{\partial w} \right]. \tag{13}$$

From this we can derive the following result.

Proposition 2. *If symmetric firms produce differentiated products, we find that the distribution of the total harm due to $dw > 0$ is distributed over downstream firms and final consumers as follows*

$$CHS = \frac{e_w^p}{|e_w^q| PCM + \frac{nzW}{npq}}. \tag{14}$$

Analogously, to the case of homogeneous products, Eq. (14) says that (ceteris paribus) the consumer harm share is smaller (i) the larger is the industry aggregate price cost margin PCM , (ii) the larger is the elasticity of a firm's output level with respect to w ($|e_w^q|$), (iii) the smaller is the pass-through elasticity $|e_w^p|$, or (iv) the higher is the share of the input in revenue, $zw/(pq)$.

Note that the expression in Eq. (14) is the same as in Eq. (5) for the case where firms are symmetric. It is only that firms producing differentiated products tend to face a demand function that is less elastic.²⁶

²⁵ Note that in contrast to the case of a homogeneous good treated in Section 3, θ here measures the effect of firm i 's quantity on firm j 's quantity (not on the total quantity Q which is not defined with differentiated goods).

²⁶ Note that Eq. (10) can be written as $dCS/dw = (npq/w) \times |e_w^q|/|e_p^q|$. Hence, if one can find an estimate of $\frac{npq}{w}$, $|e_w^q|$, and $|e_p^q|$ (for the latter two, see Section 4), it is possible to determine (the level of) the harm done to consumers. Together with an estimate of CHS (see Section 4), one can then also calculate the harm done to downstream firms ($d\pi/dw$), which, again, is a task we do not focus on in this paper.

Example 4. (Linear demand) Let inverse demand be given by $p_i(q) = \alpha - \beta q_i - \gamma \sum_{j \neq i} q_j$ where $\beta > \gamma > 0$ and $\alpha > 0$.

- (i) If costs are given by $C(q_i, w) = (c + w)q_i$ we get $CHS = \frac{\beta + \gamma(n-1)}{3\beta + \gamma(2\theta + 1)(n-1)}$.²⁷ Again, the CHS is independent of the size of the market (α), marginal production costs (c), and the wholesale price (w). The only items to be estimated are the conjectural variation θ and the demand parameters β and γ . Note that $CHS = 1/3$ for $n = 1$ (monopoly).
- (ii) If costs are given by $C(q_i, w) = \frac{1}{2}cwq_i^2$ we get $CHS = \frac{2(\beta + \gamma(n-1))}{4\beta + cw + \gamma(3\theta + 1)(n-1)}$. In this case the CHS does also depend on the cost parameter c and the wholesale price w . The higher either c or w the lower CHS.

Example 5. (Constant-elasticity demand) Let inverse demand be given by $p_i(q) = \beta\gamma \left(\sum_{j=1}^n q_j^\beta\right)^{\gamma-1} q_i^{\beta-1}$ and assume that $0 < \beta\gamma < 1$ (for strict concavity), $\gamma < 1$, and $\beta \leq 1$. If $\beta > 1$, $\beta = 1$, $\beta < 1$, goods are partial substitutes, homogeneous, complements.

- (i) If costs are given by $C(q_i, w) = (c + w)q_i$ we get $CHS = \frac{\beta n(\gamma - 1)}{n - \beta^2 \gamma(\gamma + n\theta - 1 + \theta(\gamma(n-1) - n))}$.
- (ii) If costs are given by $C(q_i, w) = \frac{1}{2}cwq_i^2$ we get $CHS = \frac{2n(1 - \beta\gamma)}{2n - \beta^2 \gamma(n - (1 - \gamma)(1 + \theta(n-1)))}$.

For both linear and quadratic costs the CHS does neither depend on the cost parameter c nor the wholesale price w .

3.3. Tax incidence intuition

To see the equivalence between our approach on the distribution of harm and the results in the tax incidence literature, we go back to the case of homogeneous goods.

We define a supply curve for oligopoly in the following way. Consider the following perturbation of the inverse demand function

$$p(Q) + \varepsilon$$

where ε is thought to be small and either positive or negative. Hence changes in ε lead to parallel shifts of the inverse demand function as illustrated in Fig. 2. Different values for ε generate different equilibrium combinations for p and Q . Mapping out these points $(Q(\varepsilon), p(\varepsilon))$, as in Fig. 2, gives what we call – for want of a better name – the (oligopoly) supply curve.

Note the difference between the supply curve defined in this way and a supply relation as defined in the literature (e.g., in Eq. (4) in Bresnahan (1989)). In the literature a supply relation usually is the first-order condition of profit maximization. (The sum of the first-order conditions for all firms is referred to as industry supply.) However, we refer to a supply curve as the locus of equilibrium combinations for p and Q in reaction to the change in a demand shifter.

Under perfect competition, in equilibrium price equals marginal costs. Thus the curve created in this way is the marginal cost curve of the sector, which is indeed the supply curve as it is used in, for instance, the tax literature. Then we know that the slopes of the marginal costs and demand curves determine the incidence. We define the slope, ψ , of the (oligopoly) supply curve as:

$$\psi = \left. \frac{dp}{dQ} \right|_{supply} = \frac{dp/d\varepsilon}{dQ/d\varepsilon} = \frac{p'(Q) \frac{dQ}{d\varepsilon} + 1}{\frac{dQ}{d\varepsilon}}. \tag{15}$$

²⁷ For $\beta = \gamma$ this expression is the same as in example 2. To verify this, note that θ with differentiated goods is defined as $\theta^d = \partial q_j / \partial q_i$ for $j \neq i$, while for homogeneous goods we define it as $\theta^h = \partial Q / \partial q_i$. Hence for the symmetric case here, we have $\theta^d = (\theta^h - 1) / (n - 1)$.

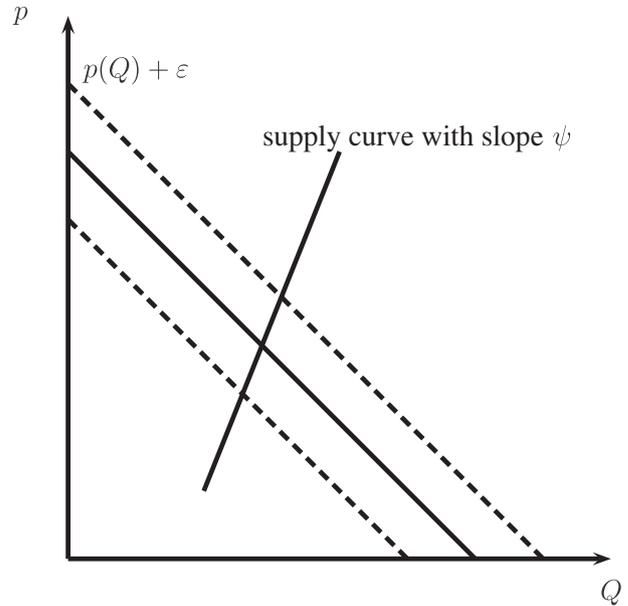


Fig. 2. Demand shifts ε plot out the (oligopoly) supply curve.

For concreteness, consider cost function $c(q, w) = wq + c(q)$. Then we have $z_i = q_i$ and Eq. (5) can be rewritten as follows:

$$\frac{dCS/dw}{d(CS + \Pi)/dw} = \frac{1}{PCM|e_p^q| + \frac{1}{-p'(Q)dQ/d\varepsilon}} = \frac{1}{PCM|e_p^q| + 1 + \frac{\psi}{-p'(Q)}}. \tag{16}$$

where $e_p^q = \ln q / \ln p$ denotes the demand elasticity faced by an individual firm.

Under perfect competition, we have that $PCM = 0$ and thus $CHS = -\frac{p}{\psi - p}$. Hence we replicate the result that the incidence of harm due to $dw > 0$ is determined by the relative slopes of demand and supply.²⁸ Under oligopoly, however, there is an additional term as $PCM > 0$, but the main intuition from the tax literature applies here as well. The steeper the slope of the supply curve relative to the demand curve, the more downstream firms bear the harm relative to final consumers.

To get some idea of what determines the slope ψ , consider the first order condition for q written as

$$p + \varepsilon - (w + c'(q)) + p'(Q)\theta q = 0. \tag{17}$$

Differentiating with respect to ε yields

$$\frac{dQ}{d\varepsilon} = \frac{n}{-p''(Q)Q\theta - p'(Q)(n + \theta) + c''(q)}.$$

Substituting this into Eq. (15) yields

$$\psi = -\frac{1}{n} (\theta p''(Q)Q + \theta p'(Q) - c''(q)) > 0 \tag{18}$$

Hence higher n and lower θ (for given Q) lead to a flatter supply curve. Thus, the more firms there are on the market and the more aggressive their conduct is (lower θ) the flatter the supply curve. In this case, the firms do not absorb the increase $dw > 0$ and hence

²⁸ Compare this to the familiar formula $\Delta P / \Delta MC = e_p^S / (e_p^S - e_p^D)$ of the change of the consumer price (ΔP) relative to the change in marginal costs (ΔMC) following the imposition of a unit tax in a competitive market. Here, e_p^S (e_p^D) denotes the price elasticity of supply (demand). See, e.g., Pindyck and Rubinfeld (2005), p. 326.

consumers bear a bigger fraction of the harm. On the other hand, the more convex the cost function is (higher $c''(q)$), the steeper the slope ψ and the higher the share of the harm borne by firms.

4. Empirically estimating the harm

The CHS expression consists of two types of variables: elasticities and other variables. In this section, we describe how the values of these variables can be estimated. We illustrate how the harm distribution can be estimated in practice using the homogeneous good case. It is easy to adjust this for the heterogeneous good case.

In a typical abuse case, one has available (or can relatively easily get) the following information for the firms in the relevant market: output per firm, the input price causing the harm, the amount of the input used per firm, other costs and cost shifters, price of the downstream firms' output and demand shifters. We need to have this information for a number of periods t (usually years). Let us consider each in turn.²⁹

It should be relatively easy to get the information on the downstream firms' output levels q_{it} as they may actually be bringing the case and in that sense should be expected to cooperate. Also, information on output is relatively easy to verify. With this information, we can calculate total output $Q_t = \sum q_{it}$ per period as well. The input price causing the harm, is here denoted by w_{0t} . Information on other input prices is denoted by w_{jt} . To calculate PCM we need information on marginal costs. That is usually hard to get and one can use average variable costs as an approximation. We only need PCM on the industry level. This can be approximated by operating profits divided by sales, where operating profits are defined as sales minus material and payroll costs (Aghion et al. (2005) and Scherer and Ross (1990)).

The price of downstream firms' output is denoted by p_t . Demand shifters include consumers' income and changes in demand for complementary goods. For instance, in Porter (1983) a demand shock for a U.S. railroad cartel is identified by whether or not the shipping routes on the Great Lakes were free of ice. We denote demand shifters by y_{kt} . Finally, we need to know total expenditure on the input, $w_{0t}Z_{0t}$.

With this information we calculate

$$PCM_t = \frac{\text{operating profit}_t}{\text{sales}_t}$$

$$H_t = \sum_i \left(\frac{q_{it}}{Q_t} \right)^2$$

$$\frac{\sum w_{0t}Z_{0t}}{p_t Q_t} = \frac{w_{0t}Z_{0t}}{p_t Q_t}$$

Now turning to the elasticities e_w^p and e_w^q , the following regressions need to be run³⁰:

$$\ln p_t = \alpha_0 + \alpha_{w0} \ln w_{0t} + \sum_j \alpha_{wj} \ln w_{jt} + \sum_k \alpha_{yk} \ln y_{kt} + \varepsilon_t$$

$$\ln q_{it} = \beta_{i0} + \beta_{wi0} \ln w_{0t} + \sum_j \beta_{wji} \ln w_{jt} + \sum_k \alpha_{yki} \ln y_{kt} + \varepsilon_{it}$$

The first equation allows one to identify the pass-through elasticity as $e_w^p = \alpha_{w0}$. The second equation can be estimated for each firm separately or as a panel if elasticities are assumed to be the same across firms. The relevant elasticity can then be identified as $e_w^q = \beta_{wi0}$.

When estimating these equations, there can be an endogeneity problem with w_{0t} on the right hand side. In particular, if demand in the downstream market shifts out, p_t tends to increase and demand for the input goes up. If upstream firms face increasing marginal

costs, w_{0t} will increase as well. This leads to a biased estimate of α_{w0} . Under either of the following two conditions one does not need to worry about this endogeneity bias. First, if all relevant demand shifts in the downstream market are picked up by the demand shifters y_{kt} variables. Second, if the downstream sector under consideration is one of many sectors buying the input from the upstream sector and upstream firms are not able to price discriminate between firms from different sectors. In this case, it is unlikely that shifts in this downstream market affect w_{0t} . Hence, the variation in w_{0t} is then caused by exogenous cost shifts for the upstream firms.

If neither of these conditions holds, one needs to collect data on upstream cost shifts. These are then used to instrument w_{0t} . The instrumented wholesale price is then used to estimate α_{w0} and β_{wi0} in the equations above.

A final problem that we address is the following. As suggested by studies on cartels (e.g. Harrington (2008) and references therein), if the upstream firms form a cartel, there may be a tendency to keep w fairly constant over time (even though the costs of producing the downstream input for the upstream firms does vary over time). This can make it problematic to identify the elasticities e_w^q , e_w^p in Eq. (5).³¹ If this is the case, there are three ways to deal with this.

First, although w is – more or less – constant over time during the cartel, there may be more variation in w before the cartel started or after it ended. Then it may be possible to identify the elasticities with respect to w using the periods when the cartel was not active.

Second, one can use another input for downstream firms and see how changes in the price of the alternative input affect q_i and Q . If these inputs are used in fixed proportions, then using this method is perfectly fine. If there is some room for substitution between the inputs, this method can be seen as an approximation.

Third, if none of the other inputs are similar enough to the input under consideration such that they can be used to find the elasticities e_w^q , e_w^p , one can also use shifts in demand as a way to get information on the effects of cost shifts. We illustrate this idea with the example in Section 3 where we consider demand shifts of the form $p(Q) + \varepsilon$ and cost function $c(q, w) = wq + c(q)$. In this case, equivalent changes in demand and costs satisfy $d\varepsilon = -dw$. This implies that we can use Eq. (5) with $|e_w^q| = e_\varepsilon^q$, $|e_w^p| = e_\varepsilon^p$. That is, one can identify these elasticities using demand shifts instead of changes in costs.

5. Summary and concluding remarks

One of the reasons why the U.S. Supreme Court ruled out a pass-on defence in the 1968 landmark case *Hanover Shoe* was that the task of showing the extent of pass-on “would normally prove insurmountable.” In fact, forty years after this ruling Bulst (2006, p. 738) states that: “There seems to be no reported court decision, neither in the United States, the United Kingdom, France nor Germany, in which a court calculated or estimated the amount of an overcharge passed on to an intermediate purchaser.”

In this paper we suggest a general framework that allows to determine how the total harm due to e.g. price-fixing in an upstream market is distributed over firms in a downstream market and final consumers. In this framework we make no specific assumptions regarding demand, costs, the mode of competition, or the kind of production technology that downstream firms use in order to turn inputs into final consumer goods. We show how the consumer harm share can be determined both when goods produced downstream are homogeneous and differentiated. Furthermore, we sketch how a practitioner can actually estimate the relevant items in the expression of the consumer harm share.

The motivation for this exercise is two-fold. First, with the framework we put forward here we hope to contribute to showing that in

²⁹ Note that in many countries this type of firm level data is present at the national statistical office. There it is used for the country's national accounts.

³⁰ Note the similarity with the Panzar–Rosse statistic (Panzar and Rosse (1987)) defined as the sum of factor price elasticities of firms' revenues or output levels.

³¹ Note that a low variance in w over time does not complicate the estimation of the other factors in Eq. (5) such as the income share of the input.

principle the task of apportioning antitrust harm in vertically related industries is not “insurmountable” — an assessment that was perhaps never shared by all economic observers. We see this as complementary to recent efforts of reconsidering the determination of the absolute amount of harm resulting from anti-competitive price-fixing cases as put forward in e.g. Hellwig (2007), Verboven and Van Dijk (2009), Basso and Ross (2010), and Han et al. (2008).

Second, not allowing a pass-on defence may create unjustified windfall profits for direct purchasers as they can claim the entire overcharge even if they passed on some or all of this overcharge to their customers. Van Dijk and Verboven (2008) hint at the possibility that this may lead to distorted prices. Moreover, in the 1977 *Illinois Brick* ruling, indirect purchasers were denied the right to sue for anti-trust damages. This implies the problem that parties who were harmed cannot sue for compensation. Due to these problems, the two court rulings of *Hanover Shoe* and *Illinois Brick* have attracted a lot of criticism.³² In response, changes in the law have already been established (such as the *Illinois Brick* repealers) while others are likely to be implemented in the future (see e.g. the suggestions of the Anti-trust Modernization Committee as cited in Section 2). This creates a sense of urgency to develop methods for the practical apportionment of harm over the various links in a production/supply chain. With this paper we hope to make a contribution towards this goal.

We end this paper with some remarks.

First, in the models above we only assumed that the upstream sector “somehow” manages to illegally increase the wholesale price w . Hence, our analysis does not only apply to plain price-fixing agreements, but to all kinds of anticompetitive strategic behavior that result in an elevated wholesale price such as (input) foreclosure, predatory pricing (after having been successful), limit pricing or exclusive dealing.

Second, our results equally apply to the question of how cost savings upstream (due to, say, merger) are passed on to downstream firms and consumers. For a related discussion see Ten Kate and Niels (2005).

Third, in our analysis we did not consider the possibility that the unlawful rise in the upstream price may lead to adjustment by firms in the form of entry or exit. We leave this as a topic for future research. We note, however, that the practitioner faced with the task of estimating the consumer harm share given in Eqs. (5) and (14) could use long-run instead of short-run elasticities to take this into account.

Fourth, for simplicity our analysis above assumed an industry structure consisting of only three layers. However, it is conceivable that the production or supply chain consists of more than three layers.³³ If this is the case, the *CHS* developed in this paper can be applied several times to determine the share of the total harm that is borne by each layer of the industry. For example, let us assume that there are four layers: an upstream sector (U), two consecutive downstream sectors (D_1 and D_2), and final consumers (C). Furthermore, assume that the upstream sector charges the illegally raised wholesale price w to downstream sector D_1 , which in turn increases the price p_1 it charges to firms in the downstream sector D_2 , which in turn increases the final consumer price p_2 . In this case, one can use our framework computing two consumer harm shares. The first (CHS_1) only considering the chain $U - D_1 - D_2$ and substituting the final consumer demand we used in our analysis above with the demand function of downstream sector D_2 . The second (CHS_2) considering the chain $D_1 - D_2 - C$ where D_1 takes the role of the upstream sector raising price p_1 . Note that CHS_1 can be used as a screening device for how

³² Of course there are several reasons in favor of ruling against a pass-on defence and against indirect purchasers to have standing as put forward by e.g. Landes and Posner (1979). Among those reasons are that direct purchasers might have an informational advantage due to their closeness to the infringer, and that indirect purchasers might have small and dispersed claims which lessens their incentives to sue for damages.

³³ Note again, that Han et al. (2008) consider a model with an arbitrary number of layers.

severe the pass-on from the upstream sector down the production chain really is. If CHS_1 is “sufficiently small,” then the entire case can be dismissed and there would be no need to determine CHS_2 . If CHS_1 turns out to be “sufficiently big,” however, one can use the two *CHS*s to determine the share of the total harm that is borne by each layer in the chain.

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Appendix A. Proofs

Proof of lemma 1. Differentiate Eq. (3) with respect to w as follows

$$\left[p'(Q) + p''(Q)\theta q_i \right] \frac{dQ}{dw} + \left(p'(Q)\theta - \frac{\partial^2 c_i}{\partial q_i^2} \right) \frac{dq_i}{dw} = \frac{\partial^2 c_i}{\partial q_i \partial w}.$$

The assumptions $p'(Q) < 0$, $p''(Q)Q + p'(Q) < 0$ and $0 \leq \theta q_i \leq Q$ imply that the term in square brackets is negative. Further, the assumption $\frac{\partial^2 c_i}{\partial q_i^2} \geq 0$ implies that the second term in brackets is negative as well. Next, $\frac{\partial^2 c_i}{\partial q_i \partial w} > 0$ implies $dQ/dw < 0$ for the following reason. Suppose by contradiction that $dQ/dw \geq 0$, then we find $dq_i/dw < 0$ for all i . However, since $Q = \sum_i q_i$ this leads to a contradiction. *Q.E.D.*

Proof of proposition 1. Summing Eq. (4) over all i yields

$$\frac{dII}{dw} = p'(Q)Q \frac{dQ}{dw} \left(1 - \theta \sum \frac{q_i}{Q} \frac{dq_i}{dw} \right) - \sum \frac{\partial c_i}{\partial w}. \tag{A.1}$$

Hence, comparing the loss in profits to the loss in consumer surplus (CS), given in (1), we get

$$\frac{dII/dw}{dCS/dw} = \theta \sum \frac{q_i}{Q} \frac{dq_i/dw}{dQ/dw} + \frac{\sum \frac{\partial c_i}{\partial w}}{Qp' dQ/dw} - 1. \tag{A.2}$$

Now, write Eq. (3) as

$$\frac{p - \frac{\partial c_i}{\partial q_i}}{p} = - \frac{dp}{dQ} \frac{Q}{p} \theta \frac{q_i}{Q}$$

and multiply both sides of this equation by q_i/Q to get

$$PCM = \sum_i \frac{q_i}{Q} \frac{p - \frac{\partial c_i}{\partial q_i}}{p} = \frac{\theta H}{\left| e_p^Q \right|}$$

or

$$\theta = \frac{\left| e_p^Q \right|}{H} PCM. \tag{A.3}$$

where $e_p^Q = d \ln Q / d \ln p$ denotes the demand elasticity.

Using (A.3), rewrite Eq. (A.2) as

$$\frac{dII/dw}{dCS/dw} = \frac{\left| e_p^Q \right|}{H} PCM \sum \left(\frac{q_i}{Q} \right)^2 \frac{dq_i/dw}{dQ/dw} + \frac{\sum \frac{\partial c_i}{\partial w}}{p' \frac{Q}{p} \cdot \frac{dQ}{dw}} - 1. \tag{A.4}$$

Using Shepard's lemma $\frac{\partial c_i}{\partial w}(q_i, w) = z_i(q_i, w)$, Eq. (A.4) is equivalent to

$$\frac{d\Pi/dw}{dCS/dw} = \frac{|e_p^Q|}{H} PCM \sum \left(\frac{q_i}{Q}\right)^2 \frac{|e_w^{q_i}|}{|e_w^Q|} + \frac{\sum w z_i(q_i, w)}{pQ} \frac{|e_p^Q|}{|e_w^Q|} - 1. \quad (A.5)$$

where $e_w^Q = d \ln Q / d \ln w$.

Hence

$$\frac{d(\Pi + CS)/dw}{dCS/dw} = \frac{d\Pi/dw}{dCS/dw} + 1 = \frac{|e_p^Q|}{H} PCM \sum \left(\frac{q_i}{Q}\right)^2 \frac{|e_w^{q_i}|}{|e_w^Q|} + \frac{\sum w z_i(q_i, w)}{pQ} \frac{|e_p^Q|}{|e_w^Q|},$$

which can be rewritten as

$$CHS = \frac{dCS/dw}{d(\Pi + CS)/dw} = \frac{1}{\frac{|e_p^Q|}{H} PCM \sum_{i=1}^n \left[\left(\frac{q_i}{Q}\right)^2 \frac{|e_w^{q_i}|}{|e_w^Q|}\right] + \frac{\sum w z_i(q_i, w)}{pQ} \frac{|e_p^Q|}{|e_w^Q|}}.$$

To facilitate interpretation, we write this equation using the cost pass-through elasticity. In particular, note that

$$\frac{|e_p^Q|}{|e_w^Q|} = \frac{\frac{d \ln Q}{d \ln p}}{\frac{d \ln Q}{d \ln w}} = \frac{1}{e_w^p}$$

where

$$e_w^p = \frac{d \ln p}{d \ln w}$$

is the (equilibrium) elasticity of the final output price p with respect to the input price w , that is, the cost pass-through elasticity. To see why this holds, let $Q = f(p)$ denote the demand function and $Q = g(w)$ the equilibrium output level as a function of input price w . Then by definition $f(p(w)) \equiv g(w)$. Differentiating this identity with respect to w gives the equation. Using this we write CHS as given in Eq. (5). Q.E.D.

Proof of Corollary 1. Profits for affected and unaffected firms are given by, resp.

$$\pi_a = p(Q)q_a - c(q_a, w + dw) \quad (A.6)$$

$$\pi_u = p(Q)q_u - c(q_u, w). \quad (A.7)$$

The first order condition for a firm $i = a, u$ can be written as

$$p(Q) - c'_{q_i} + p'(Q)\theta q_i = 0$$

and total output is given by

$$Q = (n - m)q_u + mq_a.$$

The effect of dw (evaluated at $dw = 0$) on total industry profits can now be written as

$$\frac{d\Pi}{dw} = Qp'(Q)\frac{dQ}{dw} + (P(Q) - c'_q)\frac{dQ}{dw} - mc'_w, \quad (A.8)$$

where we can write $c'_q = c'_{q_a} = c'_{q_u}$ precisely because we evaluate at $dw = 0$. To find the effect of dw on Q we differentiate the first order conditions for q_a, q_u with respect to w to get

$$-SOC \frac{dq_u}{dw} = [p'(Q) + p''(Q)\theta q_u] \frac{dQ}{dw} \quad (A.9)$$

and

$$-SOC \frac{dq_a}{dw} = [p'(Q) + p''(Q)\theta q_a] \frac{dQ}{dw} - c''_{wq_a}, \quad (A.10)$$

where $SOC = 2p'(Q)\theta - c''_{qq} + p''(Q)\theta^2 q < 0$ stands for the second order condition. Multiply Eq. (A.9) by $n - m$ and Eq. (A.10) by m , then add the two equations to get

$$[-SOC - np'(Q) - p''(Q)\theta Q] \frac{dQ}{dw} = -mc''_{qw}.$$

Put differently, $\frac{dQ}{dw}$ is linear in m . Using $\frac{dCS}{dw} = -Qp'(Q)\frac{dQ}{dw}$, we find

$$\frac{d(CS + \Pi)/dw}{dCS/dw} = -\frac{P(Q) - c'_q}{Qp'(Q)} + \frac{c'_w}{Qp'(Q)} \frac{m}{dQ/dw},$$

which is independent of m because – as found above – dQ/dw is linear in m . Hence, also CHS (the reciprocal of $\frac{d(CS + \Pi)/dw}{dCS/dw}$) is independent of m . Q.E.D.

Proof of Proposition 2. First, using Eqs. (10) and (13) we get

$$\frac{d\Pi/dw}{dCS/dw} = \frac{-(1 - \theta) \frac{dq}{dw} \left(\frac{1}{|e_p^q|} - \frac{1}{|e_{p_i}^q|} \right) - \frac{z}{p}}{\frac{dq}{dw} \frac{1}{|e_p^q|}} \quad (A.11)$$

$$= -(1 - \theta) \left[1 - \frac{|e_p^q|}{|e_{p_i}^q|} \right] + \frac{|e_p^q|}{|e_w^q|} \frac{nzw}{npq}. \quad (A.12)$$

Next, from Eq. (11) we find

$$PCM = \sum_{i=1}^n \frac{q}{Q} \frac{p - c'_q}{p} = (1 - \theta) \frac{1}{|e_{p_i}^q|} + \frac{\theta}{|e_p^q|} \quad (A.13)$$

or

$$\theta = \left(\frac{1}{|e_{p_i}^q|} - PCM \right) \frac{|e_{p_i}^q| |e_p^q|}{|e_p^q| - |e_{p_i}^q|}. \quad (A.14)$$

Substituting this expression for θ into Eq. (A.12) leads to

$$\frac{d\Pi/dw}{dCS/dw} = -1 + |e_p^q| PCM + \frac{|e_p^q|}{|e_w^q|} \frac{nzw}{npq}. \quad (A.15)$$

Finally, from $\frac{d(\Pi + CS)/dw}{dCS/dw} = \frac{d\Pi/dw}{dCS/dw} + 1$ and

$$\frac{|e_p^q|}{|e_w^q|} = \frac{\frac{d \ln q}{d \ln p}}{\frac{d \ln q}{d \ln w}} = \frac{1}{e_w^p}$$

the equation in the proposition follows. Q.E.D.

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