Discussion Paper No. 15-060

Information Exchange Through Non-binding Advance Price Announcements: An Antitrust Analysis

Willem Boshoff, Stefan Frübing,
and Kai Hüschelrath

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH
Centre for European Economic Research

Discussion Paper No. 15-060

Information Exchange Through Non-binding Advance Price Announcements: An Antitrust Analysis

Willem Boshoff, Stefan Frübing,
and Kai Hüschelrath

INFORMATION EXCHANGE THROUGH NON-BINDING ADVANCE PRICE ANNOUNCEMENTS: AN ANTITRUST ANALYSIS[1]

Willem Boshoff[2], Stefan Frübing[3] and Kai Hüschelrath[4]

August 2015

Abstract
We study the welfare effects of non-binding advance price announcements. Applying a differentiated Bertrand model with horizontal products and asymmetric information, we find that such announcements can help firms to gain information on each other thereby allowing them to achieve higher profits. However, our results also show that the overall welfare effects of such announcements in a context of heterogeneous products are not as clear-cut as previous research in a homogeneous products framework has suggested. We conclude that – although non-binding advance price announcements may raise competition concerns – in many settings, their positive effects are likely to outweigh the potential detrimental effects on welfare.

Keywords Antitrust policy; collusion; information exchange; price announcements

JEL Class L41; K21

[1] We thank Cedric Argenton, Eckart Bueren, Jens-Uwe Franck, Georg Götz, Catarina Marvao, Matthew Olczak and Konrad Stahl as well the audiences at the 2015 International Industrial Organization Conference in Boston, the 2015 BECCLE Competition Conference in Bergen, the 2015 CLEEN Workshop in Tilburg and the 2014 MPI-ZEW Private Law and Economics Workshop in Mannheim for valuable comments and suggestions.

[2] Department of Economics, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa. E-mail: wimpie2@sun.ac.za.

[3] ZEW Centre for European Economic Research, Competition and Regulation Research Group and MaCCI Mannheim Centre for Competition and Innovation. Address: P.O. Box 10 34 43, D-68034 Mannheim, Germany, E-mail: fruebing@zew.de.

[4] ZEW Centre for European Economic Research, Competition and Regulation Research Group and MaCCI Mannheim Centre for Competition and Innovation. Address: P.O. Box 10 34 43, D-68034 Mannheim, Germany, E-mail: hueschelrath@zew.de; University of Mannheim, L7, 3-5, 68131 Mannheim, Germany. *Corresponding author.*

1 Introduction

Announcing prices or price changes before they become effective is a common practice in a number of markets, including transport services and intermediate goods such as cement, concrete, asphalt or chemical products. Competition authorities are to some extent concerned about the potential welfare-decreasing effects of such practices. In particular, the standard theory of harm suggests that by giving advance notice of their price intentions, firms are able to coordinate on higher prices, increasing their own profits at the expense of buyers and overall welfare.

Despite these potential detrimental effects on welfare, authorities are fully aware that there might also be non-collusive, welfare-enhancing explanations for the implementation of advance price announcements (APAs). Examples include the intention of firms to shift demand over time or the customer's desire to know their costs in advance (e.g., for planning purposes). The Horizontal Guidelines of the European Commission (2011) take account of this ambiguity by classifying binding advance price announcements as in accordance with competition law, whereas private non-binding advance price announcements are considered likely to violate competition law and public non-binding advance price announcements constitute a grey area.

In this paper, we study the welfare effects of non-binding advance price announcements. Applying a differentiated Bertrand model with horizontal products and asymmetric information, we find that such announcements can help firms to gain information on each other thereby allowing them to achieve higher profits. However, our results also show that – even in the absence of welfare-enhancing buyer reactions – the overall welfare effects of such announcements in a context of heterogeneous products are not as clear-cut as previous research in a homogeneous products framework has suggested. We conclude that the net welfare effect of non-binding advance price announcements is likely to be positive in the circumstances we analyzed.

The remainder of the paper is organized as follows. In the subsequent Section 2, we provide a selective review of the economics literature on communication among firms in general and advance price announcements in particular (in Section 2.1), followed by a complementary summary of recent antitrust cases in which such announcements played a role (in Section 2.2). In Section 3, we introduce private non-binding advance price announcements in a standard model of Bertrand competition with differentiated goods, showing their implications on both firm profits and overall welfare. In particular, we start off in Section 3.1 by modeling the state of unknown costs, followed by the state of an unknown demand

parameter in Section 3.2. Section 3.3 combines the preceding two sections by assuming more than one missing piece of information. Section 3.4 presents the results of several rounds of simulations of the respective three states of the model, followed by a brief discussion of possible model extensions in Section 3.5. Section 4 concludes the paper.

2 Advance price announcements in competition theory and practice

This section presents a selective review of the economics literature on communication among firms in general and advance price announcements in particular, followed by a complementary summary of recent antitrust cases in which such announcements played a role.

2.1 Review of the existing literature

According to basic oligopoly theory, firms have an incentive to coordinate in order to achieve supracompetitive prices and therefore greater profits. However, successful collusion regularly requires some form of communication among firms. Direct or express communication is the measure of first choice in achieving a collusive outcome. Such explicit collusive practices are prohibited in most countries, providing incentives for firms to rely on second-best solutions in order to achieve some form of tacit collusion.

The literature distinguishes between two types of tacit collusion: conscious parallelism and concerted action. By definition, conscious parallelism does not include any direct communication among firms; however, some mutual understanding of the industry can lead to an equilibrium with higher market prices and profits than under competition. Following Harrington (2012), the standard example of such a form of behavior is two adjacent gasoline stations that can observe price changes and react in a way to stabilize supracompetitive price levels. Conscious parallelism is classified as legal by most competition laws.

In contrast, concerted actions are located between explicit collusion and conscious parallelism in the sense that these actions involve some form of direct communication. Importantly, the communication does not involve the respective firms expressing their intent to reach a collusive agreement. Nevertheless, the extent of mutual understanding is higher than under conscious parallelism (see Harrington 2012) and the direct form of communication might be helpful to reach and sustain supracompetitive prices. Examples generally include various forms of (public or private) announcements, for example, announcements on future pricing policy. Consequently, the competition law treatment of concerted action is somewhat of a grey area in most competition laws.

Given the potential negative welfare effects of concerted action, one would expect greatest interest in the study of these forms of communications. However, Harrington (2012)[5] and Kaplow and Shapiro (2007) note that economic theory has difficulties in answering the question of how firms decide whether to explicitly or tacitly collude and how they decide on which of the (usually many) possible equilibria to play. These authors note that economic theory is equally unable to explain which types of direct communication can be considered sufficient in realizing a (tacitly) collusive outcome.

In an effort to provide some answers to the puzzles around communication, an early literature on focal pricing emphasized the relevance of communication in general and the role of 'focal points' in coordinating outcomes in strategic situations (Schelling (1960) and Scherer (1967) are early applications to conscious parallelism, while Bennett and Collins (2010) provide a more recent analysis). Focal points can be defined as points of convergence for expectations and therefore provide first answers to the question of how firms might reach certain collusive outcomes without express communication.

The related literature on cheap talk suggests that non-binding and unverifiable communication – with no direct effect on payoffs – may help coordination on a particular equilibrium (see, for example, the seminal paper by Farrell (1987) and the survey by Farrell and Rabin (1996)). Although such forms of communication may also have no effect – that is the players simply ignore the respective information – Farrell and Rabin (1996) show that many of these equilibria are in fact implausible.

In their survey, Kaplow and Shapiro (2007) point towards a different strand of literature that studies the role of communications to convey private information. For example, Athey and Bagwell (2001, 2008) allow firms to communicate about private cost information in a repeated pricing game, while Compte (1998) and Kandori and Matsushima (1998) investigate communications when firms observe private but imperfect signals about the past.

Guided by early results of experimental economics (and the legal approach to collusion more generally[6]), Kühn (2001) proposes to fight collusion by banning certain types of communication between firms that are, on the one hand, particularly likely to facilitate collusion but, on the other hand, are unlikely to improve social welfare by enabling some kind

[5] As noted by Harrington (2012:3) "[t]he economic theory of collusion – based on equilibrium analysis – presumes mutual understanding is complete (that is, the strategy profile is common knowledge) and does not deal with how mutual understanding is achieved, nor the extent of coordinated behavior that can result when there are gaps in mutual understanding".

[6] Kühn (2001:175) generally argues that the legal approach to collusion – that focuses on communication instead of evidence from market behavior – should be adopted by the economics profession as well (partly because of the apparent difficulties in making inferences from observed market behavior).

of procompetitive information communication or exchange[7] (e.g., by reducing search costs for customers or generally improving market allocations). In particular, Kühn suggests banning the following forms of communication: any private discussion of future output prices or production plans, individualized information exchanges about past prices and quantities and (probably) the exchange of individualized cost and demand data. Most recently, Cooper and Kühn (2014) provide an experimental study of how communication facilitates the development of stable collusion. Although they find that simply allowing subjects to communicate an intent to collude is not sufficient to generate persistent collusion, their experiments point to types of communication that do have the potential to facilitate explicit collusion.

Turning from a general review of the literature on the role of communication to our concrete example of advance price announcements[8], Marshall et al. (2008) model advance price announcements as part of a broader case of explicit collusion in the U.S. vitamins industry (and not as separate strategy to reach a tacitly collusive outcome). They differentiate between two types of price announcements: ones 'with future effective date' and ones 'with immediate effective date'. While the former type of announcement can be retracted before becoming effective (i.e., it is non-binding), the latter becomes immediately effective (i.e., it is binding). In this context, the authors show that firms in a competitive market only make announcements that become immediately effective while firms operating under a collusive regime will use price announcements with future effective dates to test whether buyers accept a price increase.[9]

Harrington, Hernan-Gonzalez and Kujal (2013) provide experimental evidence on non-binding price announcements building on earlier contributions by Friedman (1967) or Holt and Davis (1990). They find that such agreements increase the frequency of collusion in a symmetric duopoly game, but do not facilitate collusion when there are more than two firms (or when the two firms are asymmetric). Furthermore, even in the symmetric duopoly world,

---

[7] Bennett and Collins (2010:314ff.) provide a detailed discussion of possible benefits of information sharing. Differentiating between the disclosure of information to consumers on the one hand and sharing information with suppliers on the other, they argue (with respect to the latter category) that information sharing (1) allow firms to benchmark themselves against other firms, (2) can help to improve allocative efficiency, (3) can allow firms to understand market trends thereby being able to better match supply with demand, (4) can reduce problems of adverse selection, or (5) may be necessary in the context of other types of beneficial horizontal agreements (e.g., in the field of research and development).

[8] Please note that we refrain from discussing the larger existing literature on price leadership as these models regularly assume sequential but binding price setting (see, for example, Mouraviev and Rey (2011) for an overview).

[9] Interestingly, Marshall et al. (2008:774) also argue that if price announcements are used as part of a cartel agreement, the cartel members would clearly prefer public over private price announcements (as buyers could otherwise resist price increases and monitoring efforts within the cartel would increase as well).

they find only little evidence that non-binding price announcements are able to generate stable supracompetitive outcomes. More generally, their experimental results provide strong evidence that the incremental gain of direct communication (through direct conversations) is large compared to indirect communication through non-binding price announcements. The gap is found to be increasing with the number of firms and the degree of asymmetry between firms.

The contribution closest to ours is Blair and Romano (2001) in which the authors consider non-binding advance price announcements in a Bertrand model with perfectly homogeneous products and asymmetric information about demand and cost conditions. Guided by the more general seminal contributions of MacLeod (1985) and Rotemberg and Saloner (1990), they find that these announcements have a negative impact on welfare when there is implicit exchange of demand information while they have a positive impact on welfare when cost uncertainty is resolved. However, the fact that Blair and Romano discuss the more realistic setting of heterogeneous products only verbally reduces the practical relevance of their approach and findings and, at the same time, suggests the development of a corresponding Bertrand model that allows for heterogeneous products. Such a model is developed and discussed in Section 3 below.

2.2 Review of related antitrust cases

Non-binding advance price announcements have not only been assessed in the academic literature, but have been the subject of competition law investigations. Under U.S. antitrust law, the unilateral disclosure of information does not violate Section 1 of the Sherman Act which generally prohibits contract, combination or conspiracy that unreasonably restricts trade – as the unilateral disclosure of information does not constitute an agreement that is required to violate Section 1. However, such disclosures may, under certain circumstances, violate Section 2 of the Sherman Act, which generally prohibits efforts to monopolize (including acts to combine or conspire with another person to monopolize). Among the criteria that are relevant to decide on the harmfulness of an unilateral disclosure of information are, for example, the nature and quantity of the information disclosed, the specificity and context of the information disclosed, whether the disclosure is public or private, the nature of industry and market and the existence of procompetitive business justifications for the disclosure of information[10] (see OECD (2012) for detailed information).

[10] From a law perspective, there are important differences between the (unilateral) disclosure of information on the one hand and (facilitated) information exchanges via certain platforms (such as trade associations) on the other (although, in principle, both types of communication can violate antitrust laws (see, for example,

Interestingly, despite the possibilities of antitrust law to intervene against cases of (anti-competitive) information disclosure, U.S. antitrust agencies have pursued only a small number of cases and only one case proceeded to court (see OECD (2012) for more information). In the litigated case[11], the U.S. Department of Justice sued eight large U.S. airlines and the Airline Tariff Publishing Company (ATP) for price fixing and therefore a violation of Section 1 of the Sherman Act. ATP acted as a platform used by airlines to exchange information, including information on fares. Although part of the information was also available to the public (via computer reservation systems), the ATP platform was also used for private dialogues on fares among the airlines (including future fare increases, restrictions, or elimination of discount fares) and allowed a constant monitoring of rivals' fare changes. Eventually, the case was resolved by a consent decree prohibiting airlines from using the ATP platform to coordinate prices for the following 10 years (see Borenstein (1999) and Miller (2010) for detailed discussions of the case and its implications).

In the European Union, the content of Articles 101 and 102 of the Treaty on the Functioning of the European Union (TFEU) is comparable to the respective Sections 1 and 2 of the Sherman Act in the United States. As a consequence, competition law enforcement in the European Union faces similar challenges in acting against forms of tacit collusion (see generally Capobianco (2004) and especially Siciliani (2014) for an overview of the possibilities to treat tacit collusion as possible violation of Article 102 TFEU). Under Article 101 TFEU, cases of information disclosure or information exchange can only be addressed if they establish or are part of an agreement, a concerted practice or a decision by an association of undertakings. Furthermore, the Horizontal Guidelines of the European Commission (2011) clearly state that "private exchanges between competitors of their individualized intentions regarding future prices or quantities would normally be considered and fined as cartels because they generally have the object of fixing prices or quantities".[12] The guidelines, however, acknowledge that there may be efficiency gains by public advance price announcements without clarifying under which circumstances they would be sufficient to approve non-binding public advance price announcements. With regard to cases in which an advance price announcement is effectively binding for the seller, the guidelines state that the inability to revise the announcements would normally ensure that there is no infringement of competition law.

OECD (2010):11ff.)). From an economics perspective, it is not the general type of communication that is of key interest, but the effects on market outcomes (as, for example, a collusive equilibrium can also be reached and maintained by mutual understanding, i.e., without any form of direct communication).

[11] United States v. Airline Tariff Publishing Company, Civil Action No. 92-2854, filed December 21, 1992.

[12] See European Commission (2011), C 11/16, n. 74.

Since the 1980s, the European Commission as well as national competition authorities have brought several influential cases with a direct relationship to advance price announcements. A famous case is Wood Pulp (1984), in which the European Commission uncovered a system of (nearly simultaneous) quarterly price announcements (usually some weeks or days before the beginning of each quarter), which were non-binding in the sense that individual downward renegotiation took place afterwards[13] (see Motta (2004) for a detailed description). The European Commission prohibited the practice in its decision in 1984 as "… the system of quarterly announcements […] constituted in itself, at the very least, an indirect exchange of information on future market conduct. […] The fact that prices were published well in advance of their entry into effect at the beginning of a new quarter guaranteed that other producers had sufficient time to announce their own – corresponding – new prices before that quarter and to apply them from the beginning of that quarter."[14] However, the Commission's decision was later overturned by the European Court of Justice[15], partly because communications arose from price announcements made to customers: "Price announcements did not constitute in themselves market behavior which lessened each company's uncertainty as to the future attitude of its competitors because at the time each company engaged in these announcements, it could not be sure of the future conduct of the others" (Shearman & Sterling (2014:3) summarizes the various joint appeals cases following the Commissions' decision in 1984).

More recently, Hall (2014) identifies and describes three competition cases from the European container liner shipping industry, the British cement sector and the Dutch mobile phone industry. In the EC container shipping case – initiated with dawn raids at companies in several European countries in May 2011 and formally opened in November 2013[16] – the European Commission expressed its concerns over the parties' regular public announcements of price increase intentions through press releases on their websites and in the specialized trade press. The case is still undecided at the time of this writing.

With respect to the UK cement industry, a market investigation by the Competition Commission (CC)[17] yielded evidence of conduct aimed at restricting competition and aiding

[13] It is important to note that the customers demanded the introduction of the announcement system. In fact, the announced prices were seen as ceiling prices, i.e., starting points for individual negotiations on the actual prices.

[14] Commission Decision of 19 December 1984 relating to a proceeding under Article 85 of the EEC Treaty (IV/29.725 - Wood pulp) OJ L 85/1.

[15] A. Ahlström Osakeyhtiö and others v. Commission [1993] ECR I-1307, para. 64.

[16] European Commission Press Release, Antitrust: Commission Opens Proceedings Against Container Liner Shipping Companies, IP/13/1144, 22 November 2013, Brussels.

[17] Competition Commission, Aggregates, Cement and Ready-Mix Concrete Market Investigation, Final Report, 14 January 2014, London.

coordination. In addition to several (structural) cement plant divestiture remedies, the CC imposed several behavioral remedies including, first, the introduction of a time lag in data sharing via an industry association and, second, the prohibition to send generic price announcement letters to cement customers; only customer-specific price announcement letters remain allowed. By ordering the implementation of the two behavioral measures, the CC aimed to reduce market transparency, thereby reducing the possibilities of coordination among cement suppliers.

In the Dutch mobile phone case, operators made statements at conferences and in the trade press concerning commercial plans in general and future prices in particular, before the respective measures were actually decided or implemented in-house. The Dutch Authority for Consumers and Markets (ACM) investigated this conduct, noting that statements aimed at reducing strategic uncertainty in the market may ease coordination among competitors. The investigation was closed[18] without the imposition of any fines, after the three major mobile-telecommunication providers in the Netherlands (KPN, T-Mobile and Vodafone) made commitments to refrain from such statements. In particular, the companies agreed, first, to refrain from publicly announcing commercial plans before they are actually decided internally and, second, to give the issue special attention as part of competition compliance workshops.

The preceding paragraphs briefly summarize selected competition cases in which some form of advance price announcement played a role. These cases suggest that advance price announcements is an issue of current important to competition policy. Consequently, we study the welfare effects of non-binding advance price announcements in a rigorous model framework.

3 General model

In this section, we introduce advance price announcements into a standard duopoly model of Bertrand competition with differentiated products. We use this model to provide examples of an environment where advance price announcements can help firms to sustain a more profitable equilibrium than would be possible without such communication. When deciding how to model advance price announcements, we aim at representing an industry vulnerable to (tacit) collusion. Thus, we envision a market with several collusion-facilitating factors such as sufficient concentration, transparency, stability and symmetry.

[18] Authority for Consumers and Markets, Investigation into Mobile Operators Concluded, Press Release, 21 November 2013, The Hague.

Before we continue with the characterization of our model approach, it is important to specify the type of advance price announcement we are focusing on in the remainder of the paper. The review in the preceding section suggests that a 'taxonomy of advance price announcements' must (at least[19]) specify whether the respective announcements are (1) binding or non-binding, (2) public or private and (3) used as part of an explicit collusive agreement or as device facilitating tacit collusion. In our model approach, we will, first, concentrate on non-binding announcements in the sense that firms are able to change the announced prices later. Second, we assume that price announcements are public in the sense that they can be observed by the two firms and by the buyers. Third, we concentrate on advance price announcements as possible tacitly collusive device (i.e., we exclude the case in which such announcements are used as part of an explicit collusive agreement).

Buyer-related efficiency improvements – such as improved planning abilities – are not easily accommodated into our model. We therefore concentrate on an assessment of the welfare effects under the extreme assumption that buyers only care about final prices and do not react to price announcements.[20] If we are unable to find – in such a 'worst case scenario' from a buyer perspective – a clear welfare loss of non-binding advance price announcements, adding the expected efficiencies are likely to result in a positive net welfare effect of such agreements.

The remainder of this section is structured as follows. In Section 3.1 we start off by modeling the state of unknown costs, followed by the state of an unknown demand parameter in Section 3.2. Subsequently, Section 3.3 brings the preceding two sections together by assuming more than one missing piece of information. After discussing the results of several rounds of simulations of the respective three states of the model in Section 3.4, the section is closed by a brief discussion of possible model extensions in Section 3.5.

3.1 Version A: Unknown costs

We consider an industry with two single-product firms, named firm 1 and firm 2, who produce differentiated products at constant marginal costs of c_1 and c_2, respectively. Each firm has private information about its own marginal costs.

---

[19] Additional degrees of freedom in the design of advance price announcements (from which we abstract in this paper) are, for example, (1) the time period from the announcement of the price to the actual transaction, (2) the advance announcement of non-price information (such as, for example, costs or business plans) which nevertheless can have clear implications on future prices or (3) the type of communication channel that is used (e.g., price announcement letters, specialized trade press or online platforms).

[20] Technically, the same results would be received for the case of private non-binding announcements in which buyers do not observe the respective announcement.

Firm 1 faces demand D_1 and firm 2 faces demand D_2 as follows:

$$D_1\,(p_1) = f_1 - a_1 p_1 + b_1 p_2 \qquad (1)$$

$$D_2\,(p_2) = f_2 - a_2 p_2 + b_2 p_1 \qquad (2)$$

Here, p_i is the price of firm i, f_i is a demand parameter, which is sufficiently large to ensure positive demand, $a_i > 0$ is the own-price effect and $b_i > 0$ represents the effect of a price change of the competing product.

We start off by assuming that firms know f_i, f_j, a_i, a_j, b_i and b_j with $j \neq i$. Moreover, we assume that the demand of each firm depends more strongly on its own price than on the price of the competitor.[21] The firms simultaneously set their prices and afterwards demand and profits are realized. The stage game described so far is repeated infinitely in each period and firms share a common discount factor $\delta < 1$. Variables and parameters that change over time are indexed t. Costs fluctuate every period, which implies that knowledge of rival's cost cannot be improved over time. More technically said, we assume that c_1 and c_2 each follow a random walk with $c_{it} = c_{it-1} + \Omega_{it}$ where Ω_{it} is an independent and identically distributed random variable with $E(\Omega_{it})$=0 and Var $(\Omega_{it}) > 0$. There is no correlation between cost changes of both firms. However, each firm observes its rival's cost of the previous period before setting its price for the next period (e.g., because financial statements or other reports for shareholders are published). We ignore possible joint cost shocks as their implementation would not affect our general argument and results. We denote the expectation that firm i has of its rival's cost by c_{Ej}. Given the random walk behavior, the expectation is equal to the rival's cost of the previous period, that means $c_{Ejt} = c_{jt-1}$.

As usual in this kind of games, there are multiple equilibria. An obvious equilibrium is the repetition of the Nash equilibrium of the stage game with prices as follows:

$$p_{C1} = \frac{2a_2(f_1+a_1c_1)+b_1(f_2+a_2c_{E2})}{4a_1a_2 - b_1b_2} \qquad (3)$$

$$p_{C2} = \frac{2a_1(f_2+a_2c_2)+b_2(f_1+a_1c_{E1})}{4a_1a_2 - b_1b_2} \qquad (4)$$

We call these prices the 'prices under competition'. However, the more interesting equilibrium is the subgame perfect Nash equilibrium with the highest aggregate profits for the two firms. We call this the 'cooperative equilibrium' or the equilibrium with tacit collusion as

[21] This assumption ensures that $4a_1a_2 - (b_1 + b_2)^2 > 0$, which gives along with $a_i > 0$ the sufficient condition for a local maximum.

firms set a higher price than under competition, taking the effect of their price increase on the competitor's profit into account. The cooperative equilibrium is achieved when the firms set prices as follows (given that the rival always behaved cooperatively in the past):

$$p_{TC1} = \frac{2a_2(f_1+a_1c_1-b_2c_{E2})+(b_1+b_2)(f_2+a_2c_{E2}-b_1c_1)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (5)$$

$$p_{TC2} = \frac{2a_1(f_2+a_2c_2-b_1c_{E1})+(b_1+b_2)(f_1+a_1c_{E1}-b_2c_2)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (6)$$

In case of a deviation, the Nash equilibrium of the stage game would be repeated infinitely. We assume that firms are patient enough – i.e. the discount factor δ is high – to have an incentive not to deviate. Unless the expectations perfectly match the true value, the aggregated profits are lower than with the prices a monopolist would set knowing c_1 and c_2. These monopoly prices are given as follows:

$$p_{M1} = \frac{2a_2(f_1+a_1c_1-b_2c_2)+(b_1+b_2)(f_2+a_2c_2-b_1c_1)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (7)$$

$$p_{M2} = \frac{2a_1(f_2+a_2c_2-b_1c_1)+(b_1+b_2)(f_1+a_1c_1-b_2c_2)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (8)$$

Based on this general model set-up, we now incorporate advance price announcements by assuming that each period consists of two stages. In stage 1, firms simultaneously announce their price intentions, which are observed by the competitor and the buyers. In stage 2, firms finally set binding prices which may equal the announcement in stage 1 or any different value. We further assume that buyers only care about final prices in their purchasing decision, i.e., they ignore the announcements. The idea of ignoring buyer reactions in this baseline model allows us to evaluate a 'worst case scenario' from the buyer's perspective that can later be compared to possible (welfare-increasing) efficiency effects of advance price announcements. This leads us to our first proposition.

Proposition 1: *In a Bertrand duopoly game with differentiated products and asymmetric information on costs, firms can achieve joint monopoly profits by introducing non-binding advance price announcements.*

Why is the non-binding preannouncement causing any difference? The reason is that firms may use the preannouncement to convey hidden information, in our case of their costs. As shown above, firms are not able to achieve joint profits equal to the profit of a monopolist if they do not know each other's costs.

However, with the possibility of advance price announcements, there is an equilibrium in which each firm first announces the optimal collusive price of its product given the information it has. Afterwards, a firm can infer the missing piece of information, namely the costs of its rival, and then set the optimal price at the second stage.

In order to sustain this equilibrium, it is necessary that implicitly reporting false costs is detected and triggers a punishment such as, for example, the infinite repetition of the Nash equilibrium of the stage game. Given a sufficient punishment and sufficient valuation of the discounted future profits, both firms have no incentive to deviate from the equilibrium strategy described in the following.

In our example, there is an equilibrium where firms announce the following prices at the first stage:

$$p_{1APA} = \frac{2a_2(f_1+a_1c_1-b_2c_{E2})+(b_1+b_2)(f_2+a_2c_{E2}-b_1c_1)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (9)$$

$$p_{2APA} = \frac{2a_1(f_2+a_2c_2-b_1c_{E1})+(b_1+b_2)(f_1+a_1c_{E1}-b_2c_2)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (10)$$

These are the optimal collusive prices given the information each firm has. From the announcements, each firm is able to infer the missing piece of information by simply solving equation 10 or 9, respectively, for the costs of the competitor, resulting in the following equations:

$$c_{1inferred} = \frac{(4a_1a_2-2b_1b_2-b_1^2-b_2^2)*(-p_{1APA})+2a_2(f_1-b_2c_{E2})+(b_1+b_2)(f_2+a_2c_{E2})}{b_1b_2-2a_1a_2+b_1^2} \qquad (11)$$

$$c_{2inferred} = \frac{(4a_1a_2-2b_1b_2-b_1^2-b_2^2)*(-p_{2APA})+2a_1(f_2-b_1c_{E1})+(b_1+b_2)(f_1+a_1c_{E1})}{b_1b_2-2a_1a_2+b_2^2} \qquad (12)$$

Given the inferred information on rivals' costs, firms are able to set optimal tacit collusion prices which are equal to the price a monopolist would charge (and thus allow the realization of larger profits than in the absence of advance price announcements).

Whereas joint profits of the firms are never decreasing following the introduction of advance price announcements in this model, the implications for total welfare, which we define as sum of profits and consumer (or buyer) surplus, are less clear-cut. We compare total welfare with and without advance price announcements, calculating consumer surplus as follows:

$$CS = \frac{1}{2} * \left[\left(\frac{f_1+b_1*p_2}{a_1} - p_1\right) * (f_1 - a_1 * p_1 + b_1 * p_2) + \left(\frac{f_2+b_2*p_2}{a_2} - p_1\right) * (f_2 - a_2 * p_2 + b_1 * p_2)\right] \qquad (13)$$

For consumer surplus without advance price announcements, we use p_{1TC} and p_{2TC}, which are the prices resulting from the most profitable equilibrium without information exchange. As shown above, after the information exchange caused by the advance price announcements, firms set $p_{1M}$and p_{2M}.

Since the uncertainty about the rival's cost may induce prices above the monopoly level, consumer surplus may increase or decrease, depending on whether firms actually underestimated or overestimated the costs of their rival. The size of the change in consumer surplus, which is important for the overall welfare implications, crucially depends on the parameters, particularly the strength of the cross-price effects (b_1 and b_2).

In particular, it is noteworthy that if the cross-price effects are equal (b_1=b_2), there is no change in welfare caused by advance price announcements. This is because the optimal prices without information exchange are the same as with knowledge about rival's cost if the cross-price effects are equal:

$$p_{TC1} - p_{M1} = c_2 * a_2 * (b_2 - b_1) + c_{E2} * a_2 * (b_1 - b_2) \qquad (14)$$

$$p_{TC2} - p_{M2} = c_1 * a_1 * (b_1 - b_2) + c_{E1} * a_1 * (b_2 - b_1) \qquad (15)$$

With $b_1 = b_2$, the difference in prices is zero, implying no change in profits, consumer surplus as well as welfare. We are summing up this finding in proposition 2.

Proposition 2: *In a Bertrand duopoly game with differentiated products and asymmetric information on costs, non-binding advance price announcement have no collusive effect if the cross-price effects are equal.*

The general effect of different cross-price effects is illustrated in Figure 1, where we plot the changes in welfare due to advance price announcements in a single period for different values of b_1, whereas all other parameters ($f_1 = f_2 = 60$, $a_1 = a_2 = 2, b_2 = 1$, $c_1 = c_2 = 20$) are fixed. For the expectation each firm has on the rival's costs, we exemplarily consider four cases, namely $c_{E1} = c_{E2} = 30$, $c_{E1} = 30$ and $c_{E2} = 10$, c_{E1}=10 and $c_{E2} = 30$, $c_{E1} = c_{E2} = 10$. The graphs show that if both firms overestimate rival's cost, there is a (weakly) positive welfare effect, whereas the opposite is true if both firms underestimate the rival's costs in a given period. If there is one overestimating firm and one underestimating firm, the welfare effect is positive if the cross-price effect of the overestimating firm is higher.

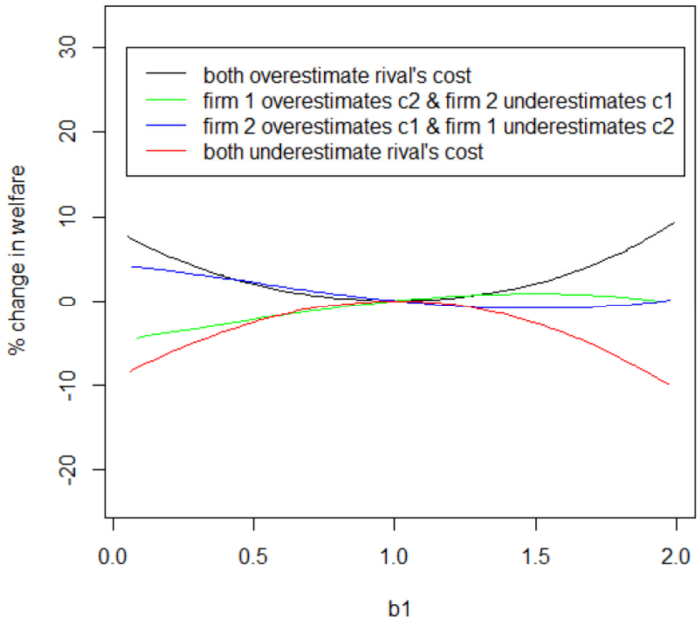

Figure 1: Changes in welfare due to APAs when resolving cost uncertainty

For a game with multiple periods and advance price announcement used in every period, there will be periods with welfare gains and periods with welfare losses, thus the overall welfare implications of such behavior remain unclear.

3.2 Version B: Unknown demand parameter

Instead of the case where firms do not know their rivals' cost, we now turn to a setting in which a demand parameter is unknown. Again, we aim at showing that the introduction of advance price announcements can lead to higher profits for firms, but also investigate whether buyers suffer from such an implicit information exchange. Such a finding would be particularly interesting as Blair and Romano (2001) found in a Bertrand setting with homogeneous products that advance price announcements resolving demand uncertainty have a different impact for buyers compared to advance price announcements resolving cost uncertainty. Differing from their approach, we consider heterogeneous products with firms facing the following demand functions:

$$D_1(p_1) = f_1 - a_1 p_1 + b_1 p_2 + \epsilon_1 \qquad (16)$$

$$D_2(p_2) = f_2 - a_2 p_2 + b_2 p_1 + \epsilon_2 \qquad (17)$$

Firms have some private information on their demand, i.e., firm i observes ϵ_i but not ϵ_j. However, in analogy to the case discussed in Section 3.1., it is common knowledge that ϵ_1 and ϵ_2 each follow a random walk with $\epsilon_{it} = \epsilon_{it-1} + \omega_{it}$ where ω_{it} is an independent and

identically distributed random variable with $E(\omega_{it})$=0 and Var $(\omega_{it}) > 0$. The firms simultaneously set their prices and afterwards demand and profits are realized. The game described so far is repeated infinitely in each period and firms share a common discount factor $\delta < 1$.

Again, we introduce advance price announcements in this game by splitting each period into two stages. In stage 1, firms simultaneously announce their price intentions (which are observed by the competitor and observed, but ignored, by the buyers). In stage 2, firms finally set binding prices which may equal the announcement in stage 1 or any different value. This leads us to our third proposition.

Proposition 3: *In a Bertrand duopoly game with differentiated products and asymmetric information on a demand parameter, firms can achieve joint monopoly profits by introducing non-binding advance price announcements.*

Similarly to the model with unknown costs, there is an equilibrium in which firms first announce the optimal cooperative prices given their information, which the competitor then uses to infer the missing piece of information. The communicated advance price announcements here are:

$$p_{1APA} = \frac{2a_2(f_1+\epsilon_1+a_1c_1-b_2c_2)+(b_1+b_2)(f_2+\epsilon_{2E}+a_2c_2-b_1c_1)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (18)$$

$$p_{2APA} = \frac{2a_1(f_2+\epsilon_2+a_2c_2-b_1c_1)+(b_1+b_2)(f_1+\epsilon_{1E}+a_1c_1-b_2c_2)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \qquad (19)$$

After observing firm 2's announcement p_{2APA}, firm 1 is able to solve equation 16 for ϵ_2 wheras firm 2 is able to solve equation 15 for ϵ_1. This gives:

$$\epsilon_{1inferred} = \frac{(4a_1a_2-2b_1b_2-b_1^2-b_2^2)*(-p_{1APA})+2a_2(f_1+a_1c_1-b_2c_2)+(b_1+b_2)(f_2+\epsilon_{2E}+a_2c_2-b_1c_1)}{-2a_2} \qquad (20)$$

$$\epsilon_{2inferred} = \frac{(4a_1a_2-2b_1b_2-b_1^2-b_2^2)*(-p_{2APA})+2a_1(f_2+a_2c_2-b_1c_1)+(b_1+b_2)(f_1+\epsilon_{1E}+a_1c_1-b_2c_2)}{-2a_2} \qquad (21)$$

Having inferred the actual demand of the competitor, both firms are able to achieve joint monopoly profits. Thus, they perform better (in terms of level of profit) than in the absence of advance price announcements.

As in model version A in Section 3.1, we find that Blair and Romano's (2002) clear result for the case of homogeneous products is not reproducible with differentiated products. Whereas they found that advance price announcement that resolve uncertainty concerning

demand would always hurt buyers, we find mixed evidence. For instance, Figure 2 shows the changes in welfare due to advance price announcements in a single period for different values of b_1, whereas all other parameters ($f_1 = f_2 = 60, a_1 = a_2 = 2, b_2 = 1, c_1 = c_2 = 20, \epsilon_1 = \epsilon_2 = 0$) are fixed. For the expectation each firm has on the rival's demand shock, we exemplarily consider four cases, namely $\epsilon_{1E} = \epsilon_{2E} = 10$, $\epsilon_{1E} = 10$ and $\epsilon_{2E} = -10$, $\epsilon_{1E} = -10$ and $\epsilon_{2E} = 10$, $\epsilon_{1E} = \epsilon_{2E} = -10$. Here, we find that the case of an overestimation of both firms tends to make advance price announcement beneficial from a welfare perspective, whereas in case of an underestimation, the opposite is true. In case of equally strong opposing misperceptions, the effect of the firm with the higher cross-price effect dominates. For a game with multiple periods and advance price announcement used in every period, there will be periods with welfare gains and periods with welfare losses, thus the overall welfare implications remain unclear.

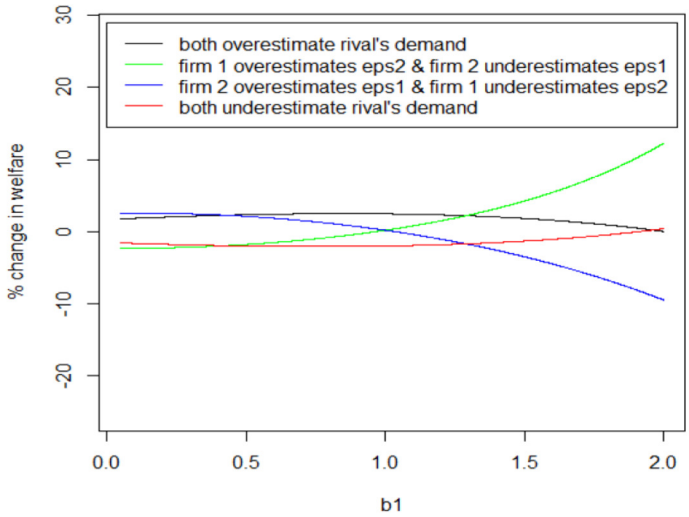

Figure 2: Changes in welfare due to APAs when resolving demand uncertainty (varying b1)

Furthermore, it is important to note that the result from Section 3.1 – which stated that advance price announcements do not have any collusive effect if the cross-price effects are equal (b1=b2) – does not hold here. This is clearly shown in Figure 3 below which plots the welfare changes for different a1 with b1=1 and all other parameters as above. Here, one can see that the positive welfare impact is increasing in a_1 when firm 2 overestimates the costs of firm 1, whereas it is decreasing in a_1 when firm 2 underestimates the costs of firm 1.

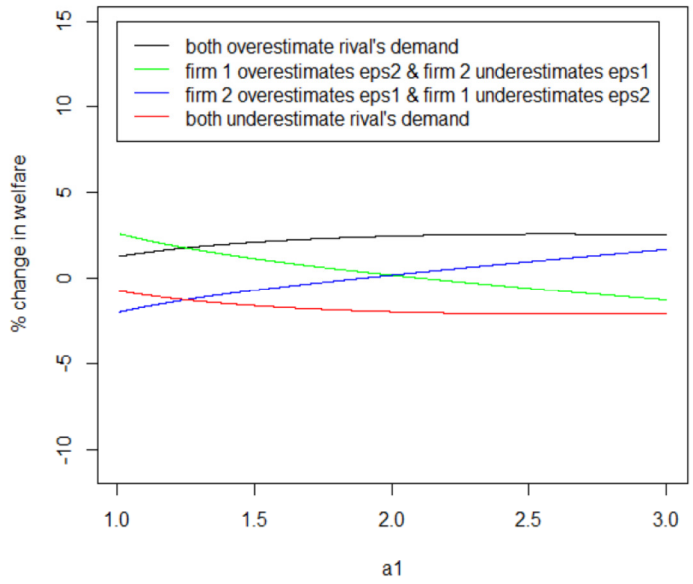

Figure 3: Changes in welfare due to APAs when resolving demand uncertainty (varying a1)

3.3 Version C: More than one missing piece of information

In Sections 3.1 and 3.2, we discussed settings in which firms were not informed about exactly one piece of information of their competitor. In this section, we relax this assumption and allow for the more realistic possibility that more than one piece of information is missing. This causes a challenge for the firms as they can still only provide one announcement, however, they need to recover more than one piece of information. Obviously, extracting full information is now impossible, however, we will show that with two missing pieces of information, firms can still achieve strictly higher profits with the information won from the announcement than they would have been able to earn without the (imperfect) exchange of information. In principle, our finding also holds for more than two missing pieces of information.

Again, we consider the market characterized in Section 3.2 above with demand given as

$$D_1(p_1) = f_1 - a_1 p_1 + b_1 p_2 + \epsilon_1 \qquad (22)$$

$$D_2(p_2) = f_2 - a_2 p_2 + b_2 p_1 + \epsilon_2 \qquad (23)$$

However, we now assume that not only ϵ_j is unknown to firm i but c_j as well. The game is again repeated infinitely in each period and firms share a common discount factor $\delta < 1$. Over time, costs and demand are fluctuating, which we model analogously to Sections 3.1 and

3.2 as random walks. Firms observe c_j and ϵ_j from the last period and take those values as expectation for the current period.

At this point, we consider the situation in which still only one advance price announcement can be made at the first stage of every period, whereas firms still set final prices at the second stage of each period. In contrast to Sections 3.1 and 3.2, firms now cannot fully decipher the signal send by the advance price announcement (although we continue to assume that the advance price announcement depicts the optimal tacit collusion price given the information of the competitor). However, from the given advance price announcements

$$p_{1APA} = \frac{2a_2(f_1+\epsilon_1+a_1c_1-b_2c_{2E})+(b_1+b_2)(f_2+\epsilon_{2E}+a_2c_{2E}-b_1c_1)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \quad (24)$$

$$p_{2APA} = \frac{2a_1(f_2+\epsilon_2+a_2c_2-b_1c_{1E})+(b_1+b_2)(f_1+\epsilon_{1E}+a_1c_{1E}-b_2c_2)}{4a_1a_2-2b_1b_2-b_1^2-b_2^2} \quad (25)$$

firm 1 can identify a subset of possible ϵ_j and c_j that would be in line with the advance price announcement, assuming that both firms still stick to the strategy of announcing the optimal cooperative price given their information.

Usually, both firms will find that the competitor's announcement differs from the value they would expect given the information from the previous period. Without having any indication whether the change results entirely from a change in demand, entirely from a change in cost or any combination, this does not provide full information. However, the firms can improve their situation by adjusting their price in the direction that the advance price announcement indicates, calculating the optimal price (assuming that all possible changes are equally likely). Sometimes, they will do worse compared to using the prices they would have used in the absence of advance price announcements; however, on average, firms will guess better than without the additional piece of information and will thus earn higher profits.[22]

Whereas firms would, at least in expectation, benefit from introducing advance price announcements, the welfare effects of such announcements in a setting with two unknown pieces of information are unclear thereby suggesting the implementation of simulations. However, before we turn to a discussion of our simulation approach and results, it is important to remark, first, that – in the previous subsections – we were able to demonstrate that firms can increase their profits with non-binding advance price announcements in situations in which a cooperative equilibrium is viable but profits are restricted due to

[22] The idea is generally similar to a problem in which a player should guess two (independently and identically distributed) integers between 0 and 100, X and Y, minimizing his error. Getting an additional piece of information (e. g., X+Y=Z) would not always improve the optimal guess, but on average.

asymmetric information. It should be noted, however, that for a large range of parameters, there is a relatively large gap between monopoly profits and profits under Bertrand competition, however, a comparatively small gap between profits in the cooperative equilibrium under asymmetric information and monopoly profits.

Second, the benefits for buyers – i.e. the efficiencies created by non-binding advance price announcements – in our model are caused by the phenomenon that firms may price above the monopoly price under full information when they face uncertainty (and assume a scenario which is better than reality). By using advance price announcements, the uncertainty is reduced or resolved and firms learn that a price decrease might be Pareto efficient because both their profits and buyer's surplus would increase.

3.4 Simulations

Due to the ambiguity of the welfare effects in all three cases investigated in the previous sections, simulations are an appropriate method to identify which effects dominate for large parameter ranges. In our case, each simulation includes a number of N games, where each game consists of n periods. At the beginning of each game, the parameters f_1, f_2, a_1, a_2, b_1 and b_2 were drawn from a uniform distribution (over the interval given in the respective Tables 1 to 3 in the Appendix) and then remained constant. Initial c_1 and c_2 values were also drawn at the beginning from the given interval and then evolved as random walk with a maximum per period change Δc. In the model of Section 3.2, Δc is 0. For Section 3.2 and 3.3, we also draw initial ε_1 and ε_2, which then evolved as a random walk with a maximum change of $\Delta\varepsilon$ per period.

In the model of Section 3.3, the firms calculate which ε_j and which c_j would make sense given that the change indicated by the observed advance price announcement originates only from a change in costs or only from a change in demand and then take the average of the two possibilities in order to calculate their final price. We report the frequency of games where a positive change in welfare was induced by the introduction of advance price announcements. The change in welfare, ΔWF, is defined as the difference between the sum of profits and buyer's surplus in the scenario with advance price announcements minus the sum of profits and buyer's surplus in the scenario with tacit collusion without advance price announcements. For the model of Section 3.3, we also report the frequency of increasing firm profits, where the change in the firm profits, $\Delta\pi$, is the change in aggregate firm profits between the two scenarios. $\Delta\pi$ is always positive in the models with only one unknown parameter, i.e. firms are gaining by using advance price announcements.

The results of our simulation exercises are presented in Tables 1, 2 and 3 in the Appendix referring to the models in Sections 3.1, 3.2 and 3.3, respectively. The simulations support our claim that firms on average benefit from the use of advance price announcements, while the impact on consumer welfare is ambiguous. In fact, the simulation results suggest that the likelihood for a positive welfare effect is (slightly) higher if advance price announcements resolve cost uncertainty rather than demand uncertainty. The total welfare loss or gain in all simulations is found to be rather small, indicating that the possibility to use the exchanged information for more efficient tacit collusion is causing a rather small total effect on welfare.

3.5 Possible model extensions

Although our model approach is able to incorporate several important features of advance price announcements, we have identified several areas for model extensions as part of future research. First, from an efficiency point of view, one of the most intuitive advantages of advance price announcements is the creation of possibilities for (efficient) intertemporal substitution. For instance, consider a firm that produces a product facing marginal costs of 60 in period 1 and marginal costs of 30 in period 2. A buyer has a willingness to pay of 100 and marginally prefers to buy in period 1 rather than in period 2. The buyer does not observe costs and assumes constant prices in the absence of price announcements. Thus, he or she would buy in period 1 at price 100, with surplus equal to 0 and firm's profit of 40. However, if the firm credibly announces to decrease its price and finally sets it to 90 in period 2, the buyer would buy in period 2, earning a surplus of 10 and the firm's profit rising to 60. Thus, the situation with an advance price announcement would provide a Pareto improvement compared to a scenario where advance price announcements are prohibited.

Second, we did not incorporate any customer gain from an improved planning ability (due to the difficulty in quantifying these gains). However, there are certainly industries in which a decent degree of planning reliability is so important to the purchasers that they might even be the side demanding the introduction of advance price announcements[23].

Generally, incorporating those two aspects would strengthen the efficiency-increasing effect of non-binding advance price announcements possibly leading to a positive net effect on welfare. Given the fact that the detrimental effects on welfare found in our baseline model (neglecting the potential efficiency-increasing effects) were rather modest, it seems likely that non-binding advance price announcements would be socially desirable if they either induce

[23] The wood pulp case mentioned in Section 2.2 above is one example.

sufficient buyer reactions or buyers indicate a high preference for a reduction in planning uncertainty.

Adequate buyer reactions are likely to emerge if the non-binding advance price announcements are sufficiently credible. Although plenty of equilibrium constellations are generally possible, an example would be buyers with low waiting costs who have an incentive to use intertemporal arbitrage possibilities based on a non-binding announcement (if firms usually stick to the direction they announced).

An important caveat against the presumption that non-advance price announcements are welfare-enhancing is that they might actually be a necessary tool to sustaining tacit collusion. We assumed throughout the paper that firms would be able to achieve some degree of tacit collusion even in the absence of advance price announcements. Considering, for instance, that advance price announcements might also allow exchanging information on the (possibly heterogeneous) discount factor, it should be kept in mind that the existence of these announcements could actually be the key to achieve tacit collusion if firms were not able to do so before.

Last but not least, future research might consider multiple advance price announcements, as with each additional round the likelihood of purely collusive reasons can be expected to increase quickly whereas a possible efficiency gain created by the respective information is likely to shrink.

4 Conclusion

Given the increasing efforts by competition authorities around the world to detect and subsequently punish hardcore price-fixing agreements, second-best strategies associated with tacit collusion may become attractive to firms seeking to chill competition. While firms might find it difficult to implement and monitor such implicit agreements, competition authorities face the problem that – in contrast to hard-core cartels – most forms of communication between firms are not necessarily welfare-decreasing, but may well be in the interest of buyers.

In this paper, we have studied the welfare effects of one particular form of communication: non-binding advance price announcements. Applying a differentiated Bertrand model with horizontal products and asymmetric information, we showed that firms generally have an incentive to use such advance price announcements in order to exchange information: such information exchange assist them in coordinating on a jointly more profitable equilibrium than would be possible without this strategy.

While non-binding advance price announcements may facilitate collusion, our modelling and simulation results suggest that buyers can profit from coordination through (non-binding) advance price announcements – even under the conservative (efficiency-related) assumption that such announcements only avoid cases in which firms (operating under uncertainty) accidentally price above the monopoly price. More generally, our results support the competition policy approach to these announcements possibly even including a safe harbor provision – as soon as it is sufficiently likely that the (additional) procompetitive effects outweigh the potential negative effects in the form of elevated price levels. In addition to the presence of general industry and market characteristics that affect the likelihood of collusion – such as, for example, the number of firms or characteristics of the respective product – situations in which procompetitive motives dominate are more likely to be present if, first, the announcements are public and reach many buyers; second, buyers are able (and willing) to shift demand over time and; third, buyers demand advance knowledge of prices for planning purposes.

References

Athey, S. and K. Bagwell (2008), Collusion with Persistent Cost Shocks, Econometrica 76, 493-540.

Athey, S. and K. Bagwell (2001), Optimal Collusion with Private Information, RAND Journal of Economics 32, 428-465.

Bennett, M. and P. Collins (2010), The Law and Economics of Information Sharing: The Good, The Bad and The Ugly, European Competition Journal 6, 311-337.

Blair, R. and R. Romano (2001), Advance Price Announcements and Antitrust Policy, International Review of Law and Economics 21, 435-452.

Borenstein, S. (1999), Rapid Price Communication and Coordination: The Airline Tariff Publishing Case (1994). In J.E. Kwoka and L.J. White, eds. The Antitrust Revolution (3rd ed.). Oxford: Oxford University Press.

Capobianco, A. (2004), Information Exchange under EC Competition Law, Common Market Law Review 41, 1247-1276.

Compte, O. (1998), Communication in Repeated Games with Private Monitoring, Econometrica 66, 597-626.

Cooper, D. and K.-U. Kühn (2014), Communication, Renegotiation, and the Scope of Collusion, American Economic Journal: Microeconomics 6, 247-278.

European Commission (2011), Guidelines on the Applicability of Article 101 of the Treaty on the Functioning of the European Union to Horizontal Co-operation Agreements, Brussels.

Farrell, J. (1987), Cheap Talk, Coordination and Entry, RAND Journal of Economics 18, 34-39.

Farrell, J. and M. Rabin (1996), Cheap Talk, Journal of Economic Perspectives 10, 103-118.

Friedman, J. (1967), An Experimental Study of Cooperative Duopoly, Econometrica 35, 379-397.

Hall, M. (2014), To Whom Are You Announcing? EU Authorities Focus on Price Signaling, "Hot Topics" in International Antitrust Law, American Bar Association, Section of International Law, International Antitrust Law Committee, May 2014.

Harrington, J. (2012), A Theory of Tacit Collusion, Working Paper, Johns Hopkins University, Baltimore.

Harrington, J., Hernan-Gonzalez, R. and P. Kujal (2013), The Relative Efficacy of Price Announcements and Express Communication for Collusion: Experimental Findings, Working Paper, University of Pennsylvania, Philadelphia.

Holt, C. and D. Davis (1990), The Effects of Non-Binding Price Announcements on Posted-Offer Markets, Economics Letters 34, 307-310.

Kandori, M. and H. Matsushima (1998), Private Observation, Communication and Collusion, Econometrica 66, 627-652.

Kaplow, L. and C. Shapiro (2007), Antitrust, in: M. Polinsky and S. Shavell, Handbook of Law and Economics, Volume 2, Amsterdam, 1073-1225.

Kühn, K.-U. (2001), Fighting Collusion – Regulation of Communication Between Firms, Economic Policy 16, 167-204.

MacLeod, W. (1985), A Theory of Conscious Parallelism, European Economic Review 27, 25-44.

Marshall, R., L. Marx and M. Raiff (2008), Cartel Price Announcements: The Vitamins Industry, International Journal of Industrial Organization 26, 762-802.

Miller, A. (2010), Did the Airline Tariff Publishing Case Reduce Collusion?, Journal of Law and Economics 53, 569-586.

Motta, M. (2004), Competition Policy – Theory and Practice, Cambridge University Press.

Mouraviev, I. and P. Rey (2011), Collusion and Leadership, International Journal of Industrial Organization 29, 705-717.

OECD (2012), Unilateral Disclosure of Information with Anticompetitive Effects – United States, DAF/COMP/WP3/WD(2012)14, Paris.

OECD (2010), Roundtable on Information Exchanges Between Competitors under Competition Law – Note by the Delegation of the United States, DAF/COMP/WD(2010)117.

Rotemberg, J. and G. Saloner (1990), Collusive Price Leadership, Journal of Industrial Economics 39, 93-110.

Schelling, T. (1960), The Strategy of Conflict, Cambridge.

Scherer, F. (1967), Focal Point Pricing and Conscious Parallelism, Antitrust Bulletin 12, 495-503.

Shearman & Sterling (2014), Beware of Public Announcements! Recent European Competition Developments on Price Signalling, Client Publication, 24 March 2014, Brussels.

Siciliani, P. (2014), Should We Act *ex post* Against Tacit Collusion – and How?, Journal of European Competition Law and Practice 5, 294-303.

Appendix

Table 1: Simulation results for model with uncertain costs

N	n	f_1	f_2	a_1	a_2	b_1	b_2	c_1	c_2	Δc	ΔWF>0
10^7	20	[80,120]	[80,120]	[2,6]	[2,6]	[0,2]	[0,2]	[20,40]	[20,40]	1	52,0%
10^7	20	60	60	2	2	[0,1.99]	1	20	20	1	52,6%
10^7	20	60	60	2	2	0.5	1	20	20	1	53,3%
10^7	20	60	60	2	2	1.9	1	20	20	1	51,0%
10^7	20	60	60	3	2	[0,1.99]	1	20	20	1	53,1%
10^7	25	600	600	2	2	[0,1.99]	1	100	100	2	50,2%
10^7	50	600	600	2	2	[0,1.99]	1	100	100	2	50,3%

Table 2: Simulation results for model with uncertain demand

N	n	f_1	f_2	a_1	a_2	b_1	b_2	c_1	c_2	ε_1	ε_2	$\Delta\varepsilon$	$\Delta WF>0$
10^7	20	[80,120]	[80,120]	[2,6]	[2,6]	[0,2]	[0,2]	[0,20]	[0,20]	[0,20]	[0,20]	2	49,3%
10^7	20	60	60	2	2	[0,1.99]	1	20	20	0	0	2	49,0%
10^7	20	60	60	2	2	0.2	1	20	20	0	0	2	50,4%
10^7	20	60	60	2	2	1.9	1	20	20	0	0	2	50,4%
10^7	20	60	60	2	2	0.9	1	20	20	0	0	2	45,7%
10^7	20	60	60	3	2	[0,1.99]	1	20	20	0	0	2	49,0%
10^7	20	60	60	1	2	[0,1.99]	1	20	20	0	0	2	49,2%
10^7	20	60	60	2	2	[0,1.99]	1	40	20	0	0	2	49,7%
10^7	20	120	60	2	2	[0,1.99]	1	20	20	0	0	2	49,3%
10^7	20	120	60	2	2	[0,1.99]	1	40	20	0	0	2	49,2%
10^7	20	120	60	2	2	[0,1.99]	1	20	40	0	0	2	49,9%

Table 3: Simulation results for model with uncertain demand and uncertain costs

N	n	f_1	f_2	a_1	a_2	b_1	b_2	c_1	c_2	Δc	ε_1	ε_2	$\Delta\varepsilon$	$\Delta\pi > 0$	$\Delta WF>0$
10^6	45	[90,360]	[90,360]	[2,3]	[2,3]	[0,2]	[0,2]	[50,90]	[50,90]	1	[0,30]	[0,30]	1	98,1%	48,0%
10^6	60	180	180	2	2	1	0.5	60	60	1	0	0	1	98,2%	48,3%
10^6	60	180	180	2	2	1	1	60	60	1	0	0	1	93,6%	41,8%
10^6	30	180	180	2	2	1	0.5	60	60	1	0	0	1	92,9%	48,8%
10^6	30	360	180	2	2	1	0.5	60	60	1	0	0	1	92,9%	49,7%
10^6	30	180	360	2	2	1	0.5	60	60	1	0	0	1	93,0%	48,0%