A New Perspective on Entry in Horizontal Merger Analysis*

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Abstract

I analyze horizontal mergers in procurement settings in which competing for a buyer's business requires sellers to incur costs, say to design prototypes or evaluate production costs. Considering existing sellers' *contest-level entry* differs from antitrust authorities' typical emphasis on new sellers' *market-level entry* to counteract a merger's anticompetitive harm. I show that profitable mergers without efficiencies can increase consumer and total surplus by inducing more and stronger contest-level entry by the merged seller. This insight echoes common claims from merging parties that their merger will create a stronger competitor, and it suggests caution by antitrust authorities: when contest-level entry costs matter, standard models prescribe blocking procompetitive mergers.

1 Introduction

A critical part of the antitrust analysis of horizontal mergers is assessing whether new entry into the market will be timely, likely, and sufficient to deter or counteract any anticompetitive harm a merger is otherwise predicted to create. The horizontal merger guidelines in the US and EU stress the importance of entry,[1] as do the judicial opinions in merger cases involving industries such as waste hauling, movie theaters, office superstores, and baby food.[2]

In this paper I use game-theoretic tools to analyze the antitrust implications of a different entry problem that is encountered in what competition authorities call *bidding markets*, in which competition for each buyer's business occurs in a separate procurement contest:[3] to compete in a contest, sellers already in the market frequently must incur entry costs, say to design prototypes, evaluate production costs, assess their product's fit with the buyer's preferences or purchasing requirements, or formulate an initial proposal. Such costs are present in a wide variety of markets, including those for external audit services, highway

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[1] See Section 9 of the U.S. Department of Justice (DoJ) and Federal Trade Commission (FTC) Horizontal Merger Guidelines, and Section VI of the European Commission (EC) Horizontal Merger Guidelines.

[2] Respectively, see *United States v. Waste Management, Inc.*, 743 F. 2d 976 (2d. Cir. 1984); *United States v. Syufy Enterprises*, 903 F. 2d 659 (9th Cir. 1990); *FTC v. Staples*, 970 F. Supp. 1066 (D.D.C. 1997); and *FTC v. H.J. Heinz Co.*, 246 F. 3d 708 (D.C. Cir. 2001).

[3] Klemperer (2005) and OECD (2006) provide overviews of antitrust issues in bidding markets.

construction, maintenance contracts, and hydro power equipment.[4] Similar costs are present in bidding markets in which bidders are buyers rather than sellers, such as in markets for oil or timber rights, radio spectrum, and large asset sales.[5] French and McCormick (1984), McAfee and McMillan (1987), and Levin and Smith (1994) provide early theoretical analyses of the strategic impact of *contest-level entry* on outcomes in bidding markets, but the role of such costs in merger analysis has not yet been formally analyzed.

In Section 2 I add contest-level entry costs to a standard procurement model that has been used in horizontal merger analysis, a simple and empirically relevant change that in Section 3 I show sharply alters merger effects: a profitable merger without efficiencies can increase both consumer and total surplus in a model with contest-level entry costs, while the same merger decreases consumer surplus and leaves total surplus unchanged in the corresponding model without such costs. These differences reveal that ignoring contest-level entry can lead to recommendations to block a merger that is procompetitive under either a consumer or total welfare standard. Moreover, the mistaken recommendation from the standard model will not be corrected by considering new sellers' *market-level entry*; because of the nature of price competition in the standard model, potential entrants will not anticipate higher expected profits postmerger despite the merger's effect on the expected price.

The existence of procompetitive mergers relies on the practical consequence of contest-level entry costs that not all sellers necessarily compete for each buyer's business, via a simple mechanism that is consistent with the story frequently told by merging parties that their merger will create a stronger competitor. Mergers have procompetitive effects in *non-overlap* contests in which one or both parties would not have competed premerger, because the stronger merged seller enters the contest. Mergers harm buyers in *overlap* contests in which both parties would have competed premerger, because the merger eliminates instances in which the merging sellers would have placed first and second in the contest, and hence the transaction price postmerger instead will be determined by the seller who premerger would have placed third. This reduction in consumer surplus is familiar from the standard analysis of horizontal mergers in bidding markets without contest-level entry costs. However, mergers increase total surplus in overlap contests by eliminating one merging seller's expenditure of its contest-level entry cost, an effect that is absent in settings without such costs.

Antitrust authorities are well-aware there is variation in entry across contests in a market, and to account for it they have developed approaches for assessing mergers that informally complement the stark insight that all mergers are anticompetitive that emerges from the standard procurement model without contest-level entry. A common quantitative approach is a *frequency analysis* that uses historical contest-level data from industry participants to assess how often the merging parties meet, and how often they place first and second in such overlap contests, with the perceived extent of harm increasing in both frequencies. This approach is described in Section 6.2 of the US Horizontal Merger Guidelines, and has been used by the European Commission in merger investigations in a variety of industries, including the supply of industrial gases (Air Liquide/Messer), railway transportation technology (Bombardier/ADtranz), secure plastic cards (Axalto/Gemplus), and city buses (MAN/Scania).[6] A simple qualitative argument is that a buyer is unlikely to be harmed if not all sellers compete for its business premerger, because competition lost through the merger of two active sellers can be replaced by sellers who were inactive premerger. This argument has appeared in EC merger cases in industries such as the supply of enterprise application software (Oracle/PeopleSoft), automotive components to OEMs (Magna/New Venture Gear), large turbines (Siemens/Alstom), and equipment

[4] Respectively, see Sullivan (2002), Krasnokutskaya and Seim (2011), Li and Zheng (2009), and OECD (2006).

[5] Respectively, see French and McCormick (1984), Athey, Levin, and Seira (2011), Binmore and Klemperer (2002), and Ye (2007).

[6] Respectively, see European Commission cases COMP/M.3314 (2004), COMP/M.2139 (2001), COMP/M.3998 (2006), and COMP/M.4336 (2006).

for mobile networks (Nokia/Siemens).[7]

In Section 4 I argue that these informal approaches do not reasonably predict merger effects, when assessed in light of the results from my formal model incorporating sellers' costly entry decisions for each contest. First, although the frequency analyses seen sensible because mergers diminish competition in overlap contests, I show that a merger can change sellers' contest-level entry decisions in such a way that a merger is more harmful the less frequently the merging sellers compete premerger. Moreover, merger effects can differ for a given frequency of overlap, depending on the frequency of various non-overlap possibilities. Second, the existence of inactive sellers premerger does not prevent a merger's anticompetitive effects in overlap contests. Those inactive sellers might not find it profitable to enter even if the merger increases the expected price, depending on the nature of post-entry price competition. Finally, both approaches ignore the procompetitive effects that arise in non-overlap contests. To my knowledge antitrust authorities normally consider mergers to be competitively neutral in non-overlap contests, and hence they do not trade off competitive benefits in such contests against whatever anticompetitive harm is expected to occur in overlap contests.

In Section 4 I also describe straightforward extensions of the basic procurement model that reflect potentially relevant market features, including efficiencies and alternative entry protocols. The extensions likely do not change the basic model's essential insight that procompetitive effects can arise because a merger leads to more and stronger contest-level entry by the merged seller. However, the extensions might be useful for conducting the sort of merger simulations that have become an oft-used tool by antitrust practitioners, as described in the context of bidding markets by Dalkir, Logan, and Masson (2000), Brannman and Froeb (2000), Bengtsson (2005), and Budzinski and Ruhmer (2010).

2 The Basic Procurement Model

Consider N risk-neutral sellers competing to supply one unit of an indivisible good to a risk-neutral buyer who places value v_B on having the contract fulfilled. These sellers comprise the set of participants in the relevant antitrust market within which merger effects will be analyzed, and competition in the market occurs in a separate procurement contest for each buyer

Competition in an arbitrary contest occurs in two stages whose structure is commonly known by the sellers and the buyer. In the first stage the sellers simultaneously choose whether to sink the cost $e \geq 0$ to enter the procurement contest for the buyer's business. In the second stage the sellers observe which other sellers entered, then each seller privately learns its production cost before the sellers make simultaneous price offers to the buyer. Seller i's cost c_i is an independent draw from the differentiable cumulative distribution F_i whose density is strictly positive on the interior of its support $[\underline{c}, \overline{c}]$, with $0 \leq \underline{c} < \overline{c} \leq v_B$. The procurement contest's winner and transaction price are determined by second-price auction rules: the seller offering the lowest price wins if its price offer is less than or equal to v_B, and the transaction price paid to the winning seller is the smaller of the second-lowest price offer and v_B. If seller i wins and the transaction price is p, then seller i's profit is $p - c_i$, all other sellers' profits are 0, the buyer's profit is $v_B - p$, and total surplus is $v_B - c_i$. If the lowest price offer exceeds v_B, then no transaction occurs. I assume the buyer cannot enforce a reserve price below v_B, and likewise does not engage in bilateral negotiations if only one seller enters, but those assumptions can be changed as circumstances warrant.

[7] Respectively, see European Commission cases COMP/M.3216 (2004), COMP/M.3486 (2004), COMP/M.3148 (2003), and COMP/M.4297 (2006).

I model post-entry price competition as a second-price auction because that auction format has been used to model competition in antitrust analyses of several industries, including retail pharmacy, timber rights, and software.[8] The outcome of a second-price auction (or equivalently, an English or oral auction) also reflects the market-clearing outcome that is worst for the buyer, so in many settings a second-price auction might reasonably proxy for whatever mechanism determines transaction outcomes. Of course, one could use other transaction mechanisms as appropriate, such as the first-price auctions analyzed by Holt (1980) or the multilateral negotiations introduced by Thomas and Wilson (2002).

A particular antitrust market might exhibit variation in the nature, size, or scope of the contracts being awarded, which in the model would be reflected as differences in the buyer's value, the entry cost, or the sellers' cost distributions. Such variation is noted in Section 4.1.4 of the US Horizontal Merger Guidelines, and has been observed in antitrust analyses of industries such as the supply of medical imaging equipment (Philips/Agilent merger), satellites and satellite subsystems (Thales/Finmeccanica/AAS/Telespazio joint venture), perioperative patient monitors (GE/Instrumentarium merger), and television audience measurement services (VNU/WPP merger).[9] While applications likely should account for such differences to quantitatively assess a merger's gains and losses across different buyers, the analysis to follow reflects an arbitrary procurement contest of the many that might occur in the market.

Because this is a dynamic game, determining the sellers' equilibrium entry decisions begins by considering the outcomes of the post-entry price competition stage for each possible entry pattern. Each set of entry choices yields a subgame, the equilibrium payoffs to which affect the sellers' strategic entry choices.

2.1 Stage 2: Post-entry Price Competition

Each of the 2^N possible combinations of the N sellers' entry decisions in stage 1 yields a set A of *active* sellers in stage 2. If there are no active sellers ($A = \{\}$), then no transaction occurs. In a second-price auction it is well known that each active seller has a dominant strategy to set its price equal to its cost.

Deriving the sellers' and the buyer's expected profits, the expected transaction price, expected total surplus, and sellers' expected market shares is easily accomplished using the cumulative distributions of the lowest and second-lowest cost draws from the set of distributions of the active sellers. The cumulative distribution of the lowest cost draw from the set A of active sellers is

$$G_{(1:A)}(c) = 1 - \left(\prod_{k \in A} [1 - F_k(c)] \right),$$

and it is defined only if there is at least one active seller. The cumulative distribution of the second-lowest cost draw from the set A of active sellers is

$$G_{(2:A)}(c) = 1 - \left(\prod_{k \in A} [1 - F_k(c)] \right) \left(1 + \sum_{k \in A} \frac{F_k(c)}{1 - F_k(c)} \right),$$

and it is defined only if there are at least two active sellers.

[8] Respectively, see Baker (1997), Brannman and Froeb (2000), and *United States v. Oracle Corp.*, 331 F. Supp. 2d 1098 (N.D. Cal. 2004).

[9] Respectively, see European Commission cases COMP/M.2256 (2001), COMP/M.4403 (2007), COMP/M.3083 (2003), and COMP/M.3512 (2004).

With multiple active sellers, active seller i's expected profit is

$$\overline{\pi}_i^A = \int_{\underline{c}}^{\overline{c}} \left(\int_c^{\overline{c}} (x-c)\, G'_{(1:A\setminus i)}(x)dx \right) F_i'(c)dc - e = \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A\setminus i} [1-F_k(c)] \right) F_i(c)dc - e,$$

where the second equality is derived using integration by parts. If seller i is the only active seller, then it is paid v_B and $\overline{\pi}_i^A = v_B - \int_{\underline{c}}^{\overline{c}} cF_i'(c)dc - e$. If seller i is inactive, then $\overline{\pi}_i^A = 0$.

With multiple active sellers, the expected price is

$$\overline{P}^A = \int_{\underline{c}}^{\overline{c}} cG'_{(2:A)}(c)dc.$$

If there is only one active seller, then $\overline{P}^A = v_B$. If there are no active sellers, then there is no price because no transaction occurs.

With multiple active sellers, the buyer's expected profit is

$$\overline{\pi}_B^A = \int_{\underline{c}}^{\overline{c}} (v_B - c)\, G'_{(2:A)}(c)dc,$$

which is simply v_B minus the expected price, $\overline{P}^A$. With one or zero active sellers, $\overline{\pi}_B^A = 0$.

With one or more active sellers, expected total surplus is

$$\overline{TS}^A = \int_{\underline{c}}^{\overline{c}} (v_B - c)\, G'_{(1:A)}(c)dc - |A|\, e,$$

where $|A|$ denotes the cardinality of the set A. With no active sellers, $\overline{TS}^A = 0$.

Sellers' market shares are used to provide guidance in antitrust analyses of horizontal mergers, and from a modeling perspective in bidding markets it is typical to equate seller i's market share with the probability it wins the procurement contest.[10] With multiple active sellers, active seller i's market share is

$$\overline{s}_i^A = \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A\setminus i} [1-F_k(c)] \right) F_i'(c)dc.$$

Seller i's share is simply the probability that seller i wins when it has cost c, integrated over all possible values of c, weighted by the density at each c. If seller i is the only active seller, then $\overline{s}_i^A = 1$. If seller i is inactive, then $\overline{s}_i^A = 0$.

As noted in the introduction, another potentially useful measure when assessing a horizontal merger is the probability that seller i wins the auction and seller j comes in second place. That probability, which effectively is a conditional market share, is

$$\overline{s}_{i,j}^A = \int_{\underline{c}}^{\overline{c}} \left(F_i(c) \prod_{k\in A\setminus\{i,j\}} [1-F_k(c)] \right) F_j'(c)dc.$$

This share is calculated by considering, for each cost for seller j, the probability that seller i's cost is lower

[10] For example, see Dalkir, Logan, and Masson (2000) and Waehrer and Perry (2003).

than seller j's, and all other sellers' costs are higher than seller j's.

Earlier I wrote that one could analyze mergers using different transaction mechanisms in the model's post-entry price competition stage, such as a first-price auction or multilateral negotiations, but one also could consider different informational or preference environments. For example, the buyer might have different preferences for different sellers' products, so the sellers would compete more generally by offering surplus to the buyer. Thomas and Wilson (2014) and Thomas (2014) consider a procurement setting in which the buyer's preferences are its private information, which is similar to the approach taken in merger cases such as Oracle/PeopleSoft (enterprise application software), Siemens/Draegerwerk (medical ventilators and anesthesia delivery systems), Siemens/VA Tech (equipment for hydroelectric power plants), and EADS/Nokia (professional mobile radio systems).[11] Engelbrecht-Wiggans, Haruvy, and Katok (2007) and Shachat and Swarthout (2010) consider settings in which each seller knows the buyer's preferences only for its product, and one also could consider preference differences that are common knowledge among all players. The latter two approaches might be appropriate in certain circumstances.

2.2 Stage 1: Strategic Entry Decisions

The sellers' equilibrium entry choices can be determined using the expected profits in each subgame associated with a possible configuration of entry choices.

The analyses by McAfee and McMillan (1987) and Levin and Smith (1994) of contest-level entry costs in symmetric models revealed there exist multiple equilibria that differ in sellers' entry decisions.[12] For example, suppose two sellers draw their costs from the same distribution, and each has an expected payoff of $4 - e$ if both sellers are active, and an expected payoff of $8 - e$ if it is the only active seller. Figure 1a shows a normal-form representation of the entry portion of the 2-stage game, where the payoffs shown are the equilibrium expected profits from the post-entry price competition stage. The entry game's Nash equilibria change as e varies. If $e < 4$, then each seller enters with probability 1. If $e > 8$, then each seller enters with probability 0. If $4 < e < 8$, then there exist three Nash equilibria of the entry portion of the 2-stage game. In one, seller 1 enters with probability 1 and seller 2 enters with probability 0, while in another the sellers' roles are reversed. In the third, each seller enters with probability $\frac{8-e}{4}$, which declines smoothly from 1 to 0 as e increases from 4 to 8.[13] If there are more than two sellers, then there are even more asymmetric equilibria for certain values of e, say in which some sellers enter with positive probability and others enter with probability 0.

Figure 1

(a)

		Seller 2: Enter	Seller 2: Stay Out
Seller 1	Enter	$4-e, 4-e$	$8-e, 0$
	Stay Out	$0, 8-e$	$0, 0$

(b)

		Strong Seller: Enter	Strong Seller: Stay Out
Weak Seller	Enter	$2-e, 4-e$	$6-e, 0$
	Stay Out	$0, 8-e$	$0, 0$

In symmetric models that have equilibria with randomization, McAfee and McMillan (1987) emphasize pure strategy entry decisions, all of which are asymmetric. By contrast, Levin and Smith (1994) emphasize

[11] Respectively, see European Commission cases COMP/M.3216 (2004), COMP/M.2861 (2003), COMP/M.3653 (2005), and COMP/M.3803 (2005).

[12] Anderson and Engers (2007) thouroughly analyze a general symmetric entry game, with a brief and limited foray into asymmetries for the purpose of explaining the strategic underpinnings of comparative statics in the symmetric game.

[13] At the endpoints of 4 and 8, there are uncountably many mixed strategy Nash equilibria.

symmetric equilibria with randomization by sellers in the entry stage. Since the latter analysis there has been a tendency to focus on the symmetric mixed strategy equilibrium, because it is not clear to which asymmetric pure strategy equilibrium the players would gravitate.

Allowing for asymmetries across sellers reveals some subtleties when considering different entry equilibria. For example, consider competition between a *weak* seller and a *strong* seller illustrated by the normal-form game in Figure 1b that represents the entry portion of the 2-stage game. The weak seller's expected payoff from entry is $2-e$ if the strong seller also enters, and is $6-e$ if the strong seller stays out. The strong seller's expected payoff from entry is $4-e$ if the weak seller also enters, and is $8-e$ if the weak seller stays out. As in the symmetric game in Figure 1a, the entry game's Nash equilibria change as e varies. If $e<2$, then each seller enters with probability 1. If $2<e<4$ or $6<e<8$, then the weak seller enters with probability 0 and the strong seller enters with probability 1. If $e>8$, then each seller enters with probability 0. There are multiple equilibria if $4<e<6$. In one, the weak seller enters with probability 1 and the strong seller enters with probability 0. In another, the strong seller enters with probability 1 and the weak seller enters with probability 0. In the third, the weak seller enters with probability $\frac{8-e}{4}$ and the strong seller enters with probability $\frac{6-e}{4}$.

Given the findings and the argument from symmetric models, when looking at the normal-form game in Figure 1b it might seem sensible to focus on the mixed strategy Nash equilibrium for any particular $e\in(4,6)$. However, examining the equilibrium entry probabilities as a function of e reveals that emphasizing the mixed strategy Nash equilibrium leads to entry probabilities that increase as entry becomes more costly. As e increases from 0, the weak seller's entry probability equals 1, drops discontinuously to 0, increases discontinuously to 1 and declines smoothly to 1/2, and finally drops discontinuously and permanently to 0 for high e. The strong seller's equilibrium entry probability exhibits a similar non-monotonicity as e increases. With more sellers there once again can be even more asymmetric equilibria, with even more complicated combinations of non-monotonicity in the sellers' entry probabilities.

It seems reasonable to expect that a seller is less likely to enter a contest if doing so becomes more costly, so in my analysis of merger effects I consider only equilibria in which sellers' entry probabilities weakly decrease as e increases. I follow Levin and Smith (1994) by treating symmetric sellers identically, and if necessary I consider randomized entry decisions that do not violate monotonicity.[14] One benefit of this approach is that it leads to a unique equilibrium of the 2-stage game, because arbitrarily asymmetric sellers drop out one at a time as e increases. That is, each seller's entry probability equals 1 for a range of low e, then drops discontinuously and permanently to 0 once e exceeds a threshold.[15]

My equilibrium selection is based on what I consider a reasonable criterion, and it is sufficient to establish that merger effects can be qualitatively different with contest-level entry costs. However, the subtleties associated with the asymmetric setting reveal some potentially interesting issues worth exploring, compared to the symmetric setting in which the symmetric equilibrium seems like a reasonable one to emphasize. For example, the buyer might prefer to strategically limit the number of sellers it invites to participate in its procurement contest, because such limitations can lead to more actual entry, on average.[16] One question in asymmetric procurement settings is whether the buyer's optimal choice of invitations leads to an outcome equivalent to the pure strategy entry equilibria I consider. The buyer perhaps might prefer inviting weaker

[14] Note that non-monotonicity does not arise with randomization in a symmetric setting emphasizing symmetric equilibria, because each seller uses the same entry probability that starts at 1 and declines smoothly to 0 as e increases.

[15] There are at least two lesser benefits of this approach. First, one must think carefully about the profitablity of a merger for which the merging sellers randomize their entry decisions premerger and postmerger, because expected profits are 0 in both cases. Second, sellers' randomized entry decisions vary with v_B, but their non-random entry decisions do not.

[16] See van Dijk (2005).

sellers rather than stronger ones, if doing so leads to greater entry and a lower expected price.

There are other approaches for modeling entry, such as having entry costs differ across sellers, or having a seller's entry cost be its private information. In Section 4 I discuss such approaches, and argue that they seem unlikely to alter the merger predictions from the basic model, because the merger makes entry by the merged seller more profitable for a larger range of entry costs, however those costs are modeled.

3 Assessing Merger Effects

In this section I evaluate how a merger of two sellers affects the expected profits of the merging sellers, their rivals, and the buyer. By varying the underlying cost distributions I can assess how merger effects vary in different premerger environments. Unfortunately, merger effects cannot be catalogued by tidy analytic solutions, so first I describe what I can using the basic procurement model from Section 2, then I demonstrate various effects with a set of numerical examples.

I model a horizontal merger of sellers i and j using a standard approach in the literature: Letting M denote the merged seller, seller M's cost draw is the minimum of the cost draws of sellers i and j. Waehrer (1999), Dalkir, Logan, and Masson (2000), Brannman and Froeb (2000), and Waehrer and Perry (2003) use this approach, which need not be interpreted literally as the merged seller keeping its members' production facilities. Rather, it reflects that the merger does not change the overall cost conditions of the two sellers jointly, in much the same way as the approach taken by Perry and Porter (1985) in the context of Cournot oligopoly. This structure's purpose is to emphasize the merger's strategic effects separately from any effects caused by cost changes in the market.[17] The merged seller's cost distribution is

$$F_M(c) = 1 - [1 - F_i(c)]\,[1 - F_j(c)]\,.$$

I assume seller M learns it cost draw by expending e, rather than $2e$ or some other amount. This seems like a reasonable approach, given my initial assumption that the N potentially asymmetric sellers incur the same cost e to learn their production cost, but I discuss it further in Section 4.

In the standard model of a second-price auction without contest-level entry costs, the cause of a merger's anticompetitive effects is easily understood: sellers have a dominant strategy to set their price equal to their production cost, both premerger and postmerger. Therefore, a merger affects the market outcome only if the merging sellers would have had the lowest and second-lowest costs, in which case the transaction price increases to what would have been the third-lowest cost premerger. A merger does not affect rivals' expected profits or expected total surplus, so the buyer's expected profit decreases by exactly the merged sellers' profit gain. Every merger is anticompetitive, but to different extents depending on the merging sellers' cost positions. Moreover, entry will not be induced when post-entry price competition occurs as a second-price auction, because the merger leaves rivals' expected profits unchanged. Therefore, new sellers' entry into the market will not deter or counteract the merger's anticompetitive harm.[18]

[17] Thomas (2004) considers a more general post-merger cost distribution that permits one to assess how changes in efficiency influence the competitive effects of mergers in bidding markets.

[18] As noted by Waehrer (1999), new entry into the market might be induced if post-entry price competition occurs as a first-price auction, because a merger might increase the expected profits of non-merging sellers, including those not presently in the market.

3.1 Theoretical Description of Merger Effects

To understand merger effects in procurement settings with contest-level entry costs, I consider how a merger affects post-entry price competition in every subgame. The important finding is that the merged seller's expected profit is higher than the sum of the merging sellers' premerger expected profits, versus any set of active rivals. This result, shown in Lemmas 1 and 2, directly influences the merger's effect on the game's equilibrium outcome, as shown in Propositions 1, 2, and 3. The Appendix contains all proofs.

Lemma 1 *Consider any subgame in which sellers i and j both are active premerger. If seller M is active postmerger in the corresponding subgame, then the merger strictly increases the merging sellers' expected profits, leaves rivals' expected profits unchanged, strictly decreases the buyer's expected profit, strictly increases the expected price, and strictly increases expected total surplus.*

In this scenario the merger's effects on rival sellers, the buyer, and the expected price occur for the same reason as in the standard model without contest-level entry costs: the merger affects the transaction price only if the merging sellers would have had the lowest and second-lowest cost draws, in which case the price increases to what would have been the third-lowest cost premerger. The merging sellers' expected profits likewise increase because of that effect on the transaction price, but they additionally increase by e because the merged seller must only pay e once to learn its production cost, whereas premerger each merging seller had to expend e. The latter effect also increases total surplus by e. Lemma 1's description of merger effects versus an arbitrary set of rivals leads immediately to Proposition 1.

Proposition 1 *Consider a contest whose premerger equilibrium has sellers i and j both entering against a set A of active sellers. Against that same set A of active sellers, seller M enters. The merger strictly increases the merging sellers' expected profits, leaves rivals' expected profits unchanged, strictly decreases the buyer's expected profit, strictly increases the expected price, and strictly increases expected total surplus.*

Proposition 1 demonstrates the anticompetitive effects that arise in overlap contests, while the following results illustrate the prospect for procompetitive effects that can arise in non-overlap contests.

Lemma 2 *Consider any subgame in which seller i is active premerger, but seller j is not. If seller M is active postmerger in the corresponding subgame, then the merger strictly increases the merging sellers' expected profits, strictly decreases rivals' expected profits, strictly increases the buyer's expected profit, strictly decreases the expected price, and strictly increases expected total surplus.*

In Lemma 2's scenario the merger essentially is equivalent to making seller i a stronger competitor, in the sense of having a more favorable cost distribution. In a second-price auction that improvement for seller i is always profitable:[19] its expected profit is the same for any particular cost draw premerger and postmerger, is higher for lower cost draws, and the merger increases the likelihood of low cost draws. Rival sellers are harmed because seller M's lower expected cost can cause a rival to lose when it would have won premerger, and can reduce the price the rival receives when it still wins the contest. Lemma 2 leads immediately to Proposition 2.

Proposition 2 *Consider a contest whose premerger equilibrium has seller i entering, but not seller j, against a set A of active sellers. Against that same set A of active sellers, seller M enters. The merger strictly*

[19] Thomas (1997) shows such an improvement need not be profitable in a first-price auction, which should be noted if one considers different transaction mechanisms in the game's post-entry price competition stage.

increases the merging sellers' expected profits, strictly decreases rivals' expected profits, strictly increases the buyer's expected profit, strictly decreases the expected price, and strictly increases expected total surplus.

The final scenario to consider is subgames in which neither merging seller enters premerger.

Proposition 3 *Consider a contest whose premerger equilibrium has neither seller i nor seller j entering against a set A of active sellers. Against that same set A of active sellers, seller M might enter. If seller M enters, then the merger strictly increases the merging sellers' expected profits, strictly decreases rivals' expected profits, strictly increases the buyer's expected profit, strictly decreases the expected price, and strictly increases expected total surplus. If seller M does not enter, then the merger has no effect.*

Seller M might enter postmerger when neither seller i nor j entered premerger, because by Lemmas 1 and 2 seller M's postmerger expected profit strictly exceeds what i, j, or i and j jointly expected to receive premerger. For the same e, seller M obtains a better average cost draw than either merging seller would have received individually. The increased expected profit might be enough to induce seller M to enter against the active rivals in A.

One nuance to consider when using the Propositions to analyze merger effects is that the merger might change rivals' entry decisions, so that seller M might not face the same active rivals as did sellers i and j. Such outcomes will be shown in the numerical examples presented in the next subsection.

Assessing merger effects likely will be even more complex if post-entry price competition uses first-price auction rules rather than the second-price auction rules I consider. Among other things, a merger might not be profitable because it changes rivals' behavior in both the entry and pricing stages, and it might reduce total surplus because of allocative inefficiency.

3.2 Numerical Demonstration of Merger Effects

In this subsection I calculate merger effects using a set of numerical examples, to complement the preceding subsection's more abstract description of possible merger effects. The analysis requires specifying parameters, and for simplicity I assume the sellers' costs are drawn from power distributions that have a uniform distribution on $[0, 1]$ as their base. The cumulative distribution of seller i's production costs is

$$F_i(c) = 1 - (1 - c)^{t_i},$$

where $t_i > 0$ can be considered the "number" of draws seller i takes from a distribution that is $U[0, 1]$. Sellers with more cost draws are stronger than sellers with fewer cost draws, in the sense of having lower expected costs. Waehrer and Perry (2003) interpret t_i as a measure of seller i's capacity in their careful analysis of second-price auctions with power distributions. A merger of sellers i and j combines their capacity, so the merged seller's cost distribution is

$$F_M(c) = 1 - (1 - c)^{t_i + t_j}.$$

Expected profits when there are at least two active sellers are

$$\overline{\pi}_i^A = \frac{t_i}{\left(1 + \sum_{j \in A \setminus i} t_j\right)\left(1 + \sum_{j \in A} t_j\right)} - e$$

and

$$\overline{\pi}_B^A = v_B - \left(\sum_{i \in A} \frac{1}{1 + \sum\limits_{j \in A \setminus i} t_j} \right) + \frac{|A| - 1}{1 + \sum\limits_{i \in A} t_i}.$$

If seller i is the only active seller (recalling that price in this case is v_B), then expected profits are

$$\overline{\pi}_i^A = v_B - \frac{1}{1 + t_i} - e$$

and

$$\overline{\pi}_B^A = 0.$$

Within any set of active sellers, sellers with higher t_i have higher expected profits.

I present four examples that each have four sellers whose capacities sum to 4, so for each example the distribution of the lowest cost in the market is as if the market consists of four equal-sized firms with costs uniformly distributed on $[0, 1]$. The first example considers a merger in an initially symmetric setting, while the next three consider three of the six possible two-seller mergers from the same initially asymmetric setting: the merger of the two small sellers, the two medium sellers, and the two large sellers. I set $v_B = 3$, and I let e vary to enable merger assessment under different premerger entry patterns.

Merger in a symmetric setting: First consider a symmetric premerger setting in which $t_i = 1$ for each $i \in \{1, 2, 3, 4\}$. Table 1 reports premerger expected profits for each post-entry subgame with at least one active seller, which depend on the number of active sellers but not their identities.

Table 1

$\lvert A \rvert$	π_i^A for $i \in A$	π_B^A
4	$0.05 - e$	2.6
3	$0.0833 - e$	2.5
2	$0.1667 - e$	2.3333
1	$2.5 - e$	0

For $e < 0.05$ each seller enters the contest with probability 1, because its expected profit is positive even if all of its rivals enter. When e reaches 0.05, a seller is indifferent between staying out of the contest and entering it, if its rivals are entering with probability 1. As e increases beyond 0.05, the sellers therefore begin to randomize their entry decisions. For $0.05 \leq e \leq 2.5$ each seller enters with probability

$$1.02273 - \frac{0.121697}{\left(6.24375 + \sqrt{1.03634 + (6.24375 - 130.68e)^2} - 130.68e\right)^{\frac{1}{3}}} + 0.120258 \left(6.24375 + \sqrt{1.03634 + (6.24375 - 130.68e)^2} - 130.68e\right)^{\frac{1}{3}},$$

which declines smoothly from 1 to 0 as e increases from 0.05 to 2.5. In this range of e the buyer's expected profit declines smoothly from 2.6 to 0 as e increases, and each seller's expected profit is 0 because willingness to randomize requires the seller to be indifferent between entering and not entering the procurement contest. For $e > 2.5$ each seller enters with probability 0, so the buyer's and the sellers' expected profits are 0. To provide a baseline for assessing merger effects, Figure 2a shows the sellers' premerger entry probabilities as a function of e, while Figure 2b shows the buyer's expected profit.

Figure 2 about here

Table 2 reports postmerger expected profits following the merger of sellers 1 and 2, for each post-entry subgame with at least one active seller.

Table 2

A	π_M^A	π_3^A	π_4^A	π_B^A
$\{M,3,4\}$	$0.1333-e$	$0.05-e$	$0.05-e$	2.5667
$\{M,3\}$	$0.25-e$	$0.0833-e$	0	2.4167
$\{M,4\}$	$0.25-e$	0	$0.0833-e$	2.4167
$\{3,4\}$	0	$0.1667-e$	$0.1667-e$	2.3333
M	$2.6667-e$	0	0	0
3	0	$2.5-e$	0	0
4	0	0	$2.5-e$	0

For $e < 0.05$ each seller enters the contest with probability 1, because its expected profit is positive even if all of its rivals enter. The merger is profitable, reduces consumer surplus, and increases total surplus, all of which reflects Proposition 1's description of merger effects in overlap contests. Figure 2b shows that the reduction in consumer surplus is modest.

Because seller M's expected profit exceeds that of sellers 3 and 4 when all sellers enter, only sellers 3 and 4 start randomizing their entry decisions when e reaches 0.05. For $0.05 \leq e \leq 0.0833$ sellers 3 and 4 each enter with probability $2.5-30e$, which declines smoothly from 1 to 0 as e ranges from 0.05 to 0.0833. Once again the merger is profitable and harms the buyer; Figure 2b shows the buyer's expected profit declines sharply from 2.5667 to 0 in that very short range of e.

Sellers 3 and 4 drop out entirely from the contest once e reaches 0.0833, whereas premerger they entered with positive probability until e reached 2.5. For $0.0833 \leq e \leq 2.6667$ only seller M enters. In this range of e the merger is profitable and reduces the buyer's expected profit to 0. Finally, for $e > 2.6667$ each seller enters with probability 0, so the buyer's and the sellers' expected profits are 0.

To sum up, the merger of sellers 1 and 2 reduces the buyer's expected profit a relatively small amount when e is small and all sellers enter both premerger and postmerger. However, the merger induces seller M to enter the procurement contest for higher values of e, which greatly diminishes the entry incentives of sellers 3 and 4. These changes in entry behavior dramatically reduce the buyer's expected profit, as shown in Figure 2b: the buyer's expected profit plummets from its premerger level once sellers 3 and 4 start randomizing their entry choices.

Notice that the most dramatic merger effects, with high e, are not arising because the contest was an overlap contest premerger; one or both of the merging sellers might not have competed in the contest. Instead, the merger harms the buyer by changing the sellers' entry decisions.

Mergers in an asymmetric setting: Now consider an asymmetric premerger setting in which $t_1 = \frac{1}{3}$, $t_2 = \frac{2}{3}$, $t_3 = \frac{4}{3}$, and $t_4 = \frac{5}{3}$. Table 3 reports premerger expected profits, and to economize on space I list only the non-empty sets of active sellers that arise in equilibrium. For low values of e all four sellers enter. Seller 1 stops entering when e increases to 0.0143, seller 2 stops entering when e increases to 0.0357, seller 3 stops entering when e increases to 0.125, and seller 4 stops entering when e increases to 2.625. For higher values of e no sellers enter the procurement contest.

Table 3

A	π_1^A	π_2^A	π_3^A	π_4^A	π_B^A
$\{1,2,3,4\}$	$0.0143-e$	$0.0308-e$	$0.0727-e$	$0.1-e$	2.5822
$\{2,3,4\}$	0	$0.0357-e$	$0.0857-e$	$0.119-e$	2.5452
$\{3,4\}$	0	0	$0.125-e$	$0.1786-e$	2.4464
$\{4\}$	0	0	0	$2.625-e$	0

A merger of sellers 1 and 2 combines the two smallest of the four sellers, and the merged seller remains the smallest ($t_M = 1 < t_3 < t_4$). The right half of Figure 3 shows the postmerger market outcomes as a function of e, which can be contrasted with the left half's premerger market outcomes to determine merger effects. For $e < 0.0143$, the merger involves an overlap contest in which sellers 1 and 2 both are active premerger. Per Proposition 1, this merger is profitable, reduces consumer surplus, and increases total surplus. For $0.0143 < e < 0.05$, the merger involves a non-overlap contest. The merger is profitable, harms rival sellers, and increases both consumer and total surplus. This range of e illustrates the two related ways a merger can be procompetitive. For $e \in (0.0143, 0.0357)$, seller 2 enters premerger and seller 1 does not. The merger strengthens the competitive position of the previously active seller 2, as in Proposition 2. For $e \in (0.0357, 0.05)$, sellers 1 and 2 both are inactive premerger, but the merger strengthens their competitive position to induce entry that otherwise would not occur, as in Proposition 3. For $e > 0.05$, the merger has no effect, because sellers 1 and 2 are inactive premerger, and seller M is inactive postmerger.

Figure 3 about here

A merger of sellers 2 and 3 combines the two medium-sized of the four sellers, and the merged seller become the new largest seller ($t_M = 2 > t_4 > t_1$). The right half of Figure 4 shows the postmerger market outcomes as a function of e. For $e < 0.0357$, the merger involves an overlap contest in which sellers 2 and 3 both are active premerger. The merger is profitable, reduces consumer surplus, and increases total surplus. For $0.0357 < e < 0.119$, the merger involves a non-overlap contest in which seller 3 is active premerger, but seller 2 is not. The merger is profitable, harms rival sellers, and increases both consumer and total surplus. In contrast to the merger of the two smallest sellers, the merger of the two medium-sized sellers has an additional range of high e in which the merger reduces consumer surplus. For $0.119 < e < 0.125$, the buyer is harmed even though the merger involves a non-overlap contest. The reason is that seller M's stronger competitive position harms seller 4, who now exits despite being active premerger in this range of e. Finally, for $0.125 < e < 2.6667$, the merger has no effect on consumer surplus, but increases total surplus, because the now-active seller M has lower expected costs than does seller 4, who was active premerger in most of this range of e.

Figure 4 about here

Finally, a merger of sellers 3 and 4 combines the two largest of the four sellers, with the merged seller continuing as the market leader ($t_M = 3 > t_2 > t_1$). The right half of Figure 5 shows the postmerger market outcomes as a function of e. This merger does not change the non-merging sellers' entry patterns, with sellers 1 and 2 dropping out at the same e as they would have premerger (0.0143 and 0.0357, respectively). Moreover, sellers 3 and 4 competed in every contest premerger with two or more sellers, so every such contest is an overlap contest. Consequently, every merger decreases consumer surplus and increases total surplus, for $e < 0.125$, and leaves consumer surplus unchanged while increasing total surplus for $0.125 < e < 2.75$.

Figure 5 about here

A general way to think about merger effects when sellers must incur contest-level entry costs is that the merger increases the range of entry costs for which the merged seller will enter, beyond the highest e for which one of the merging sellers would have entered premerger. Seller M's increased incentive to enter benefits the buyer and increases total surplus, all else equal. However, seller M's changed incentives harm rivals, and might induce them to become inactive for lower e than in the premerger setting. The latter effect can harm the buyer, as seen in Figure 4 with the merger of the two medium-sized sellers, for $e \in (0.119, 0.125)$.

While it is important to recognize that the procompetitive effects of mergers in non-overlap contests are ignored by traditional analysis, the purpose of demonstrating the possibility of such effects is not to help get mergers approved that are harmful. Rather, the goal is to provide more insight so as to get procompetitive mergers approved.

4 Policy Guidance and Modeling Extensions

While the paper's main insight for antitrust policy is the importance of considering a horizontal merger's procompetitive effects in non-overlap contests, in this section I consider three additional aspects of the analysis. First, I use Section 3's results to assess the suitability of two informal methods used by antitrust authorities in bidding markets with contest-level entry. Next, I discuss modeling extensions and their likely impact on the paper's main insight. Finally, I describe issues that seem relevant for using the basic procurement model to conduct merger simulations.

4.1 Informal Approaches for Considering Contest-Level Entry

Frequency analysis: I can use the numerical examples to assess the suitability for predicting merger effects of the frequency analysis that is based on the fraction of contests in which both merging sellers compete. This analysis is more common than is the complementary analysis that assesses how frequently the merging sellers place first and second in contests in which both compete, because the latter analysis has data requirements that are more demanding. Determining the validity of the conclusion that a merger's anticompetitive effect increases in the frequency of overlap requires an appropriate means of comparison.

As a first step I use the numerical example with symmetric sellers to show that a merger's anticompetitive harm might not increase in the frequency of overlap, which contradicts how the results from frequency analyses are interpreted. Figure 2 shows that the loss of consumer surplus is smallest in what are surely overlap contests, when $e < 0.05$. The frequency of overlap is smaller when $e > 0.05$ than when $e < 0.05$, but the loss of surplus is much greater (in both levels and percentage terms). Although this example is somewhat special because of its symmetry, the starkness of the merger effects might suitably represent asymmetric examples that consider randomized entry decisions rather than the deterministic decisions that I emphasize.[20]

Next I use the merger of small sellers in the numerical example with asymmetric sellers. Because the sellers do not make randomized entry decisions, the merger's effect on consumer surplus depends closely on e. Referring back to Figure 3, suppose that e is a random variable that has probability $\frac{1}{4}$ of being in each of the following intervals: $(0, 0.0143)$, $(0.0143, 0.0357)$, $(0.0357, 0.05)$, and $(0.05, 0.125)$. With this

[20] I began this project by focusing on mergers in settings with randomized entry decisions, because I was curious about merger profitability given that a sellers' expected profit is zero if it is randomizing its entry decisions. Such entry behavior seemingly leads to issues similar to those explored by Salant, Switzer, and Reynolds (1983) in the context of Cournot competition.

distribution for e, premerger the average expected consumer surplus is 2.5051, and the frequency of overlap is 25%. Postmerger the average expected consumer surplus increases by 0.0395 to 2.5446.

Now suppose the distribution of e shifts so the probability of e being in each of the intervals $(0.0143, 0.0357)$ and $(0.0357, 0.05)$ is $\frac{3}{8}$, while the probability of e being in the interval $(0.05, 0.125)$ is 0. With this distribution for e, premerger the average expected consumer surplus is 2.5174, but the frequency of overlap remains at 25%. Postmerger the average expected consumer surplus increases by 0.0599 to 2.5773. Consequently, the merger's effect on consumer surplus can vary while holding constant the frequency of overlap and the sellers' underlying cost distributions.

Next, starting from the original distribution for e, with probability $\frac{1}{4}$ of being in each interval, suppose the probability of e being in each of the intervals $(0, 0.0143)$, $(0.0143, 0.0357)$, and $(0.0357, 0.05)$ changes to $\frac{1}{3}$. This change in the distribution of e increases the frequency of overlap from 25% to 33%. Premerger the average expected consumer surplus is 2.5246, and postmerger it increases by 0.0527 to 2.5773. Consequently, the buyer can be better off from a given merger as the frequency of overlap increases, holding constant the sellers' underlying cost distributions.

Finally, the buyer can be worse off from the merger of the smaller sellers than from the merger of the medium-sized sellers, even though the latter merger involves greater frequency of overlap, greater frequency of the merging sellers placing first and second when both are active, and higher market shares for the merging sellers. For example, if e is distributed $U[0, 0.119]$, then straightforward calculation shows that the merger of the smaller sellers increases average expected consumer surplus by 0.0209 (from 2.4805 to 2.5014), while the merger of the medium-sized sellers increases average expected consumer surplus by 0.0311 (from 2.4805 to 2.5116).

The preceding results suggest that antitrust authorities' frequency analyses might not be useful predictors of a merger's anticompetitive effects. While the theoretical results show that anticompetitive harm arises in overlap contests, which is consistent with conclusions that are drawn from frequency analyses, the numerical results show a more nuanced picture. In particular, it is easy to generate examples in which mergers with a higher frequency of overlap are better for the buyer than are mergers with a lower frequency of overlap.

Inactive sellers: The numerical results also reveal that the premerger presence of inactive sellers in particular contests does not necessarily insulate the associated buyers from postmerger harm. The nature of post-entry price competition might be such that inactive sellers have no additional incentive to enter, even if the merger increases the expected price. For example, in each of the numerical examples, there are no instances in which a reduction in consumer surplus was prevented by contest-level entry by non-merging sellers who were inactive premerger. Likewise, mergers that increase consumer or total surplus do not do so because previously inactive non-merging sellers become active postmerger.

That being said, having inactive sellers might prevent harm if the buyer no longer invites the merged seller. For example, suppose the buyer invites two of four identical sellers to compete premerger, and a third would not participate if invited, if it thought the other two sellers would be active. If the two active sellers merge, then the seller can avoid harm by instead inviting the two non-merging sellers, leading to no net change in the buyer's expected profit. However, matters are less clear if the sellers are asymmetric, because inviting different sellers alters cost conditions and hence the buyer's expected profit. Such considerations also illustrate that the informal argument's logic is unclear, because it does not appear to consider that existing sellers might be asymmetric premerger, or that the merged seller is different than either party was premerger. The latter issue leads to an interesting question, which is how closely do merged sellers' productive capabilities in procurement settings resemble the assumptions made in the auction literature?

The problems just revealed for both approaches suggest that an analyst wants to understand how buyers set up their procurement, why some sellers do not participate, characteristics of inactive sellers, and under what circumstances they are likely to enter. Operationally, this might look something like an entry analysis, in which the inactive sellers are considered the most likely entrants. In terms of information gathering, one potential problem is that procompetitive merger effects are driven by instances in which one or both merging sellers are inactive premerger, at least when prices are determined by second-price auction rules or an equivalent mechanism. Consequently, the most relevant information likely will be from the merging parties, which is problematic from the perspective of assessing the merits of the claims.

4.2 Modeling Extensions

Many extensions of the basic procurement model might be relevant in different procurement settings. Two that seem quite important are alternative entry protocols and efficiencies.

Alternative entry protocols: The entry model I use is simple, and it follows the lead of early analyses of contest-level entry such as McAfee and McMillan (1987) and Levin and Smith (1994), but it is somewhat special because it assumes all sellers have the same commonly known entry cost. Among other things, this approach exhibits multiple equilibria, which leads to issues of equilibrium selection that can affect conclusions regarding the comparative statics associated with horizontal mergers.

There are other ways to model entry in bidding markets. One could assume that sellers have different entry costs that are commonly known. Li and Zheng (2009) instead assumes the entry costs are privately known draws from a common distribution, with the idea that sellers will use cutoff strategies: each seller i enters the contest if and only if its e_i draw is less than its equilibrium cutoff. Finally, Ye (2007) considers a game with 2-stage entry, in which a seller gets a free signal of its production cost before making the costly decision to learn its costs for sure.

The preceding entry models seem unlikely to change the model's main insight, because the merger makes entry by the merged seller more profitable for a larger range of entry costs, however those costs are modeled. Moreover, it is not clear that those models yield a unique equilibrium of the 2-stage game. However, it probably is worth investigating merger effects in these settings; doing so might generate new insights relevant to merger analysis with contest-level entry costs, and might amplify the importance of thinking more carefully about how a merger changes the merged seller's entry cost

Another issue to consider is strategic entry limitation by the buyer, which I mentioned earlier when discussing the role of inactive sellers in protecting the buyer from harm. This strategy for the buyer usually is analyzed in the context of randomized entry decisions, but perhaps it makes sense even with deterministic entry decisions; strategic invitations might be a way for the buyer to select particular entry equilibria.

A final issue worth discussing is the assumption that the merged seller pays e to enter a contest, rather than $2e$ or some other amount. If seller M literally takes a draw from each merging seller's probability distribution, say in the sense of building two prototypes for a contract with the U.S. Department of Defense, then an argument for paying $2e$ might make sense. As mentioned earlier, however, the standard approach to modeling mergers in bidding markets is not necessarily interpreted literally as seller M keeping both merging sellers' production facilities, but rather as a means of keeping their overall productive capabilities unchanged.

If seller M must pay e for each of seller i's and seller j's cost draws, and has the option of which cost draws to pay for (if any), then a merger only has anticompetitive effects when transaction prices are determined

using second-price auction rules. Informally, the argument is that seller M will not take a cost draw from the distribution of any seller i who was inactive premerger. Seller M's gain from paying for such a cost draw equals seller i's premerger expected profit. Hence, if seller i found entry to be unprofitable premerger, then seller M will not want to pay for seller i's cost draw postmerger. Not surprisingly, if seller M's postmerger entry cost is between e and $2e$, then merger effects likewise are "in-between." Operationally, this suggests it would be worthwhile for an analyst to understand what constitutes a seller's contest-level entry cost, and how the merger affects it.

Efficiencies: Efficiencies play an important role in assessing horizontal mergers that otherwise are expected to be anticompetitive, much like analyzing new market-level entry does. As articulated in the US Horizontal Merger Guidelines, efficiencies must be merger-specific, reasonably verified, and not the result of anticompetitive reductions in quality or output.

It seems like efficiencies might have even stronger procompetitive effects in the setting with contest-level entry costs than in the setting without them. The reason is that efficiencies increase the merger benefits in non-overlap contests, which is where procompetitive effects arise without efficiencies. For example, consider the merger of the medium sellers (2 and 3) from the asymmetric example in Section 3.2, suppose e is distributed $U[0, 0.1]$, and suppose the merger-specific efficiency reduces seller M's expected cost by 10%, from $\frac{1}{3}$ to 0.3. With such an efficiency, $t_M = \frac{7}{3}$, whereas it equals 2 with no efficiency.

To see the effect of efficiencies in the different models, first consider merger effects without efficiencies. In the standard model without contest-level entry costs, average expected consumer surplus is 2.5822 premerger and is 2.5524 postmerger. The merger changes average expected consumer surplus by -0.0298. In the model with contest-level entry costs, average expected consumer surplus is 2.487 premerger and is 2.5126 postmerger. The merger changes average expected consumer surplus by 0.0256. Therefore, the difference in the two models' changes in average expected consumer surplus is 0.0554 when there are no efficiencies $(= 0.0256 - (-0.0298))$.

Now consider merger effects with efficiencies. In the standard model without contest-level entry costs, average expected consumer surplus is 2.5822 premerger and is 2.5689 postmerger. The merger changes average expected consumer surplus by -0.0133. In the model with contest-level entry costs, average expected consumer surplus is 2.487 premerger and is 2.5305 postmerger. The merger changes average expected consumer surplus by 0.0435. Therefore, the difference in the two models' changes in average expected consumer surplus is 0.0568 when there are no efficiencies $(= 0.0435 - (-0.0133))$.

In this example the difference in the two models' predictions is greater with efficiencies than without efficiencies. This finding suggests that efficiencies might have even stronger procompetitive effects when one accounts for contest-level entry.

Other extensions: Several other extensions might be worth considering, both to see how they affect the paper's main insight, and to yield new ones.

In terms of the sellers' uncertainty about each other, one could consider affiliation of the sellers' production costs, a common cost setting, or serial persistence of costs across contests. These changes would potentially affect sellers' entry and pricing decisions. One also could extend my numerical examples by using other distributions of the sellers' production costs. For example, some authors have used extreme-value distributions, while the Beta distribution has the appealing property that one can change independently the distribution's mean and variance. One also could let the supports of the cost distributions differ, which is

easily implemented when using second-price auction rules because of the sellers' dominant strategy to set their price equal to their cost.

In terms of behavior, one could consider endogenous mergers, or industry dynamics including notions such as collusion among the sellers, investments in productive capabilities, switching costs for buyers to change suppliers, incumbency effects that benefit past winners, capacity constraints, or learning-by-doing. Finally, the buyer might have choices that could counteract or deter a merger's anticompetitive effect, such as using a reserve price, dual-sourcing, or using other procurement mechanisms.

4.3 Merger Simulation

In principle the model can be used for merger simulations to generate quantitative insights about a particular merger. The purpose can simply be to provide some sense of magnitudes when formulating an opinion about a merger's likely impact on competition, or to provide specific quantitative predictions for evidentiary purposes. The possibilities will depend in part on the nature and quantity of data that can be collected. For details about the purpose and implementation of the merger simulation approach, see Dalkir, Logan, and Masson (2000), Brannman and Froeb (2000), Werden, Froeb, and Scheffman (2004), van Dijk (2005), Bengsston (2005), and Budzinski and Ruhmer (2010). Here I merely sketch some possible simulation approaches that account for contest-level entry; the real details will emerge only upon implementation in actual investigations.

The idea underlying merger simulation with procurement models is straightforward, and for simplicity I begin with a setting in which the standard model might be deemed informative because all sellers tend to participate in all contests. The general approach is to select a family of probability distributions from which the sellers' costs are drawn, with parameters that can vary by seller. Calibrate the model by choosing the parameters so that the model's equilibrium outcome matches measures like sellers' market shares or profit margins. Using margins rather than prices can accommodate differences in the size of contracts, to the extent that the cost technology exhibits constant returns to scale, so that contract size is simply a multiplier that does not affect equilibrium margins. With the calibrated model in hand, one implements the merger as in Section 3, then examines its effects on market outcomes.

Contest-level entry makes merger simulation more intricate than calibrating a single set of cost distributions and calculating percentage changes in price. Accounting for variation in entry patterns across contests might involve allowing sellers to have different cost distributions across different types of contests, while trading off a merger's procompetitive and anticompetitive effects across contests likely involves accounting for contract size.

A reasonable approach to consider is using standard simulation methods separately for each meaningfully grouped set of contests. Begin the process by determining the identities of the N sellers in the market, then group contests by which sellers actively competed. Although the number of possible sets of active sellers is large if N is large, only a few might appear in the data, and patterns might emerge. Moreover, if N is very large, then the investigation might close before reaching the simulation stage if preliminary information suggests the merger creates a low likelihood of harm.

It probably makes sense initially to assume that seller i has the same F_i for each contest featuring the same set A of active sellers, which is analogous to the standard simulation approach that assumes all sellers compete in all contests. However, the factual record might suggest further delineation of contest types within those contests featuring a particular set of active sellers.

The investigation also might support grouping contests that exhibit nesting subsets of active sellers. For

example, there might be a number of contests with sellers 1, 3, 5, 7, and 8 active. Similar contests might have sellers 1, 3, 5, and 7 active, others with sellers 1, 3, and 5 active, and still others with sellers 1 and 3 active. It might be reasonable to consider those contests to be the same, in terms of the sellers' underlying cost distributions F_i, with the different activity patterns reflecting different entry costs across the contests.

Finally, another aspect of grouping is whether entry occurs via the deterministic mechanism I consider, or via the random mechanism as in Levin and Smith (1994), which can lead to different interpretations of observed activity patterns. With deterministic entry, different combinations of the same number of active sellers reflect different underlying parameters, but with randomized entry might reflect a larger set of potentially active sellers. To make this assessment, discuss with sellers what factors influence their participation decision, in general and for specific contests.

After settling upon meaningful groups of contests, determine the total or average dollar value of the associated contracts. This information will be needed to quantify the dollar value of harm or benefit by contest, to enable assessment of a merger's expected net effect on buyers.

5 Conclusion

This paper illustrates that contest-level entry costs qualitatively affect predictions about the competitive effects of horizontal mergers in bidding markets: the intuition and policy prescriptions from standard auction models can be reversed by making the simple and empirically relevant change that sellers incur costs to participate in any particular procurement contest. The prevalence of such costs is evident from the variety of merger investigations that find substantial variation in sellers' participation across contests in an industry, such as Alcatel/Lucent Technology (telecommunication technology), Metso/Aker Kvaerner (equipment for chemical pulp mills), CommScope/Andrew (coaxial cable), Syniverse/BSG (data clearing services for Mobile Network Operators), EADS/SSTL (civil institutional satellites),[21] and the many other merger cases cited throughout the paper.

I find that profitable mergers without efficiencies can be procompetitive via a mechanism that echoes common claims from merging parties that their merger will make them a stronger competitor. When contest-level entry costs matter, a horizontal merger can lead to more and stronger entry by the merged seller into contests at least one of the merging sellers would have avoided premerger. Consideration of procompetitive benefits in such non-overlap contests is missing from antitrust analyses using the standard model of procurement without contest-level entry, in which all mergers are anticompetitive. Even with approaches informally developed to complement that stark modeling result, the standard approach can lead to recommendations to block mergers that are procompetitive under both consumer welfare and total welfare standards. While care must be taken in balancing a merger's procompetitive and anticompetitive effects across different buyers, the simpler observation is that contest-level entry costs lead to qualitatively different merger effects than do models in which sellers can enter a contest without incurring any costs.

The results suggest there are many more interesting questions to ask in this unexplored area. One can consider other exchange mechanisms to determine transaction outcomes, other preference environments, collusion amongst sellers across contests, efficiencies, and other entry models. The goal of such analyses would be to examine a variety of settings to find robust predictions about the likelihood of anticompetitive harm from horizontal mergers in the many settings with contest-level entry.

[21] Respectively, see European Commission cases COMP/M.4214 (2006), COMP/M.4187 (2006), COMP/M.4819 (2007), COMP/M.4662 (2007), and COMP/M.5168 (2008).

6 Appendix

For each of the proofs to follow, consider a set A that does not include the merging sellers or the merged seller (sellers i, j, or M). For each scenario I can show that seller M's expected profit versus the set A of active sellers exceeds the sum of seller i's and seller j's expected profits.

Nature's move that selects active sellers' production costs occurs after the sellers' simultaneous entry decisions, so that the price competition stage is a subgame for each configuration of entry choices.

Proof of Lemma 1: Consider a subgame in which sellers i and j both are active premerger, facing a (potentially empty) set A of active sellers that does not include the merging sellers or the merged seller (sellers i, j, or M). To show that the merger strictly increases the merging sellers' expected profits, one must show that $\overline{\pi}_i^{A\cup\{i,j\}} + \overline{\pi}_j^{A\cup\{i,j\}} < \overline{\pi}_M^{A\cup\{M\}}$. Using the formula for an active seller's expected profit,

$$\begin{aligned}
\overline{\pi}_i^{A\cup\{i,j\}} + \overline{\pi}_j^{A\cup\{i,j\}} &= \left(\int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A\cup\{j\}} [1-F_k(c)]\right) F_i(c)dc - e\right) + \left(\int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A\cup\{i\}} [1-F_k(c)]\right) F_j(c)dc - e\right) \\
&= \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1-F_k(c)]\right) \left(F_i(c)\left[1-F_j(c)\right] + F_j(c)\left[1-F_i(c)\right]\right) dc - 2e \\
&= \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1-F_k(c)]\right) \left(F_i(c) + F_j(c) - 2F_i(c)F_j(c)\right) dc - 2e \\
&< \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1-F_k(c)]\right) \left(F_i(c) + F_j(c) - F_i(c)F_j(c)\right) dc - 2e \\
&= \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1-F_k(c)]\right) F_M(c)dc - 2e \\
&< \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1-F_k(c)]\right) F_M(c)dc - e \\
&= \overline{\pi}_M^{A\cup\{M\}}.
\end{aligned}$$

The preceding argument is essentially the same as one would make in the model without contest-level entry costs, plus the cost savings of e leads to further increase in seller M's expected profit.

Similar arguments demonstrate the merger's effect on rivals' and the buyer's expected profits, the expected price, and expected total surplus.

Proof of Proposition 1: To be completed, but follows directly from Lemma 1.

Proof of Lemma 2: Consider a subgame in which seller i is active premerger, but seller j is not, facing a (potentially empty) set A of active sellers that does not include the merging sellers or the merged seller (sellers i, j, or M). To show that the merger strictly increases the merging sellers' expected profits, one must show that $\overline{\pi}_i^{A\cup\{i\}} + \overline{\pi}_j^{A\cup\{i\}} < \overline{\pi}_M^{A\cup\{M\}}$. Using the formula for an active seller's expected profit, and

recalling that inactive seller j's expected profit is 0,

$$\begin{aligned}\overline{\pi}_i^{A\cup\{i\}} + \overline{\pi}_j^{A\cup\{i\}} &= \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1 - F_k(c)] \right) F_i(c) dc - e \\ &< \int_{\underline{c}}^{\overline{c}} \left(\prod_{k\in A} [1 - F_k(c)] \right) F_M(c) dc - e \\ &= \overline{\pi}_M^{A\cup\{M\}}.\end{aligned}$$

In this instance the merger merely improves seller i's cost distribution, so seller M earns the same expected profit for each cost draw as seller i did premerger, plus seller M's average cost draw is lower.

Similar arguments demonstrate the merger's effect on rivals' and the buyer's expected profits, the expected price, and expected total surplus.

Proof of Proposition 2: To be completed, but follows directly from Lemma 2.

Proof of Proposition 3: To be completed, but follows directly from Lemmas 1 and 2.

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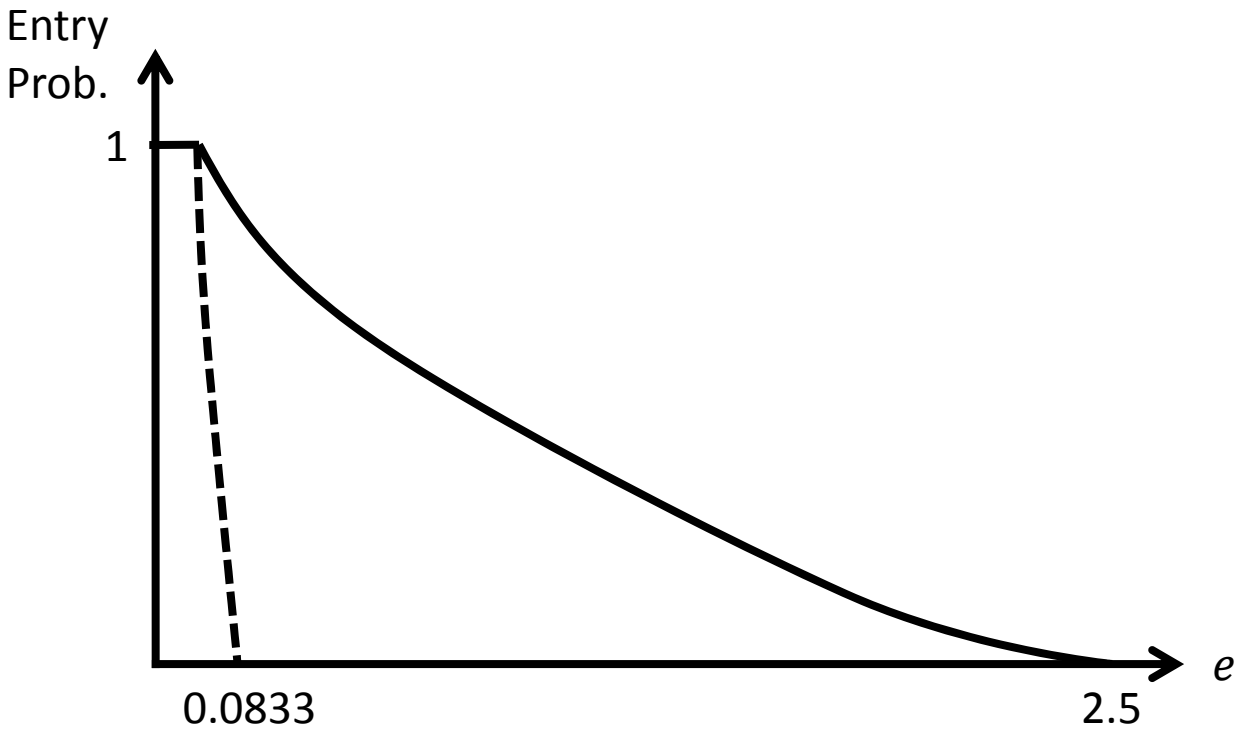
Fig. 2: Merger of Symmetric Sellers $\left(\underline{t_1 = 1}, \underline{t_2 = 1}, t_3 = 1, t_4 = 1\right)$



(a) Premerger (solid) and postmerger (dashed) entry probabilities

(b) Premerger (solid) and postmerger (dashed) π_B

Fig. 3: Merger of "Small" Sellers $\left(\underline{t_1 = {}^1/_3}, \underline{t_2 = {}^2/_3}, t_3 = {}^4/_3, t_4 = {}^5/_3\right)$

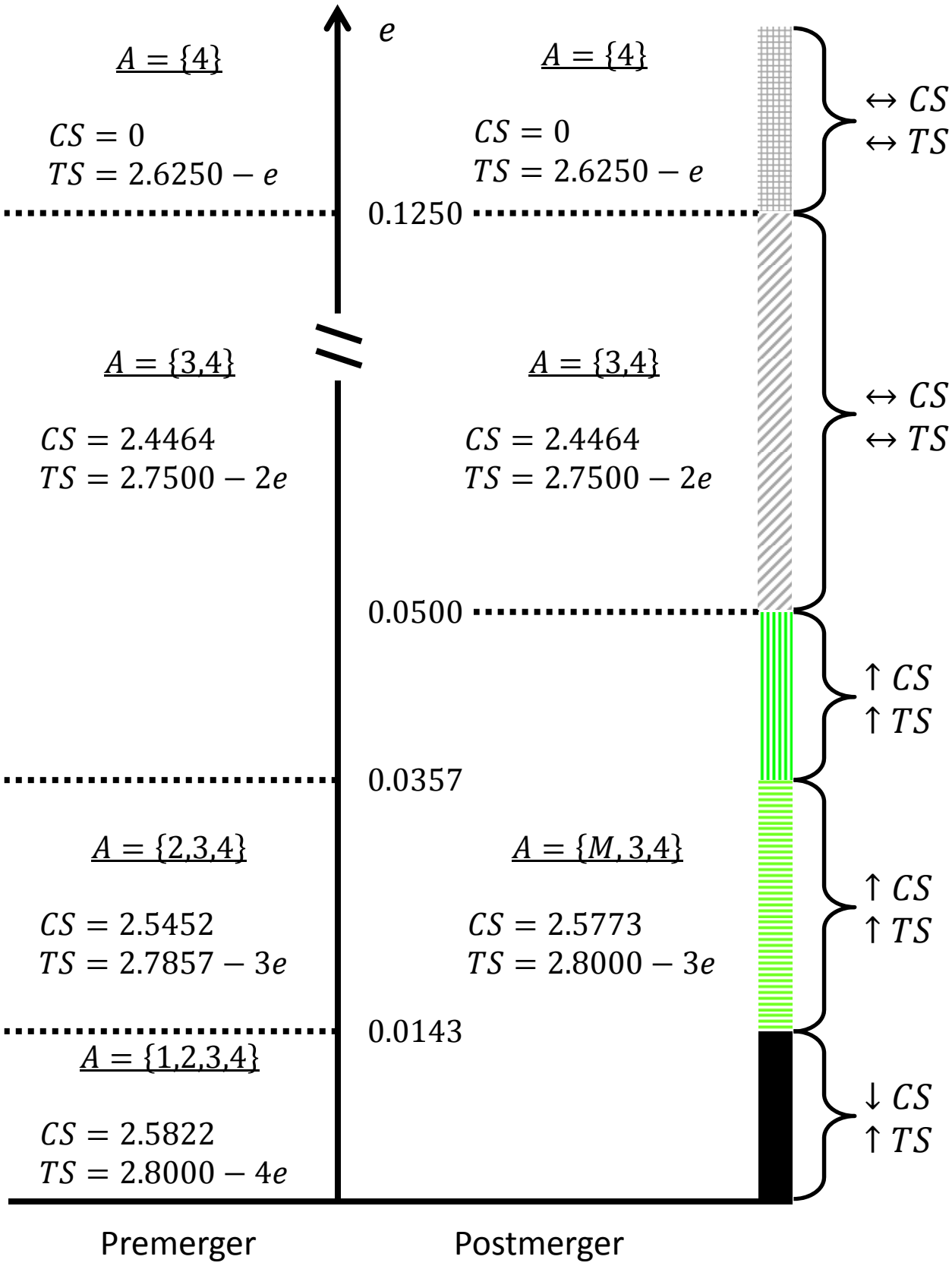


Fig. 4: Merger of "Medium" Sellers $\left(t_1 = {}^1/_3, \underline{t_2 = {}^2/_3}, \underline{t_3 = {}^4/_3}, t_4 = {}^5/_3\right)$

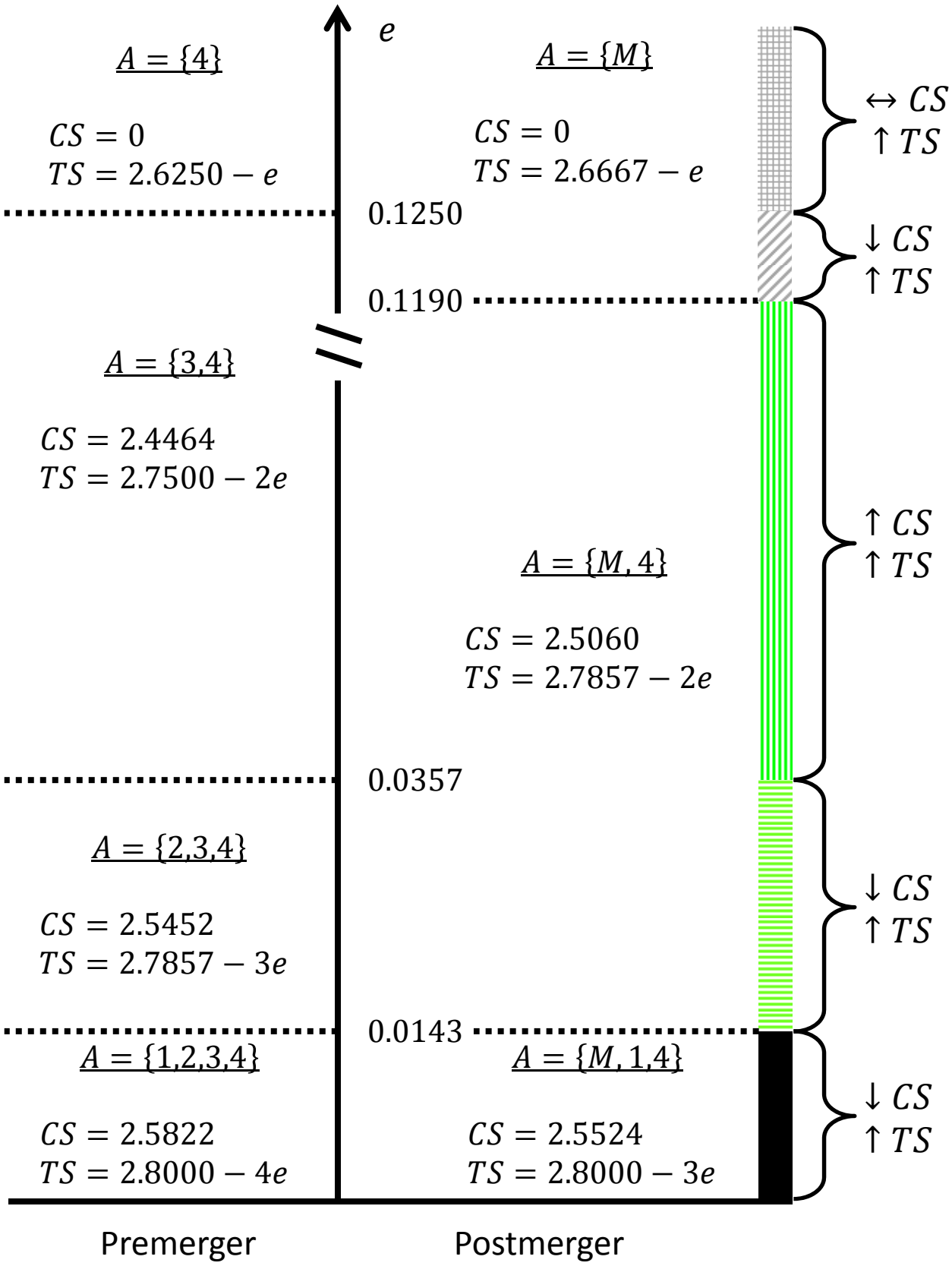


Fig. 5: Merger of "Large" Sellers $\left(t_1 = {}^1/_3, t_2 = {}^2/_3, \underline{t_3 = {}^4/_3}, \underline{t_4 = {}^5/_3}\right)$