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Mergers, concurrent marketing mechanisms and the performance of sequential auctions

Mohamed Jeddy

Fisheries and Oceans Canada and CREATE Université Laval, Quebec, QC, Canada

Bruno Larue

CREATE, Université Laval, Québec, QC, Canada

Bruno.larue@eac.ulaval.ca

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Abstract. We analyze the effects of mergers and the introduction of concurrent marketing mechanisms on the seller's revenue, price trend and efficiency in sequential auctions under complete information with asymmetric bidders. First, we provide conditions for bidders to be strategic when the number of objects is less or greater than the number of bidders as this impacts upon the set of possible mergers. Second, we show that mergers may simultaneously increase the seller's revenue and improve efficiency. Third, we show that having a marketing mechanism working alongside the auction can increase or decrease the average auction price. We use weekly data about Quebec's daily hog auction to ascertain the effects of a merger and of changes in the weights of concurrent marketing mechanisms on daily auction prices. Our empirical analysis relies on an endogenous structural change test which detected three breaks corresponding to: i) the introduction of a new concurrent mechanism, ii) a joint-venture partnership of the two largest hog processing firms and iii) an announcement by Canada's Competition Bureau authorizing the full merger of the same two firms.

Fusions, mécanismes de mise en marchés concomittant et la performance des enchères séquentielles

Résumé : Nous analysons les effets des fusions sur l'introduction de mécanismes de mise en marché concomittant sur le revenu du vendeur, la tendance des prix et l'efficacité de l'enchère séquentielles en information complète en présence d'enchérisseurs asymétriques. Dans un premier temps, nous dérivons des conditions pour départager les enchérisseurs dits stratégiques des non-stratégiques lorsque le nombre d'objets est plus bas ou plus élevé que le nombre d'enchérisseurs. Deuxièmement, nous montrons qu'une fusion d'entreprises/d'enchérisseurs peut accroître le revenu du vendeur et l'efficacité de l'enchère. Troisièmement, nous montrons que la présence d'un mécanisme de mise en marché utilisé en même temps que l'enchère peut faire augmenter ou baisser le prix moyen généré par l'enchère. Nous utilisons des données hebdomadaires sur l'encan électronique du porc au Québec pour évaluer les effets d'une fusion entre deux entreprises et les effets des variations dans l'importance donnée à divers mécanismes de mise en marché. Notre analyse empirique a détecté trois changements structurels coïncidant avec i) l'introduction d'un nouveau mécanisme de mise en marché, ii) un partenariat entre les deux plus gros entreprises de transformation et iii) l'annonce par le bureau de la concurrence autorisant la fusion complète des mêmes entreprises.

Keywords: Multi-unit sequential auctions; mergers; concurrent marketing mechanisms; endogenous structural changes.

Mots-clés: Enchères à demandes multi-unitaires séquentielles, fusions, mécanismes de mise en marché, changement structurel endogène.

JEL Classification: D4; L7.

1. Introduction

Mergers have inspired a vast and rich literature in industrial organisation. A perennial concern of competition regulations with mergers is their effects on prices and welfare. Farrell and Shapiro (1990) warned that mergers involving firms with combined pre-merger market shares exceeding 50% are likely to reduce welfare, but Heubeck et al. (2006) argue that such misgivings might be unwarranted even in the absence of direct cost efficiencies. The profitability of horizontal mergers has attracted much attention ever since the seminal paper of Salant et al. (1983). In one example (Salant et al., 1983, p.159), they showed that mergers between Cournot oligopolists producing a homogenous good with identical linear cost functions and facing a linear demand curve are unprofitable unless the proposed merger brings together at least 80% of the firms in the industry. The same result holds under Stackelberg competition (Daughety, 1990), but Deneckere and Davidson (1985) show that mergers are always profitable for the merging firms under Bertrand competition because prices are strategic complements. In the aforementioned studies, a merged firm is modeled as a multiplant fully integrated firm. However, Huck et al. (2004) allow for more decentralized organizational structure and show that bilateral mergers can be profitable and welfare-improving in linear markets.

The analysis of the impact of mergers on prices, allocation efficiency and the seller's revenue is also of great interest in the literature on auctions. Waehrer and Perry (2003) found that mergers are profitable and anti-competitive as they increase the expected price in second-price procurement auctions when the cost parameter of bidding firms are drawn from the same type of distributions. Tschantz, Crooke and Froeb (2000) relied on a three-firm numerical example to show that a merger between two identical bidders has a larger (smaller) price effect when the merging firms are larger (smaller) than the third firm.

Thomas (2004) shows that mergers may decrease the expected price in one-shot procurement first-price auctions. The above studies assume that bidders are incompletely informed and have single unit-demands.

Mergers have not been analyzed under the complete information framework even though it is most suitable in the context of frequently repeated auctions involving the same bidders endowed with precise information about each other's costs, capacity and market opportunities (e.g., Bernheim and Whinston, 1986, Gale et al., 2000). Our analysis fills this gap in the literature on multi-unit demand sequential auctions under complete information pioneered by Krishna (1999) and Katzman (1999) by considering auctions involving several asymmetric bidders with diminishing marginal valuations over several objects.

It is often assumed in single-unit private value auctions that the valuation of a merged firm is the maximum of its members' valuations. This implies that the merged firm wins the auction that any of its pre-merger components would have won (e.g., Baker, 1997). The allocation efficiency is maintained because the object is still won by the bidder with the highest valuation, but the expected price is lower because of the impact of the smaller number of bidders on the probability of winning. In a sequential multi-unit demand auction under complete information, we show that the higher payoff of the merged bidder need not be at the seller's expense. If the pre-merger allocation is inefficient, a merger can produce an efficient allocation and increase the seller's revenue.

Most studies about marketing mechanisms tend to compare one mechanism against another, like two different types of auctions, or auctions versus contracts as in Bulow and Klemperer's (1996) classic paper. However, little is known about the performance of a

given marketing mechanism when a different marketing mechanism is being used concurrently. The Quebec hog industry experimented with different mixes of marketing mechanisms.¹ Between 1989 and 1994, all of the hogs were sold through a daily electronic auction. Between 1994 and 2000, no less than 72% of the provincial hog supply was “formula-priced” in relation to a U.S. price, and “pre-attributed” to individual processors based on historical market shares. The remaining hogs were sold on the daily electronic auction. In 2000, a third mechanism was added as one-month supplies were being auctioned. Table 1 illustrates the relative importance of each marketing mechanism over time during what looks like a controlled experiment. We demonstrate that the presence of a pre-attribution scheme, as in the Quebec hog industry, may increase or decrease the average price generated by the sequential auction and may impact on price trends and allocation efficiency. This theoretical ambiguity justifies the subsequent empirical analysis.

We use weekly data about Quebec’s daily hog auction between 1996:1 and 2006:52 to ascertain the effects of a merger and of changes in the weights of concurrent marketing mechanisms on auction prices given that there are a large number of events that could have induced structural changes. We rely on a flexible endogenous structural change test which detected three break dates corresponding to: i) the introduction of a new

¹ Quebec’s daily electronic hog auction had specific features that rationalize a complete information framework. First, the number of bidders (processors) was small (seven) and these bidders competed in the same domestic and foreign output markets with fixed production capacities. Thus, it is likely that they know about each other’s costs and output prices. Secondly, the Quebec federation of hog producers became an official marketing board in the 1980s and as such had exclusive rights about the marketing of all of the hogs produced in the province of Quebec. Because it chose to set up a daily electronic hog auction in 1989, as opposed to directly negotiate prices with processors, signals that it was poorly informed. Thirdly, to mitigate quality uncertainty, prices were determined for lots of virtual hogs scoring 100 on a quality index. Prices of delivered hogs scoring higher or lower than 100 were automatically adjusted through a grid of discounts and premia negotiated on a regular basis with processors.

mechanism (i.e., an auction of monthly supplies), ii) a joint-venture partnership of the two largest hog processing, and iii) an announcement by Canada's Competition Bureau authorizing the full merger of the same two firms. We compared the prices predicted by the different regimes and found significant differences. Prices increased after the introduction of the third mechanism, but decreased after the partnership and eventual merger between the two largest processors.

This paper is structured as follows. The next section provides conditions when bidders can be strategic as well as when a merger can take place. The concept of strategic bidder matters for our analysis of the effects of mergers on price trend, efficiency and seller's revenue. The third section focusses on how the presence of a concurrent pre-attribution mechanism impacts on the performance of the auction. The fourth section features an empirical analysis of the prices generated on the Quebec hog auction. Conclusions and policy implications are presented in the last section.

2. Mergers, efficiency and seller's revenue

In this section, we derive necessary conditions for a merger to take place and investigate the implications of mergers on the seller's revenue, price trend and efficiency in sequential auctions. As in Krishna (1999), we begin with a simple example of a second-price sequential auction under complete information to present definitions and concepts to be used in our analysis of mergers.

Consider a sequence of two second-price auctions with three asymmetric individual bidders (A, B and C) with diminishing marginal valuations.² The seller is non-strategic and

² Dalkir et al. (2000) and Thomas (2011) argue that inappropriately using a symmetric model may severely overstate a horizontal merger's price effect. However, our analysis of sequential second-

incompletely informed. We denote by V_j^i bidder j 's i^{th} highest valuation. The valuations are ranked as follows: $V_A^1 = 10 > V_B^1 = 8 > V_A^2 = 7 > V_C^1 = 6 > V_B^2 = 5 > V_C^2 = 3$. The strategic behaviour of bidders in second-price multi-unit sequential auctions under complete information is well-documented in the literature (e.g., Krishna, 1993, 1999; Katzman, 1999; Gale and Stegeman, 2001; Jeddy et al., 2010 and Jeddy and Larue, 2012). Each bidder is assumed to follow the weakly dominant strategy of sincere bidding in the last round. It is a weakly dominant strategy for each bidder to place a bid so as to be indifferent between winning and losing the first round object.

The outcome tree of the game is illustrated in Figure 1. Arrows denote the allocation in each subgame and prices are given next to the paths at the various nodes of the tree. At each node, the bidders' gross payoffs are put in parentheses. Each unit could be won by either bidder A (left branch), bidder B (middle branch) or bidder C (right branch). The equilibrium outcome is solved by backward induction and bids reflect the opportunity cost of not winning. The outcome tree, unlike the extensive form tree, features net payoffs at every node which are obtained through subgame replacement. At nodes associated to the j^{th} object, net payoffs are defined as the sum of valuations for objects won along the given path minus the sum of prices for objects that would be won among the last $n-j+1$ objects. For the last object, gross payoffs are the sum of the valuations.

Starting at the bottom of the tree in Figure 1, we can see that the vector of gross payoffs when bidder A wins both objects is (17; 0; 0), which is simply the sum of the valuations for the objects won by the bidders. Provided the first object is won by bidder A,

price auctions under complete information involving pre merger and post merger asymmetric bidders with multi-unit demands is primarily motivated by the structure of the Quebec hog processing sector.

the second object may be won by bidder A, bidder B or bidder C. In these cases, the vectors of net payoffs are $(17; 0; 0)$; $(10; 8; 0)$ and $(10; 0; 6)$, respectively. It follows that at node N_1 , the second object is worth at most 7 ($17 - 10 = 7$) for bidder A, at most 8 ($8 - 0 = 8$) for bidder B and at most 6 ($6 - 0 = 6$) for bidder C. If the game was to reach node N_1 , the second object would be won by bidder B at price 7. Therefore, the net payoff at this node is $(10; 8 - p_2; 0) = (10; 1; 0)$.

The same reasoning could be used at nodes N_2 and N_3 . The vectors of net payoffs at these nodes are respectively $(4; 8; 0)$ and $(2; 0; 6)$. At N_0 , it is a dominant strategy for bidder C to bid up to 6 to prevent the other bidders from acquiring the first object. Because bidders A and B know that bidder C's bid will be 6, bidder A bids 6 and bidder B bids 7. Bidder B wins the first object and pays 6. Consequently, the seller's revenue is equal to $R^S = 6 + 6 = 12$ and the bidders' payoffs are given by: $\pi^A = (10 - 6) = 4$, $\pi^B = (8 - 6) = 2$ and $\pi^C = 0$. The price trend is constant, $p_1 = p_2 = 6$, and the allocation is efficient since the objects end up in the hands of the bidders with the highest valuations. The above example is interesting because even though bidder C has not won an object, his presence matters because equilibrium prices are equal to his highest valuation. However, unlike when bidders have independent private valuations and the addition of bidders increase the likelihood of high-valuation bidders, the addition of bidders in a complete information setting may not have any impact on prices.³

³ Consider the 4-bidder single object auction under complete information with $V_A^1 > V_B^1 > V_C^1 > V_D^1$. In this second-price auction, bidder A wins and pays $p = V_B^1$ and bidders C and D are irrelevant.

Definition 1: In auctions of n objects involving k bidders with valuations for the first object $V_A^1 > V_B^1 > \dots > V_K^1$, a player i is strategic if its highest valuation V_i^1 is one of the two largest valuations in at least one the k^{n-1} nodes where the allocation of the last object is done in the outcome tree. The top two valuations in each of the k^{n-1} comparisons are said strategic, as they do impact on the allocation and price sequence determination. The lowest strategic valuation is called the residual strategic valuation.

Discussion: From the bottom nodes of the outcome tree, we are pitting the valuation of each bidder for the last object at each of the k^{n-1} paths allocating the first $n-1$ objects. To be strategic, a player's highest valuation must be in the top two in at least one of the k^{n-1} comparisons. For example, in a 5-bidder 2-object auction where each bidder i has valuations $V_i^1 > V_i^2$ for the first and second objects, we have:

- (i) $V_A^2 \text{ vs } V_B^1 \text{ vs } V_C^1 \text{ vs } V_D^1 \text{ vs } V_E^1$; (ii) $V_B^2 \text{ vs } V_A^1 \text{ vs } V_C^1 \text{ vs } V_D^1 \text{ vs } V_E^1$; (iii) $V_C^2 \text{ vs } V_A^1 \text{ vs } V_B^1 \text{ vs } V_D^1 \text{ vs } V_E^1$;
 (iv) $V_D^2 \text{ vs } V_A^1 \text{ vs } V_B^1 \text{ vs } V_C^1 \text{ vs } V_E^1$ and (v) $V_E^2 \text{ vs } V_A^1 \text{ vs } V_B^1 \text{ vs } V_C^1 \text{ vs } V_D^1$.

From $V_A^1 > V_B^1 > \dots > V_K^1$ and from iii)-v), we know that V_A^1 and V_B^1 are strategic. From ii), we have that either V_A^1 and V_B^2 are strategic or either V_A^1 and V_C^1 are. Finally, from i) either V_A^2 and V_B^1 are strategic or V_B^1 and V_C^1 are. Intuitively, we know that bidder A is strategic because V_A^1 is the highest valuation. However, the second highest valuation is either V_A^2 or V_B^1 . From iii) we know that bidder B is strategic because $V_B^1 > \max(V_C^2, V_D^1) > V_E^1$. We know that bidders D and E cannot be strategic from i) to v). However, bidder C may or may not be

strategic and V_C^1 may-- or may not be the residual strategic valuation.⁴ The latter case occurs when $V_C^1 < \min(V_A^2, V_B^2)$. Clearly, increasing the number of objects tends to increase the number of strategic players. If 3 objects were auctioned, and that the valuation of player i for a third object is V_i^3 , then bidder C could be strategic under the following condition: $V_C^1 > \min(V_A^3, V_B^3)$. This condition is less restrictive than $V_C^1 > \min(V_A^2, V_B^2)$ for the two-object case. The implication of the above definition is that the analysis of auctions can be simplified by taking into account only the strategic bidders.

Lemma 1: *The price of the last object is bounded from below by the residual strategic valuation.*

Proof: The equilibrium path on the outcome tree auction may or may not include nodes involving the residual valuation. When it does not, the price of the last object is higher than the residual valuation. To see this, consider an auction with 5 bidders and 2 objects such that $V_A^1 > V_A^2 > V_B^1 > V_C^1 > V_D^1 > V_E^1$. Bidder A has the two highest valuations and must decide whether his payoff is maximized with one or two objects, knowing that if he wins only one object, the other object will be won by bidder B. Thus, the parts of the outcome tree with the first object going to bidders C, D and E are irrelevant and we can focus on the branches for which the first object is attributed to bidder A or bidder B. When bidder A lets bidder B win the first object, the residual valuation is $\max(V_B^2, V_C^1)$. If $V_A^2 + \max(V_B^2, V_C^1) > 2V_B^1$ then $p_1 = p_2 = V_B^1 > V_B^2$ and bidder A wins both objects, but if

⁴ From i) and ii), bidder C being strategic can be supported by the following sequences of valuations: $V_A^1 > V_B^1 > V_B^2 > V_C^1$, $V_A^1 > V_A^2 > V_B^1 > V_C^1$ and $V_A^1 > V_B^1 > V_C^1$.

$V_A^2 + \max(V_B^2, V_C^1) < 2V_B^1$, then bidder B (A) wins the first (second) object and

$p_1 = V_A^2 + \max(V_B^2, V_C^1) - V_B^1 > \max(V_B^2, V_C^1) = p_2$, which is similar to the 2x2 example in

Katzman's (1999, p.81). **QED**

Proposition 1: *In complete information sequential second-price auctions with n objects and k bidders such that $n < k$, with bidders with declining valuations, $V_j^1 > V_j^2 \dots > V_j^n$ where V_j^i is bidder j 's i^{th} highest valuation, and without loss of generality, $V_A^1 > V_B^1 > \dots > V_K^1$, then bidder j is strategic if and only if its highest valuation is among the $(n+2)$ highest valuations.*

Proof: Going back to the proof of lemma 1 where bidder A has the n highest valuations and

acts as a monopsonist, the residual valuation is the $(n+2)^{\text{th}}$ highest valuation, whether it

belongs to bidder B or bidder C. Bidder C is strategic only when V_C^1 is the residual valuation.

The result holds for other patterns of valuations. Let us derive the condition for bidder K to

be strategic assuming that $n=k-1$ and that V_{K-1}^1 is the n^{th} highest valuation. This implies that

objects are broadly allocated. For bidder K to be strategic, V_K^1 must be the residual strategic

valuation or better. For this to happen it must be the highest or second highest valuation when

the last object is being allocated at one or more of the bottom k^{n-1} nodes in the outcome

tree. Thus, V_K^1 matters at nodes where it competes with no more than one $V_j^1, j < k$. As a

result, the other competing $k-2$ valuations must be the at most second highest valuations

for the other $k-2$ bidders and it must be that $V_k^1 > V_l^i \forall l \neq \{k, j\}, 2 \leq i \leq n$. This allows for

$V_k^1 \geq V_j^2$. For example, in a 4-bidder 3-object auction with $V_A^1 > V_B^1 > V_C^1 > V_D^1$ and V_C^1 the

3rd highest valuation, V_D^1 is strategic if: i) $V_D^1 > \max(V_A^2, V_B^2)$ or ii) $V_D^1 > \max(V_B^2, V_C^2)$ or

iii) $V_D^1 > \max(V_A^2, V_C^2)$. Note that i) is consistent with $V_C^1 > V_D^1 > \max(V_A^2, V_B^2, V_C^2)$ and

$V_C^1 > V_C^2 > V_D^1 > \max(V_A^2, V_B^2)$. The same can be deduced from ii) and iii) and it follows that

V_D^1 must be at most the $(n+2)^{\text{th}}$ highest valuation to be strategic. **QED**

Proposition 2: *In complete information sequential second-price auctions with k bidders and n objects such that $k \leq n$, with bidders with declining valuations, $V_j^1 > V_j^2 \dots > V_j^n$ where V_j^i is bidder j 's i^{th} highest valuation, and without loss of generality, $V_A^1 > V_B^1 > \dots > V_K^1$, then bidder j is strategic if and only if its highest valuation is among the $(2n)$ highest valuations.*

Proof: Let us assume, $V_A^1 > V_A^2 > \dots > V_A^n > V_B^1 > V_C^1 > \dots > V_K^1$ where bidder A can be likened to

a monopsonist which must decide between buying only the last object, the last two, ..., the last $n-1$, or all n objects. If bidder A gets only the last object, bidder B gets between 1 and $n-1$ objects. When bidder B gets the remaining $n-1$ objects, then at the last node, it must be that: $V_A^1 > \max(V_B^n, V_C^1) > \min(V_B^n, V_C^1) > V_D^1 \dots > V_K^1$. Bidder A wins the last object and V_A^1

is the residual valuation if it is the $2n^{\text{th}}$ highest valuation. In such a case, bidder C is strategic even though it does not win any object. Bidder D can be strategic if bidder C wins at least one object. Consider the allocation with bidders A, B, C winning respectively 1, $n-2$, and 1 objects. At the last node of the equilibrium path in the outcome tree, we would have:

$V_A^1 > \max(V_B^{n-1}, V_C^2, V_D^1, \dots, V_K^1)$. Bidder D would be strategic if: $V_D^1 > \max(V_B^{n-1}, V_C^2)$. This

could be supported by the following valuation ranking

$V_A^1 > \dots > V_A^n > V_B^1 > \dots > V_B^{n-2} > V_C^1 > V_D^1$ in which case V_D^1 is the $2n^{\text{th}}$ highest valuation.

Similarly, V_K^1 can be strategic when bidder $K-1$ is allowed to win at least one object. Let us assume that the equilibrium allocation has bidder $K-1$ win $n-k-2$ objects and bidders A, B, ...,

$K-2$ win one object each. Then at the last node, $V_A^1 > \max(V_B^2, \dots, V_{K-2}^2, V_{K-1}^{n-k-1}, V_K^1)$. Bidder K

is strategic if its first valuation is the maximum among the $k-1$ valuations in the parentheses.

Given our assumptions, we must have:

$V_A^1 > \dots > V_A^n > V_B^1 > V_C^1, \dots, > V_{K-2}^1 > V_{K-1}^1 > \dots > V_{K-1}^{n-k-2} > V_K^1$. Thus, bidder K is strategic if its

highest valuation is among the $2n$ highest valuations. **Q.E.D.**

Since the necessary conditions invoked in propositions 2 and 3 are only about the number of objects and not the number of bidders, the impact of mergers in our sequential auctions is a priori different from that in Cournot markets in which the number of strategic players is reduced after mergers and the market structure is affected (e.g., Huck et al., 2000). For example, if we start with a pre merger auction game with four bidders A, B, C and D and n objects such that bidder A has the n highest marginal valuations and all bidders, except bidder D, are strategic, the merger between A and D do not affect the post merger equilibrium outcome and the number of strategic bidders is the same. These results will be useful in our analysis of mergers, but they are interesting in their own right as they extend the literature on sequential multi-unit auctions under complete information which tend to focus on auctions with small number of bidders and/or objects or symmetric bidders (Krishna, 1993, 1999; Katzman, 1999; Gale and Stegman and Jeddy et al. 2010).⁵

Defining s_i as the number of strategic valuations associated with bidder i , the merger of firms produces two effects impacting on the allocation of objects and the price sequence. First, the new merged firm has weakly more strategic valuations than any of the firms involved in the merger had prior to the merger, and second, the merger weakly decreases

⁵ Rodriguez (2009) considers an environment game of complete and imperfect information to examine multi-unit demand sequential auctions for an arbitrary number of bidders and objects. Focusing on the presence of local externalities, he shows the existence of residual monopsonist procedure along an equilibrium path which raises the possibility of inefficiency.

the residual strategic valuation. The first effect tends to increase efficiency while the second tends to decrease it.

Proposition 3: *A merger will take place if and only if it decreases the residual strategic value of the auction.*

Proof: We assume that the individual firms' valuations are unaffected by mergers. As such, the mergers do not produce synergies in production and marketing activities and a merged firm simply optimizes based on the valuations of the firms involved in the merger.⁶ These simplifying assumptions allow us to focus on the residual valuation. Consider a 3-bidder 2-object auction and let bidders A and B merge. Without loss of generality, let $V_A^1 > V_B^1$. The merged firms will have valuations $\{V_A^1, V_B^1\}$ if $V_B^1 > V_A^2$ or $\{V_A^1, V_A^2\}$ if $V_B^1 < V_A^2$. In the latter case, one might think that bidder A would not have an incentive to merge because the merged firm ends up with its pre-merger valuations, but this is not necessarily the case. Let $V_A^1 > V_A^2 > V_B^1 > V_B^2 > V_C^1 > V_C^2$. It is easy to verify that bidder A wins both object in the pre-merger equilibrium if $V_A^2 + V_B^2 > 2V_B^1$ and pays the residual strategic valuation V_B^1 for both objects. The equilibrium payoff vector is $(V_A^1 + V_A^2 - 2V_B^1, 0, 0)$. If bidders A and B merge, the residual valuation is either V_C^1 or V_C^2 whether $V_A^2 + V_C^2 \begin{matrix} > \\ < \end{matrix} 2V_C^1$. In the first case, the merged firm wins both objects, pays $p = (V_C^1, V_C^1)$ and ends up with a payoff of $V_A^1 + V_A^2 - 2V_C^1$ while in the second case it wins only one object with equilibrium prices and payoffs given by $p = (V_A^2 + V_C^2 - V_C^1, V_C^2)$ and $(V_A^1 - V_C^2, 2V_C^1 - V_A^2 - V_C^2)$. In both cases, post-merger

⁶ The organizational structure of new merged firms can clearly impact on their productivity and hence on input valuations. It is an active area of research (e.g., Prechel et al., 1999 and Huck et al., 2004).

equilibrium prices are lower than pre-merger prices⁷ and when the residual valuation is at its lowest, the allocation is no longer efficient. It is easy to verify that mergers between bidders A and C and between B and C would produce the same prices as the pre-merger equilibrium because the strategic valuations remain the same with or without mergers. Thus mergers between A and C and between B and C would not be observed. **Q.E.D.**

Corollary: *A strategic firm has no incentives to merge with a non-strategic firm.*

Let us now consider a numerical example, based on the game described in Figure 1, to gain some insights as to how mergers can impact on the price trend, allocative efficiency and the seller's revenue. We will show that the seller's revenue may increase after the merger which is akin to what is known as a pro-competitive effect in the industrial organisation literature. In what follows, we examine the equilibrium outcomes for three potential mergers A&C; B&C and A&B. It is initially assumed that valuations of bidders remain the same which would be the case if the merger could not create synergies between merging firms. We then discuss the implications of relaxing this assumption.

The pre-merger equilibrium is efficient. It is characterized by a constant price trend ($p_1 = p_2 = 6$) and payoffs for bidders A,B,C are $(4, 2, 0)$. Figure 2a illustrates the outcome tree when bidders A and C are merged. The valuations are ranked as follows: $V_{A\&C}^1 = 10 > V_B^1 = 8 > V_{A\&C}^2 = 7 > V_B^2 = 5$. As for the pre-merger equilibrium, the price trend is constant, but prices are lower: $p_1 = p_2 = 5$. Hence, the seller's revenue is $R^S = 10$

⁷ If $V_A^2 + V_B^2 < 2V_B^1$ and $V_A^2 + V_C^2 < 2V_C^1$ the post merger price of the second object is lower than the pre merger price of the second object ($V_B^2 < V_C^2$) while the post merger price of the first object is lower than the pre merger price of the first object if and only if $V_B^2 - V_C^2 > V_B^1 - V_C^1$.

and the payoffs are given by: $\pi^{A\&C} = (10-5) = 5$ and $\pi^B = (8-5) = 3$.

Since $\pi^{A\&C} > \pi^A + \pi^C$ the merger generates a net gain of 1 to be shared by A and C.

Figure 2b illustrates the outcome of an auction taking place after the merger between bidders A and B. The valuations are ranked as follows: $V_{A\&B}^1 = 10 > V_{A\&B}^2 = 8 > V_C^1 = 7 > V_C^2 = 5$. In contrast to the benchmark model, the price trend of this game is declining and prices are lower: $p_1 = 5$ and $p_2 = 3$. The seller's revenue falls to: $R^S = 8$ and the payoffs are given by: $\pi^{A\&B} = (10-3) = 7 > 6 = \pi^A + \pi^B$ and $\pi^C = (6-5) = 1 > 0$. It follows that bidder C also gains from the merger between bidders A and B. The allocation is inefficient.

Figure 2c illustrates the outcome of an auction taking place after the hypothetical merger between bidders B and C. The valuations are ranked as follows: $V_A^1 = 10 > V_{B\&C}^1 = 8 > V_A^2 = 7 > V_{B\&C}^2 = 6$. Prices are as in the benchmark case: $p_1 = p_2 = 6$. Hence, the seller's revenue is $R^S = 12$ and the payoffs are given by: $\pi^{B\&C} = (8-6) = 2$ and $\pi^A = (10-6) = 4$. The net gain of this potential merger being zero, it would not be observed.

As already established by proposition 3 and its corollary, not all potential mergers are profitable. Mergers involving bidders with the highest valuations are more profitable because they tend to lower the residual valuation which in turn tends to induce inefficient allocations. The insight is similar to Katzman (1999)'s proposition 1. In our case, a merger makes it more likely that it will be profitable for the merging firms to "give up" one or more

objects to get lower prices on the remaining objects. This inefficiency is caused by the elimination of competition among members of the merged firm as in Deneckere and Davidson (1985) and Mailath and Zemsky (1991). For regulators, pre and post merger market shares as indicators of competition could be misleading. Going back to our example, firm C does not get an object in the pre-merger equilibrium, but it wins one when firms A and B merge.⁸ The anti-competitive effect of the merger between bidders A and B is revealed by the changes in prices and seller's revenue. However, the seller's revenue need not always fall after a merger.

Proposition 4. *If the pre-merger allocation is inefficient, a merger can produce an efficient allocation and increase the seller's revenue.*

Proof. See appendix A.

The above result is an illustration of second-best theory. Figures A.1-A.4 illustrate the outcome tree of a game involving bidders A, B and C while figure A.5 depicts the outcome tree of the game between merged firm A&B and firm C. The valuations are ranked as follows:

$$V_A^1 = 18 > V_A^2 = 17 > V_A^3 = 16.5 > V_B^1 = 15.39 > V_C^1 = 14.3 > V_B^2 = 14.2 > V_B^3 = 14.1 > V_C^2 = 13.5$$

$> V_C^3 = 9.9$. It is easy to verify that the seller's post-merger revenue is slightly higher than the pre-merger benchmark: $R_{A\&B,C} = 43 > R_{A,B,C} = 42.92$. The merger improves upon a bad equilibrium in which the bidder with the three highest valuations, bidder A, acts as a

⁸ This result is in contrast with the literature supporting the result that competitors often suffer when other firms merge (e.g., Banerjee and Eckard, 1998).

dominant firm by giving up one object to bidder B to induce lower prices.⁹ The merger between bidders A and B eliminates the competition between A and B and hence changes the incentives. The weakly higher prices under the merger generate higher gains for the merged firm relative to the gains of firms A and B prior to the merger because the gains under the merger are computed using the three highest valuations, V_A^1, V_A^2, V_A^3 , as opposed to V_B^1, V_A^1, V_A^2 under the pre-merger equilibrium. Our result contrasts with the widely-held view that mergers are anti-competitive and lower welfare in the absence of post-merger synergies (e.g., Farrell and Shapiro, 1990).

In our analysis, we have assumed that a merger could not produce synergies between merged firms. However, in the presence of synergies enhancing payoffs through cost savings, the post merger valuations of the merged firm become naturally higher. When the first valuations of the merged firm increase relatively more, the dominant firm/inefficiency effect alluded to earlier becomes more likely as the merged firm has more incentives to exploit the low valuations of its rivals by “giving up” objects to secure lower prices on subsequent objects. In contrast, when the last valuations increase relatively more, the merged firm will have incentives to get more objects. This tends to increase efficiency.

⁹ In our example, the allocation is inefficient and the price trend is declining. However, it is worth pointing out that sometimes the merger induces an efficient allocation even though the price trend is declining. In Katzman’s (1999) analysis, a declining price trend was indicative of inefficiency. Thus, results derived from specific low-dimensional cases (i.e., $n=k=2$) may not generalize in higher dimensions.

3. Concurrent marketing mechanisms and the performance of the auction

Most studies about marketing mechanisms tend to compare one mechanism against another, as in Bulow and Klemperer (1996). The aim of this section is to analyze how the performance of sequential second-price auctions is impacted by the introduction of concurrent mechanisms like the pre-attribution mechanism used in the marketing of hogs in Quebec. Between 1989 and 1994, all of the hogs produced in Quebec were sold through a daily electronic auction. Hog producers were critical of the performance of the auction and a pre-attribution mechanism was introduced to work alongside the daily auction. Hog processors were pre-attributed shares of the hog supply based on historical market shares. The price paid for these hogs was a US price minus a negotiated discount. As mentioned earlier, a third mechanism was introduced in 2000 and the relative importance of each mechanism changed over time.

We consider the benchmark model where valuations of bidders A and B are given by: $V_A^1 = 10 > V_B^1 = 8 > V_A^2 = 7 > V_B^2 = 6 > V_A^3 = 5 > V_B^3 = 3$. Bidder B wins the first two objects and pays $p_1 = 5$ and $p_2 = 4$ while bidder A wins the third object and pays $p_3 = 3$. The payoffs are $\pi^A = 7$ and $\pi^B = 5$. The price trend is declining and the allocation is inefficient. We are assuming that only one object is pre-attributed. Hence, there are two possible cases depending on who gets the pre-attributed object.

We consider the situation where bidder A gets the pre-attributed object. This bidder plays the auction game with valuations 7 and 5 because his highest valuation is used up on the pre-attributed object. The benchmark valuations of bidder B remains unchanged. In equilibrium, $p_2 = 5$, $p_3 = 5$, $\pi^S = p_{pre} + 10$, $\pi^A = (10 - p_{pre}) + (7 - 5) = 12 - p_{pre}$ and

$\pi^B = 8 - 5 = 3$, where p_{pre} is the exogenously determined price for the pre-attributed object. In the benchmark case, prices were : $p_1 = 5, p_2 = 4$ and $p_3 = 3$. Thus the average auction price increases from 4 to 5. Prices on pre-attributed hogs were set in relation to a U.S. price, but prices over the 1979-2000 period reported in Larue et al. (2004, p.241) indicate that average daily auction prices in Quebec were systematically above (below) US prices after (before) the introduction of pre-attributions in 1994.

We consider the situation where bidder B gets the pre-attributed object. This bidder plays the auction game with valuations equal to 6 and 3 because his highest valuation is used up on the pre-attributed object. The valuations of bidder A are as in the benchmark case. Equilibrium prices and payoffs are $p_2 = 4, p_3 = 3, \pi^S = p_{pre} + 7, \pi^A = 7$ and $\pi^B = (8 - p_{pre}) + 2 = 10 - p_{pre}$. Thus, the average auction price decreases when the pre-attributed object is allocated to bidder B. This outcome happens because of the relatively low valuations of bidder B for the second and third objects. When the first object is pre-attributed to bidder B, bidder A is willing to let bidder B win the first object on the auction to get the last object at a very low price.

Proposition 5. *The introduction of a concurrent pre-attribution scheme may increase or decrease the average auction price and change the price trend and allocative efficiency of the auction.*

Proof: Consider an initial 2-bidder (A and B) 3-object second-price auction. The bidders' valuations are decreasing and ordered as: $V_A^1 > V_A^2 > V_A^3 > V_B^1 > V_B^2 > V_B^3$. This ordering supports several equilibrium allocations (bidder A winning 1,2 or all 3 objects), but it implies that the high-valuation bidder A always wins the last object. Let us define

conditions C1, C2 respectively as $V_A^3 - V_B^1 > V_B^1 - V_B^2$, $V_A^3 - V_B^1 < V_B^1 - V_B^2$ and C3, C4 respectively as $V_A^2 - V_B^2 > V_B^2 - V_B^3$, $V_A^2 - V_B^2 < V_B^2 - V_B^3$. When C1 and C3 hold, two equilibrium allocations are possible. If C5 holds, $V_A^3 - V_B^1 > 2(V_B^1 - V_B^2)$, then bidder A wins all three objects and pays $p_{C1,C3,C5}^3 = (V_B^1, V_B^1, V_B^1)$. If C6 holds, $V_A^3 - V_B^1 < 2(V_B^1 - V_B^2)$, a declining price trend ensues, $p_{C1,C3,C6}^3 = (V_B^2 + (V_A^3 - V_B^1) - (V_B^1 - V_B^2), V_B^2, V_B^2)$, as bidder B wins the first object and bidder A wins the last two. Now, consider what happens when the first object is pre-attributed/sold to bidder B and the remaining two objects are auctioned. Two equilibria are possible. If C3 holds, then bidder A wins both objects at constant prices $p_{C3/B}^2 = (V_B^2, V_B^2)$. If C4 holds, bidder B wins the first object auctioned and bidder A wins the last one at a lower price as $p_{C4/B}^2 = (V_B^3 + V_A^2 - V_B^2, V_B^3)$. If the first object is pre-attributed/sold to bidder A, bidder A wins both objects when C1 holds and $p_{C1/A}^2 = (V_B^1, V_B^1)$ while bidder B gets one and bidder A gets one when C2 holds. They then pay: $p_{C2/A}^2 = (V_A^3 - V_B^1 + V_B^2, V_B^2)$. Comparing the average price of $p_{C1,C3,C5}^3$ with the average price of $p_{C3/B}^2$ and $p_{C1/A}^2$, we find that the average price is either lower or the same when one object is pre-attributed. If instead our benchmark is $p_{C1,C3,C6}^3$, it is easy to see that the average prices under $p_{C3/B}^2$ and $p_{C1/A}^2$ are respectively lower and higher than the average price when all three objects are auctioned. Under our assumptions, selling a pre-attributed object to the low valuation bidder lowers the average auction price. If two objects were pre-attributed, then equilibrium auction prices would be V_B^1 , V_B^2 and V_B^3 if

bidder A gets both pre-attributed objects, one or zero. The pre-attribution of two objects has an ambiguous effect on the average auction price. **QED**

Clearly, giving pre-attributed objects to bidders with rapidly decreasing valuations (like hog processors with low processing capacities) is not a good strategy for the seller, especially in the presence of a bidder with high valuations (i.e., a large processor). The pre-attribution of hogs in Quebec was based on historical market shares. The data made available to us reveals a slowly declining market share for the largest processor over time which is consistent with dominant firm-like behaviour of trading market share for lower prices.

4. Empirical analysis

In this section, we analyze prices generated by the Quebec daily hog auction. As hinted by our discussion about the evolution of the industry, there are a large number of events that could have induced structural changes, like the changes in the mix of marketing mechanisms displayed in Table 1. The merger of the two largest processors might also have caused structural changes in the prices generated by the daily auction. Because there is uncertainty regarding the number of structural changes, we must use an empirical approach that allows for several endogenous changes.

We use the flexible method developed by the seminal paper, Bai and Perron (2003), to determine endogenously the number of breaks and the dates at which they occurred. Following several works (e.g., Ben Aissa and Jouini, 2003; Jouini and Boutahar, 2003 and Ben Aissa et al., 2004), the model and test statistics of the Bai-Perron recommended sequential procedure are briefly discussed below. A priori, we do not know which of the “events” we know about had a significant impact nor do we know whether bidders

anticipated the events or responded with a delay to these events. Our data contains average weekly prices between 1996:1 and 2006:52. The data was provided by the FPPQ. We regressed the Quebec auction price on the U.S. reference price, total quantity of hogs available in the Quebec market, three dummy variables for seasonality and lagged dependent variables to account for marketing and biological production constraints. The total quantity variable is exogenous because it is announced before each auction. We consider the following multiple linear regression with m breaks ($m + 1$ regimes):

$$y_t = x_t' \beta + z_t' \delta_j + u_t ; \quad t = T_{j-1} + 1, \dots, T_j \quad (1)$$

for $j = 1, \dots, m+1$. Variable y_t is the observed dependent variable (“aucprice”) at time t ; $x_t (p \times 1)$ and $z_t (q \times 1)$ are vectors of covariates whose influence are respectively fixed and variable across regimes and β and δ_j ($j = 1, \dots, m+1$) are the corresponding vectors of coefficients; u_t is the disturbance at time t . The break points (T_1, \dots, T_m) are unknown such that $T_0 = 0$ and $T_{m+1} = T$. We set $p = 1$, the number of regressors x_t and $q = 8$, the number of regressors z_t , and $m = 5$ as the maximum number of breaks.¹⁰ Each break date is asymptotically distinct and bounded from the boundaries of the sample. The estimation method is based on the least-squares principle proposed by Bai and Perron (1998). For each m -partition (T_1, \dots, T_m) denoted $\{T_j\}$, the associated least-squares estimates of β and δ_j are obtained by minimizing the sum of squared residuals

¹⁰ The test does not suffer from size distortions and there is no need to simulate critical values because the number of regressors is less than ten and the size of our sample exceeds 125 (see Prodan, 2008 for details).

$\sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} (y_t - x_t' \beta - z_t' \delta_i)^2$. Let $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$ denote the resulting estimates.

Substituting them in the objective function and denoting the resulting sum of squared residuals as $S_T(T_1, \dots, T_m)$, the estimated break points $(\hat{T}_1, \dots, \hat{T}_m)$ are such that $(\hat{T}_1, \dots, \hat{T}_m) = \arg \min_{(T_1, \dots, T_m)} S_T(T_1, \dots, T_m)$ where the minimization is taken over all partitions (T_1, \dots, T_m) such that $T_i - T_{i-1} \geq q$. Thus the break-point estimators are global minimizers of the objective function.

The sequential procedure consists of estimating the model with a small number of breaks that are thought to be necessary (or start with no break). It performs parameter constancy tests for every subsample (those obtained by cutting off at the estimated breaks), adding a break to a subsample associated with a rejection of the null hypothesis of no break using the $\sup F_T(l+1/l)$ test. This process is repeated increasing l sequentially until the test $\sup F_T(l+1/l)$ fails to reject the null hypothesis of no additional structural changes. As it was recommended by Bai and Perron (2003, 2006), a useful strategy is to first look at the UDmax or WDmax tests to see if at least a break is present.

Although the number of break dates can be determined by using the Bayesian Information criterion (BIC) suggested by Yao (1988) or the modified Schwarz criterion (LWZ) suggested by Liu et al. (1997), the sequential procedure is favoured because it directly addresses the presence of serial correlation in the errors and heterogeneous variances across segments (Bai and Perron (1998)). Bai and Perron (2006) compare the adequacy of different testing strategies in finite samples and in the presence of

autocorrelation and/or heteroscedasticity. They show that even though the BIC works reasonably well in the absence of autocorrelation, sequential methods are still preferable. Several other studies have used the sequential procedure (see Jouini and Boutahar (2003), and Kerekes (2007) among others).

We conclude in favour of the presence of three breaks that correspond to the estimates found by the sequential procedure, using a null hypothesis of m breaks determined sequentially. These breaks are estimated at (2000:18); (2002:21) and (2005:20) with 95% non-overlapping confidence intervals given by [(2000:06); (2000:39)], [(2002:05); (2002:32)] and [(2005:11); (2005:22)], respectively.¹¹

The introduction of the third mechanism in January of 2000 coincides with the first break identified by the sequential procedure. The second break corresponds to the date at which Olymel and Brochu, the two largest Quebec hog processors at the time, engaged in a partnership by purchasing Prince Foods, a processing firm specialized in bacon products. Olymel and Brochu submitted their merger proposal to Canada's Competition Bureau in October of 2004 and their merger was approved in April of 2005 which falls within the confidence interval of the third break. It was also announced on May of 2005 that three plants would close and that important capital investments would be made in three other plants.¹²

¹¹ The repartition procedure also used in Bai and Perron (2003) selects three break dates, two of which identical to the ones found by the sequential procedure: (2002:21) and (2005:20). However, the third date identified by the repartition procedure, (1999:14), end up being a full year before the introduction of the third mechanism in January of 2000 and hence is less plausible. The BIC procedure suggests a single break that is also identified by the other procedures: (2005:20).

¹² See <http://www.ledevoir.com/economie/81238/olymel-supprime-366-emplois>

The identification of three breaks implies four regimes which are described in Table 2 and identified as R1, R2, R3 and R4. For each regime, we report coefficients along with their respective p -value. The parameter estimates associated with the U.S. price at date t in all four regimes are respectively 0.77, 0.55, 0.63 and 0.62, all with p -value close to zero. The changes in the coefficients suggest that the immediate impact of US hog prices on the Quebec auction price decreased substantially from the first to the second regime, but was not affected much when the third regime ended and the fourth one began.

We used matched pair tests, reported in table 2, to compare prices predicted over the same period by the current regime estimator and the previous regime estimator. We found significantly higher prices after the introduction of the third mechanism, significantly decreased prices after the partnership and eventual merger between the two largest processors. Clearly, the smaller supply on the daily auction had a strong competitive effect offsetting the price-depressing effect of valuations transferred to the third mechanism. Moreover, the market share of the dominant processing firm had been declining and so had auction prices. This suggests that the dominant processor was giving up objects to get lower prices on the remaining ones.

5. Conclusion

In this paper, we have analyzed the impact of mergers and the introduction of concurrent marketing mechanisms on the performance of multi-unit sequential auctions under complete information with asymmetric bidders. Agricultural supply chains are characterized by a high degree of concentration at the processing and retail levels. In some cases, collective actions have led to the creation of producers-controlled marketing boards

to counter the possible market power of processors and retailers. As shown in Table 1, the Quebec hog-pork sector has been experimenting with different combinations of marketing mechanisms in search of an ideal way of marketing hogs. Over the years, the relative importance of the electronic auction varied tremendously. Between 1989 and 1994, the electronic auction was the only mechanism in use, while starting in 2000, three different mechanisms were being used concurrently. Processing activities became even more concentrated when the two largest processors invested in a joint venture.

We show that even in the absence of post-merger synergies, mergers can increase the seller's revenue and have pro-competition effects in sequential auctions under complete information. This occurs when the pre-merger allocation is inefficient and the post-merger allocation is efficient. Thus, whether a merger has pro-competition, anti-competition or no effects at all is an empirical question. The evidence produced through an endogenous structural change test confirmed that the merger did have an impact, but an anti-competitive one on prices received by Quebec hog producers.

Finally, we have shown that a pre-attribution scheme used concurrently with an auction may increase or decrease the average auction price and impact on efficiency and the price trend, depending on how pre-attributed objects are allocated. Larue et al. (2004) had shown that long biological lags in hog production makes the hog supply very inelastic in the short run, thus making producers vulnerable to quasi-hold ups. Our theoretical results suggest that a pre-attribution/price commitment scheme skewed toward the high valuation bidder can increase the average auction price. Our empirical evidence indicate that the introduction of a new marketing mechanism in 2000 had a positive effect on the average auction price.

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Table 1. Evolution of hog supply shares sold on the three marketing mechanisms

Period	Shares of Hog Supply Allocated to Different Marketing Mechanisms		
	% Pre-attribution	% Daily Auction	% Monthly Auction
1996 :1 to 1997 :8	72%	28%	0%
1997 :9 to 1999 :8	76%	24%	0%
1999 :9 to 2000 :3	72%	28%	0%
2000 :4 to 2000 :52	60%	25%	15%
2001:1 to 2003 :53	55%	25%	20%
2004 :1 to 2006 :52	50%	25%	25%

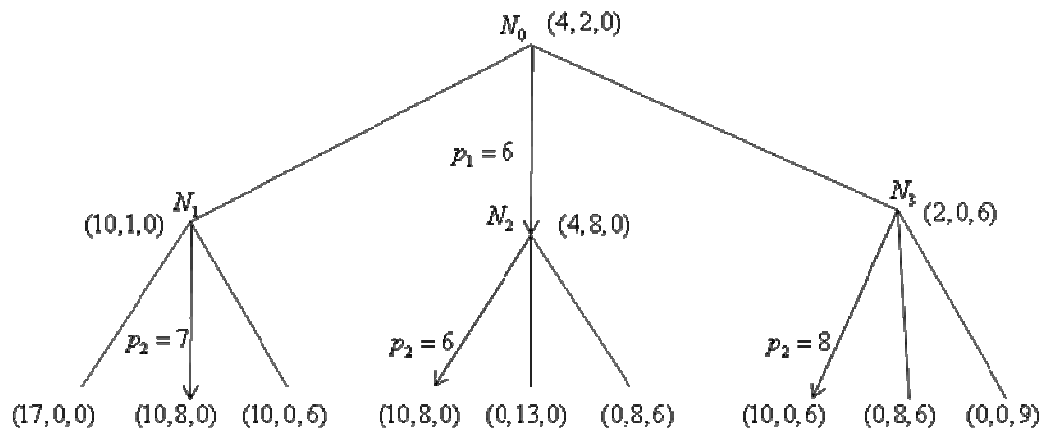


Figure 1. The outcome tree for the benchmark game. Bidder B wins the first object and bidder A wins the second. Prices are constant: $p_1 = p_2 = 6$.

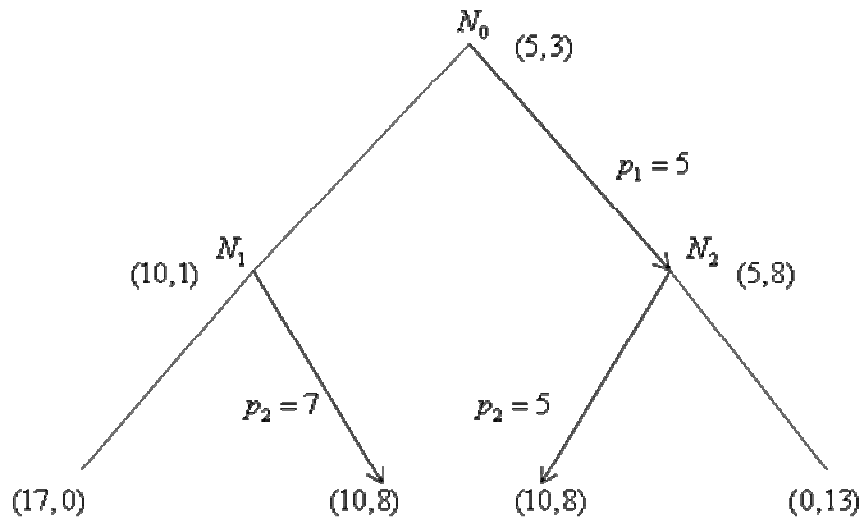


Figure 2a. The outcome tree for the merger between bidders A and C.

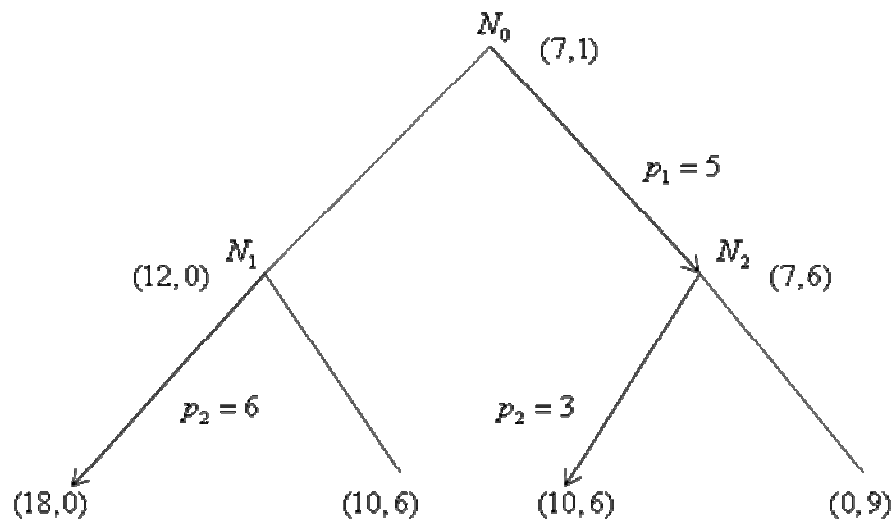


Figure 2b. The outcome tree for the merger between bidders A and B.

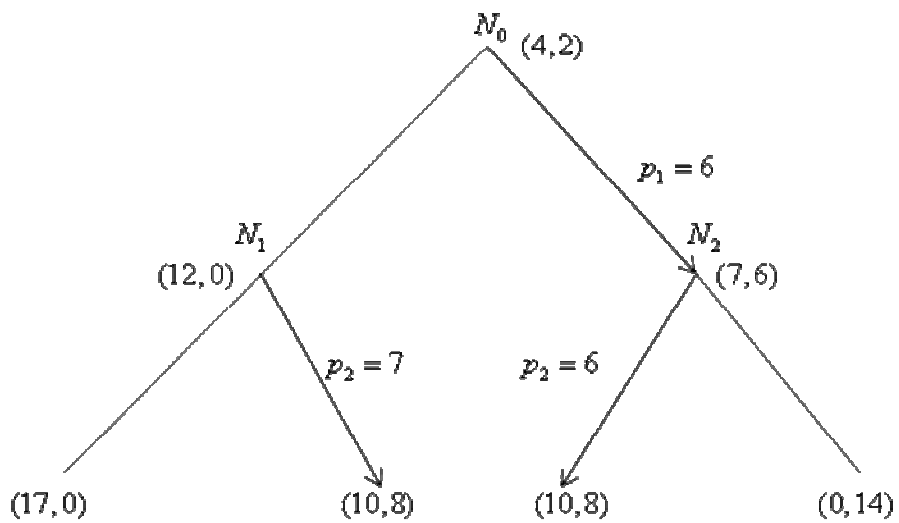


Figure 2c. The outcome tree for the merger between bidders B and C.

Table 2. Parameter estimates for each of the four identified regimes.¹³

	Regime 1		Regime 2		Regime 3		Regime 4	
observed mean price	151.38		171.31		151.9		135.28	
predicted mean price	-		$P^{R1} = 108.34$		$P^{R2} = 168.77$		$P^{R3} = 145.29$	
	-		$P^{R2} = 170.86^{**}$		$P^{R3} = 152.11^{**}$		$P^{R4} = 134.96^{**}$	
	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
aucprice(t-1)	0.357137	0	0.445065	0	0.553014	0	0.168963	0.026
aucprice(t-2)	-0.133176	0.004	-0.076974	0.331	-0.2427	0	0.103964	0.108
aucprice(t-37)	-0.005416	0.581	0.040761	0.062	-0.002429	0.874	0.118788	0
usprice(t)	0.766781	0	0.550153	0	0.630775	0	0.624878	0
qty(t)	0.000015	0.426	0.000029	0.315	0.000032	0.089	-0.000069	0.009
S1	4.004291	0	4.023262	0.003	6.974186	0	-3.190844	0.066
S2	4.064395	0	4.245774	0.002	5.545976	0	-2.088833	0.126
S3	0.753047	0.401	2.335926	0.115	0.179032	0.867	-0.343951	0.77
Constant	2.526223	0.347	2.526223	0.347	2.526223	0.347	2.526223	0.347

** indicates that predicted mean price P^{Rj+1} is statistically different from mean predicted price P^{Rj} .

¹³ We relied on estimated autocorrelation functions and estimated partial autocorrelation functions to guide our model specification. The lagged price variables are used to account for marketing and biological constraints. The break dates identified by the structural change test were robust to specification changes involving lagged US prices as opposed to lagged auction prices.

Appendix: Proof of proposition 4.

We assume that $V_A^1 > V_A^2 > V_A^3 > V_B^1 > V_C^1 > V_B^2 > V_B^3 > V_C^2 > V_C^3$ such that $V_A^3 + V_C^1 - 2V_B^1 > 0; V_A^2 + V_B^2 - 2V_B^1 > 0; V_A^2 + V_B^2 - 2V_C^1 > 0$ and $V_A^3 + 2V_C^1 - 3V_B^1 < 0$. The game is depicted by the outcome trees in Figure A.1-A.4. Bidder B wins the first object and pays $p_1 = V_A^3 + 2V_C^1 - 2V_B^1$ while bidder A wins the other two objects and pays $p_2 = p_3 = V_C^1$. The outcome is inefficient and the seller's revenue is $R(3) = 4V_C^1 + V_A^3 - 2V_B^1$. Let us now consider the merger between bidder A and bidder B. The auction is a 2-bidder and 3-object game between the merged firm A&B and firm C such that: $V_{A\&B}^1 > V_{A\&B}^2 > V_{A\&B}^3 > V_C^1 > V_C^2 > V_C^3; V_{A\&B}^3 + V_C^2 - 2V_C^1 > 0; V_C^3 + V_{A\&B}^2 - 2V_C^2 < 0$ and $V_{A\&B}^3 + 2V_C^3 - 3V_C^1 - 2V_C^2 + 2V_{A\&B}^2 > 0$. Since the valuations of the merged firm is the maximum of its coalition member valuations, we have: $V_{A\&B}^1 = V_A^1; V_{A\&B}^2 = V_A^2$ and $V_{A\&B}^3 = V_A^3$. Figure A.5 illustrates the outcome tree of this auction game. The merged firm wins all three objects and pays $p_1 = V_C^1 + 2V_C^2 - V_C^3 - V_A^2$ and $p_2 = p_3 = V_C^1$. The payoff of the merged firm is higher than the pre-merger payoffs of firm A and B: $\pi_{A\&B} = V_A^1 + V_A^2 + V_A^3 - 3V_C^1 - 2V_C^2 + V_C^3 + V_A^2 > \pi_A + \pi_B = (V_A^1 + V_A^2 - 2V_C^1) + (V_B^1 - V_C^1)$ and the merger is incentive compatible. The seller's revenue is given by: $R(2) = 3V_C^1 + 2V_C^2 - V_C^3 - V_A^2$. Therefore, $R(2) > R(3)$ if and only if $2V_B^1 + 2V_C^2 - V_A^2 - V_A^3 - V_C^1 - V_C^3 > 0$ (see p. 15 for a numerical example). The merger generates an efficient allocation and an increase in the seller's revenue. The payoff of bidder C is not affected by the merger as it remains zero. As such, the merger creates a Pareto improvement and it is clearly pro-competition. **QED**

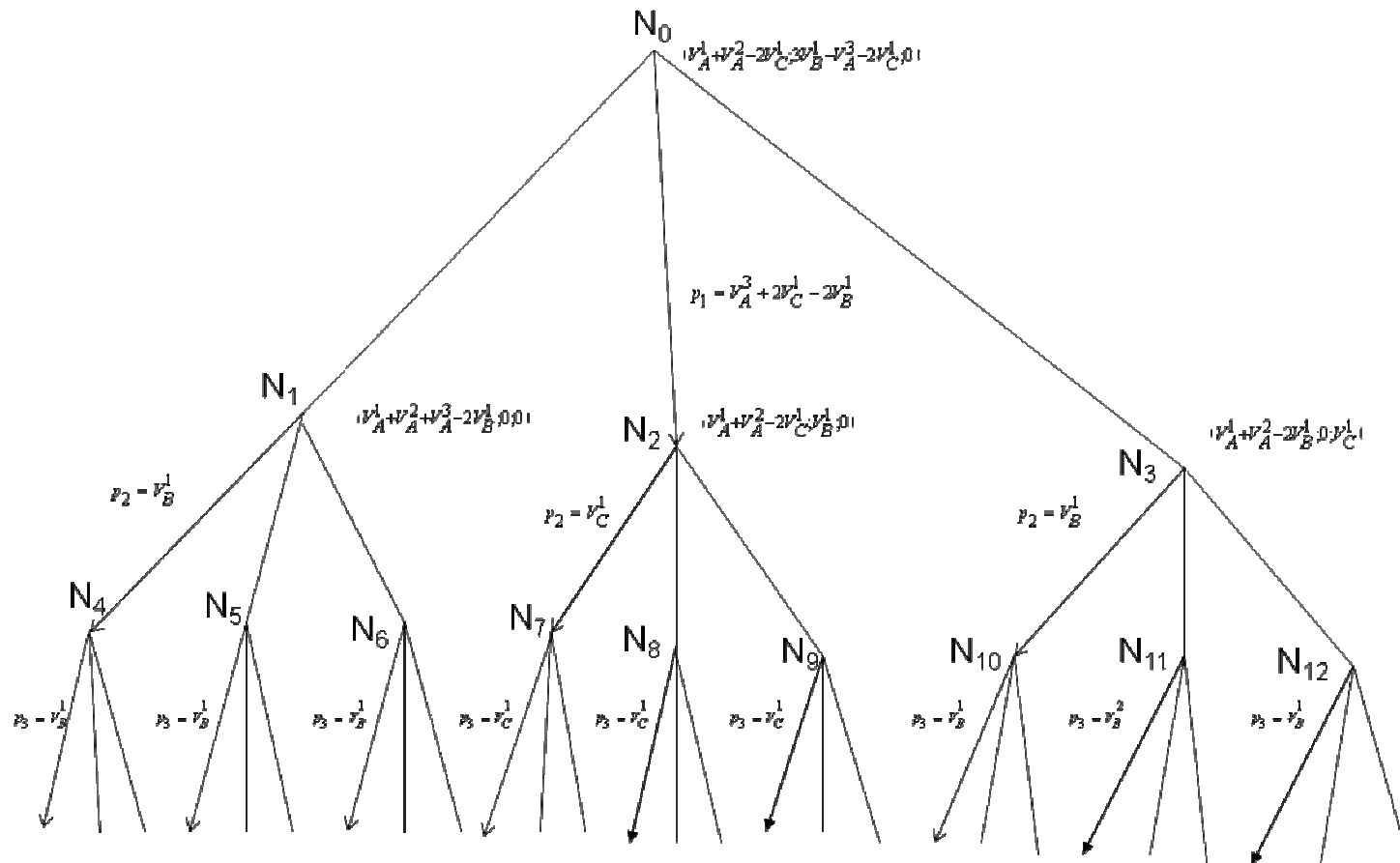


Figure A.1. The pre-merger auction game with three bidders and three objects.

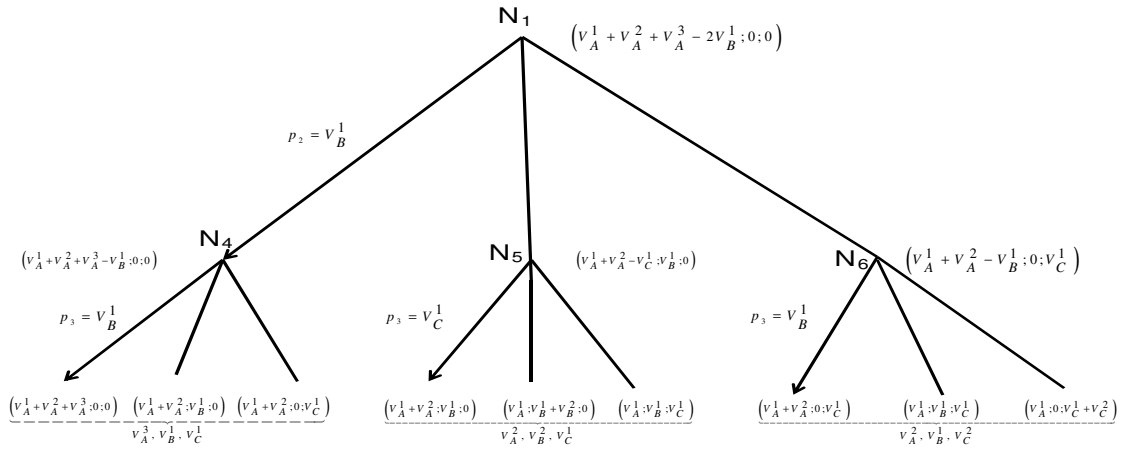


Figure A.2 The outcome tree at node N1.

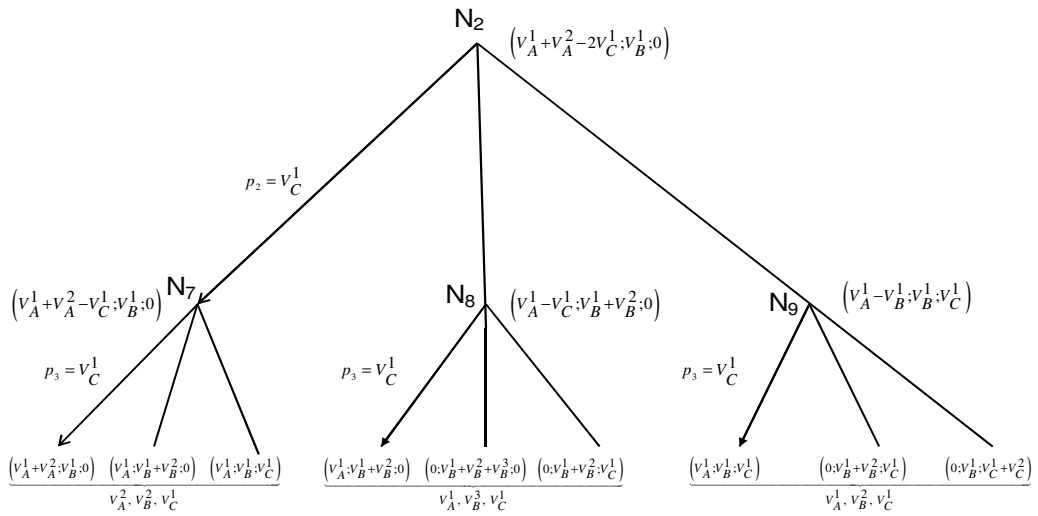


Figure A.3 The outcome tree at node N2.

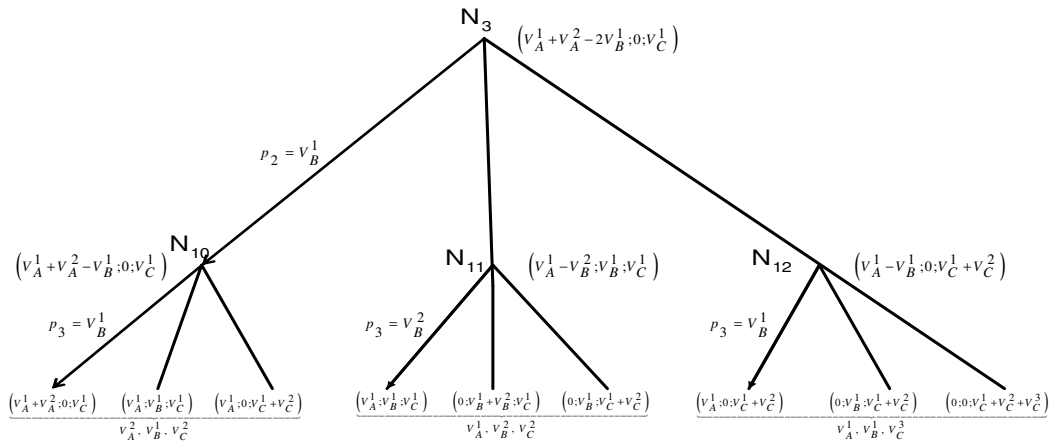


Figure A.4 The outcome tree at node N4.

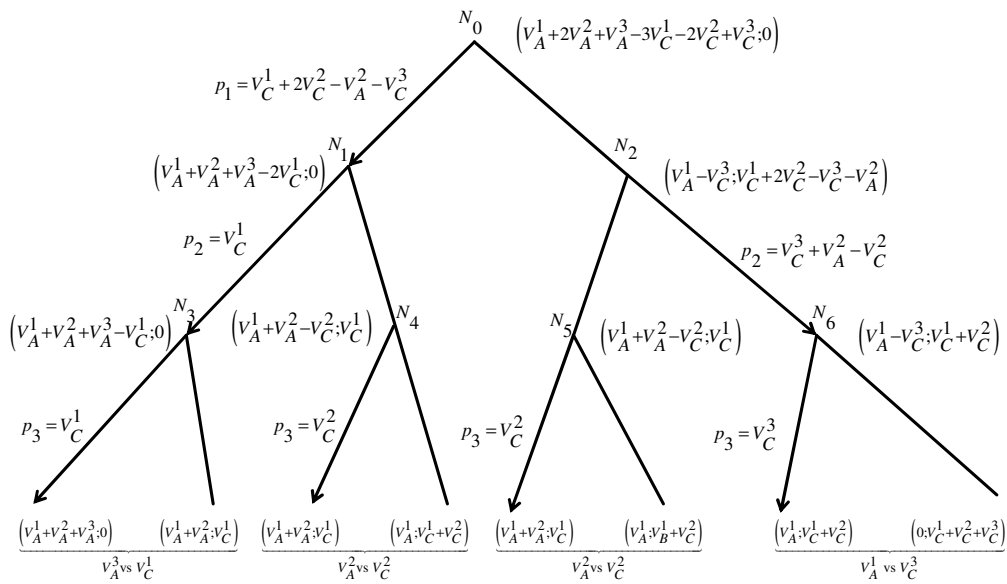


Figure A.5. The postmerger auction game with two bidders and three objects.