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WP 11-01R

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Abstract

Abstract: This paper reports an experiment that evaluates three regimes for triggering the conversion of contingent capital bonds into equity: (a) a "regulator" regime, where socially motivated regulators make conversion decisions based on observed prices, (b) a "fixed trigger" regime where a price threshold triggers a mandatory conversion, and (c) a "prediction market" regime where we supplement the regulator's information set with the results of a prediction market that elicits traders' perceived likelihood of a conversion. Consistent with theory, we observe informational and allocative inefficiencies as well as numerous errors in conversion decisions in both the regulator and fixed trigger regimes. Contrary to theory, however, we also observe inefficiencies and frequent conversion errors in the prediction market regime. Although the fixed trigger and prediction market regimes are more informationally efficient than the regulator regime, allocative efficiencies remain low and conversion error rates high in all three regimes.

Keywords: bank regulation; experiments; contingent capital

JEL codes: C92; G14; G28

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1. Introduction

In the aftermath of the 2008 global financial crisis, economists and policymakers have devoted considerable attention to improving financial regulation. A primary focus of attention has been on developing policies to ensure that banks have equity cushions sufficient to maintain solvency in times of financial distress, in this way reducing the chance of collapse and taxpayer-funded bailout. One innovative proposal that has received particular attention involves having banks carry on their balance sheets a new class of subordinated debt that converts to equity in times of financial distress.[1] These "contingent capital" bonds offer a number of important advantages, the most prominent of which is that they allow banks to convert debt into equity on pre-specified terms in times of financial distress — precisely when raising equity is most difficult.[2] These advantages were of sufficient appeal in the U.S. for Congress to mandate a study of the characteristics of contingent capital in the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 and in the U.K. for the Independent Commission on Banking to recommend that banks use loss-absorbing debt like contingent capital in their capital structure.

Perhaps the most important and controversial issue for implementing contingent capital is determining what trigger to use for conversion. The two most prominent options are (i) leaving the conversion decision at the discretion of a regulatory authority, or (ii) using some market-based performance measure, such as a bank equity price, as a basis for a mandatory trigger.[3] Some government agencies have indicated a preference for leaving conversion at the discretion

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[1] Most of the proposed regulatory changes to capital requirements have focused on making them higher and procyclical. Indeed, some commentators argue that capital requirements should be much higher (e.g., Admati, DeMarzo, Hellwig and Pfleiderer, 2010). Contingent capital is not an alternative to raising capital requirements, but is instead a complement. Higher capital requirements certainly make a bank less likely to encounter financial distress, but at a cost. A variety of theories in corporate finance suggest that equity is an expensive source of funds (e.g., Myers and Maljuf (1984)) and in any case debt is an important part of a bank's financial structure. Further, unless capital requirements are extremely high, a bank could still find itself in a situation of financial distress and in that case, contingent capital would still be valuable.

[2] Another alleged benefit of contingent capital is that it gives incentives for managers to avoid excessive risk-taking (Calomoris and Herring, 2011) because equity owners are punished, at least when conversion substantially dilutes existing equity. Proposals to include contingent capital bonds on banks' balance sheets are not without critics. For example Acherya, Cooley, Richardson and Walter (2009) argue that contingent capital fails to eliminate financial institutions' incentives to take excessive risks because it fails to fully account for a bank's large volumes of other government-guaranteed assets, such as deposits and other non-contingent debt. Hart and Zingales (2010) argue that requiring banks to carry substantial contingent capital bonds on their balance sheets will delay the timing of defaults and thus delay needed managerial reorganizations. This list is not exhaustive. For example Admati, DeMarzo, Hellwig and Pfleiderer (2010) also articulate pertinent reservations.

[3] A third option is to rely on accounting measures. A problem with this option is that these measures often lag the actual condition of a bank.

of a bank regulator.[4] A group of academics, however, strongly advocate the use of a market price trigger (e.g., Flannery, 2009; McDonald, 2010; and Calomiris and Herring, 2011). These commentators argue that the political pressure imposed on discretionary regulators would make it harder for them to commit to convert when a bank was in trouble and would create harmful uncertainty as to when a conversion will occur.

Only recently has any bank issued contingent capital, so there is no empirical evidence to even analyze how it might work in practice.[5] Nevertheless, recent theoretical analysis suggests that basing contingent capital on a market-price trigger will not work. Bond, Goldstein and Prescott (2010) (‘*BGP’*) and Birchler and Facchinetti (2007) show that equilibrium need not exist in a rational expectations model where a regulator uses prices to decide whether to take actions that feedback to the value of the bank. They interpret nonexistence as indicating that prices need not efficiently transmit information, which will lead to errors in when the regulator takes an action. However, *BGP* also show that if there is a prediction market for whether the regulator intervenes then an equilibrium exists.

The potential for informational inefficiency, however, is not purely a consequence of leaving the conversion decision to a discretionary regulator. Sundaresan and Wang (2011) (‘*SW*’) show under quite general conditions that if conversion automatically occurs when the price of equity drops below some number, then no unique price exists for equity. They interpret this inability to price equity as a significant problem for implementing contingent capital.

This paper provides an additional source of information on the effectiveness of contingent capital with a market price trigger. We generate data with laboratory asset market experiments where the fundamental values of the traded security are affected by a contingent-capital like conversion. We examine the three regimes just discussed: a “regulator” regime, where an imperfectly informed, but socially motivated regulator makes conversion decisions[6]; a “fixed trigger” regime where crossing a publicly known price threshold triggers a mandatory conversion; and a “prediction market” regime where we supplement the information available to agents (both regulators and traders) with traders’ perceptions of the likelihood of a conversion. In

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[4] For example, Sundaresan and Wang (2011) report that the Canadian Office of the Superintendent of Financial Institutions prefers regulator discretion as a conversion trigger.

[5] Sundaresan and Wang (2011) report four issuances of contingent capital bonds, all since the recent financial crisis.

[6] It should be noted that our experiment with a discretionary regulator is not designed to study a regulator’s commitment problem, but instead how the regulator reacting to the price influences the information content of the prices as well as whether the regulator can effectively use the prices to decide when to intervene.

each regime we consider cases where the conversion transfers value from holders of contingent capital bonds to equity owners ("value-increasing conversions" for equity owners), as well as the case where the reverse occurs and conversion transfers value away from equity owners to holders of contingent capital bonds ("value-decreasing conversions" for equity owners).[7]

Our experimental results indicate that concerns about the potential for informational inefficiencies are well founded and merit prominent consideration in the debate over the appropriate conversion trigger. Relative to a base condition where no capital conversions occur, placing the conversion decision in the hands of a regulator results in sizable informational efficiency losses in the sense that prices fail to closely track the underlying asset value. As a consequence, markets with regulators generate both considerable allocative (trading) efficiency losses and numerous errant conversion actions. Trading inefficiencies and conversion errors occur not only when the conversion is value-increasing for equity owners (as predicted by *BGP*) but also when it is value-decreasing (not predicted by *BGP*). In a fixed-trigger regime, informational efficiency improves to some extent, particularly in the case of a value-decreasing conversion. Nevertheless, use of a fixed trigger fails to improve allocative efficiency or reduce the overall incidence of conversion errors. Similarly, supplementing the information available to agents with results of a prediction market also improves informational efficiency, but again fails to either improve trading efficiency or reduce the overall incidence of conversion errors.

We do observe, however, that both the fixed trigger and prediction market regimes narrow considerably the range of fundamental realizations where conversion errors occur. This range is narrower than the ranges identified as theoretically problematic. Thus either the prediction market, or an operationally much simpler fixed trigger may effectively reduce the problem of informational inefficiency observed in the regulator markets.

Prior to continuing, we observe that the use of experimental methods to examine the potential effects of regulatory proposals offers some important advantages. Laboratory experiments are far less costly than naturally occurring social experiments. Further, only in the laboratory can the investigator observe directly the relationship between fundamentals and asset

[7] Both value-increasing and value-decreasing conversion scenarios are quite possible and depend on the bond-to-equity conversion ratio. For example, suppose that a contingent capital bond, valued at $10 converts to ½ a share of equity when the share price falls to $5.00. Upon conversion, the bank retires $10 of debt at a very low cost in terms of equity dilution, thus raising equity value. An identical conversion, but with a bond-to-equity conversion ratio of 4 would retire the same $10 of debt at a far higher equity dilution cost, thus reducing equity value for incumbent equity holders.

prices, a relationship that is inherently unobservable in natural contexts. Indeed, in contingent capital proposals it is the unobservability of fundamentals that partly drives recommendations that regulators use asset prices as a reflection of value. Our ability to set fundamentals and then observe trading prices allows us to assess directly the information loss in prices associated with the possibility of intervention, as well as the extent to which regulators in the various regimes err. The low cost and additional control of laboratory experimentation make it an ideal test bed for evaluating potential effects of regulatory proposals, and that is our primary objective here.[8] The remainder of this paper is organized as follows. Section 2 reviews theoretical predictions in the context of our experimental design. Section 3 describes the experiment design and procedures. Section 4 presents experimental results. Finally, the paper concludes.

2. Market-Based Conversion Policies

2.1 A Regulator Regime. To understand the theory that finds potential for informational inefficiencies and to motivate our experimental design, consider the problem of a monitor who uses the price of a firm's equity as an indication of the firm's underlying fundamental value.[9] Suppose that a firm's fundamental value is randomly drawn from a uniformly distributed range of values between \$2.00 and \$8.00, and that this fundamental realization θ is known (collectively) by traders. Unlike the traders, the monitor cannot see the underlying fundamental, but can only observe transactions prices. The monitor acts out of concern for social welfare, and conversion is desirable socially only if the (unaided) fundamental value of the firm is below a critical value $\hat{\theta} = \$5.00$.

We consider two conversion scenarios. The first is a value-increasing scenario in which the bond-to-equity conversion ratio is set at a level high enough that contingent capital bond holders transfer ω=\$2.00 of value per share to incumbent equity owners, making the post-conversion equity value $\theta+\omega$. The second is a value-decreasing scenario in which the bond-to-equity conversion ratio is set sufficiently low that the conversion transfers ω=\$2.00 of share

[8] Laboratory experiments have been used to evaluate market institutions and regulatory structures in a variety of contexts, including markets for gastroenterology fellowships (Niederle and Roth, 2005), pollution emission trading schemes (e.g, Cason, Gangadharan and Duke, 2003), markets for water irrigation rights (Cummings, Holt and Laury, 2004) and the design of radio-spectrum auctions (e.g., Plott and Salmon, 2004).
[9] In what follows, except for the label of the regulator treatment, we will use the more neutral terms "monitor" and "firm" instead of "regulator" and "bank."

value away from incumbent equity owners to contingent capital bondholders. Consequently the post-conversion equity value becomes θ-ω.[10]

We focus first on the value-increasing scenario. The informational problem is most easily seen with a fundamental realization relatively close to but below the critical $\hat{\theta} = \$5.00$ conversion cutoff. For specificity, let $\theta = \$3.50$. In this case conversion is socially warranted, and, if done, would leave incumbent equity holders with an asset worth $\theta + \omega = \$5.50$. The traders could trade the asset at \$5.50 under the assumption of conversion, but what if $\theta = \$5.50$? In that case conversion is not warranted, but the price would also be \$5.50. What should the monitor infer about the fundamental if he sees that price? What should traders assume the monitor will do? Figure 1 illustrates. At prices below \$3.00 the monitor can unambiguously infer that conversion is desirable, since it must be the case that $\theta < \$3.00$ no matter what traders assume that the monitor will do. Similarly, at prices above \$7.00 the monitor can conclude that conversion is not desirable, since it must be the case that $\theta > \$5.00$. However, at prices between \$3.00 and \$7.00, it is not clear what the monitor should infer about the fundamental and what traders should infer about what the monitor will do. Clearly, the price schedule illustrated in Figure 1 cannot be an equilibrium. Furthermore, it can be shown that no price schedule exists that is an equilibrium.[11]

In contrast, the possibility of a value-decreasing conversion does not undermine the monotonic relationship between fundamentals and prices. Figure 2 illustrates. When conversion reduces firm value, trading prices represent an upper rather than a lower bound on the *ex post* asset value. Thus, any $\theta < \hat{\theta}$ should induce all traders to discount the value of an impending conversion and price the asset at $P(\theta-\omega)$. For example, if $\theta = \$3.50$, price is bound by the value without a conversion, \$3.50, and the value with a conversion, \$1.50. Since the monitor can infer that an intervention is warranted in either case, no ambiguity arises. Similarly, for any $\theta > \hat{\theta}$

[10] Most attention regarding bond to equity conversion rules focuses on value-decreasing conversions, under the argument that a punitive conversion will provide a firm with correct risk management incentives. Nevertheless, the value-increasing scenario is more than a theoretical concern. A value-increasing conversion arises any time incumbent equity holders expect a bailout. *BGP* provide a variety of additional instances of such value-increasing corrective actions.

[11] The formal proof of nonexistence is simple. No price schedule with $P(\theta_1)=P(\theta_2)$, for $\theta_1 \neq \theta_2$ is an equilibrium because the monitor would intervene with the same probability for these two states, which means their prices would differ. No price schedule with a unique price for each value of θ is an equilibrium either because then the monitor could figure out the fundamental from the price and would intervene only for $\theta < \hat{\theta}$. But then, there would not be a unique price for each value of θ, which is a contradiction.

individuals have no reason to suspect that a conversion will occur and the price remains *P(θ)*. Notice finally that no prices in the range between $P(\hat{\theta})$ and $P(\hat{\theta}+\varpi)$ ($3.00 to $5.00 in Figure 2) should be observed. For any fundamental realization above $5.00, traders have no reason to believe that a conversion will occur, and assets should trade at prices close to the market fundamental (without conversion). For any fundamental realization below $5.00, traders should anticipate and fully discount the value of the conversion.[12]

2.2 A Fixed-Trigger Regime. A natural proposal for eliminating the informational ambiguity that the presence of an active monitor can create is to replace the monitor's discretion with a fixed price rule that triggers a mandatory intervention; the traders do not need to guess how the monitor will respond. As *SW* establish, however, in the case of a value-increasing conversion, such a trigger fails to eliminate ambiguity. Further, in the case of a value-decreasing conversion, a fixed-price trigger introduces multiple equilibria.

To understand these effects intuitively, replace the monitor in the previous subsection with a mandatory conversion that occurs any time prices fall below $\hat{\theta}$=$5.00. Consider first the case of a value-increasing conversion, and suppose that the fundamental realization is $3.50, as shown in Figure 1. Traders, aware that equity is worth $5.50 if transaction prices remain below the trigger, are faced with the same conflicting incentives observed in the regulatory regime. On the one hand, if a conversion is triggered, the market value of units exceeds $5.00 and traders could increase their payoffs by purchasing units for anything up to $5.50. On the other hand, prices above $5.00 will prevent a conversion, keeping value at $3.50. *SW* show that, just as for the regulator regime, when the underlying fundamental is between $3 and $5, no equilibrium exists.

Now consider a value-decreasing conversion scenario. For specificity, consider a market fundamental of $5.50. Given that the fundamental value exceeds $5.00, traders, confident that intervention will occur, should trade at prices close $5.50. In this case, no conversion occurs

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[12] No prices in the [$3.00, $5.00] range are consistent with an equilibrium. To see this suppose first that traders with values in the $5.00 to $7.00 range are for some reason pessimistic about possibility of a conversion and incorporate the value-decreasing conversion into equity prices. This pessimism would generate prices between $3.00 and $5.00. A subsequent monitor conversion cannot be an equilibrium, since conversion would reduce monitor payoffs. In turn, a failure of the monitor to convert would make trader beliefs about conversion incorrect *ex post*. On the other hand, suppose that traders have fundamentals in the $3.00 to $5.00 range but optimistically assume that no conversion will occur. If the monitor fails to convert *ex post*, she could unilaterally increase her payoff by deviating and converting. But if the monitor does convert, traders bought units on the *ex post* incorrect belief of no conversion and could unilaterally increase payoffs by incorporating the value of the conversion into their offers.

making traders' *ex ante* beliefs correct, establishing an equilibrium. Suppose, however, that despite knowledge that a conversion is socially undesirable, traders pessimistically suspect that a conversion will occur. If traders incorporate the value of the intervention into bids and offers, the price will fall to $3.50, triggering a conversion. Since there is no monitor who could increase her payoff by changing her conversion decision, trading prices that include the conversion will also constitute an equilibrium: traders' *ex ante* beliefs were correct *ex post* and no trader can unilaterally increase his or her payoffs by failing to incorporate the value of the conversion. Multiple equilibria similarly arise for any market fundamental in the [$5.00, $7.00] range.

2.3 *A Prediction-Market Regime.* An alternative to a fixed-price trigger rule is to find a mechanism that provides additional information that allows the monitor to distinguish between two fundamentals that deliver the same price. *BGP* prove in their environment that a "prediction market" that elicits the market's assessment of the likelihood of a conversion is one such mechanism. Empirically, the accuracy of prediction markets has been extensively documented. In over a decade of experience, prices in political stock markets have consistently predicted ultimate vote counts more accurately than polls (see, e.g., Berg, Forsythe, Nelson, and Rietz, 2008), and prediction markets are now increasingly used in business and policy contexts to assess event probabilities.[13]

The potential information-correcting role of a prediction market is easily understood intuitively. Consider again the parameters in the regulator regime, but suppose that in addition to equity, traders buy and sell "conversion likelihood tickets", which take on a value of $1.00 if the regulator elects to make a conversion following the close of trading and $0.00 otherwise. The ticket price, which is between $0 and $1.00, reflects traders' collective expectation of a conversion. Ticket prices close to $1.00 imply that traders collectively regard conversion to be very likely. In a value-increasing conversion scenario, for example, a ticket price of $0.95 allows the monitor to conclude that a price of, say, $6.00 incorporates fully the value of the expected conversion (implying that the underlying market fundamental is close to $4.00). Similarly, a ticket price of $0.05, would allow the monitor to conclude that the same $6.00 equity price reflects the asset's underlying fundamental value, absent a conversion-induced adjustment.

[13] In discussing an internal prediction market conducted by Google, Cowgill, Wolfers, and Zietwitz (2009) observe that a host of firms have begun using prediction markets to predict events pertinent to the firm. In addition to Google, examples include Abbott Labs, Arcelor Mittal, Best Buy, Chrysler, Corning, Electronic Arts, Eli Lilly, Frito Lay, General Electric, Hewlett Packard, Intel, InterContinental Hotels, Masterfoods, Microsoft, Motorola, Nokia, Pfizer, Qualcomm, Siemens, and TNT.

As discussed above, in the case of a value-decreasing conversion, a unique equilibrium exists for every fundamental realization. Nevertheless, to the extent conversion errors occur in the experiments with value-decreasing actions, a prediction market may improve informational efficiency because it provides the monitor with information regarding the appropriate interpretation of prices in the [$3.00, $5.00] range, where no prices are consistent with an equilibrium. A monitor, for example, might interpret an equity price of $3.50 as reflecting a failure of traders to fully incorporate the value of an intervention if ticket prices are close to $0.00, but as reflecting trader pessimism if ticket prices are close to $1.00.

3. Experimental Design and Procedures

3.1 Background. A relatively large experimental literature examines asset markets. The branch of this literature most pertinent to the present investigation examines the capacity of traders to aggregate disparate information regarding a valued asset in a repeated single-period design.[14] Plott and Sunder (1988) evaluate 12-trader markets in which traders are uniformly endowed with a portfolio consisting of cash and a number of homogenous assets, the value of which is determined at the end of the period by its fundamental. Traders are divided into three groups, each of which is told one of the three values that the asset will *not* take. Traders then buy and sell assets in a standard open book double auction. Plott and Sunder find some evidence that trading does allow sellers to identify the underlying value. Nevertheless, information aggregation is often incomplete in the sense that prices often deviate substantially from the underlying fundamental. Using a similar design, Forsythe and Lundholm (1990) find that experience appears to improve information aggregation. More recently Hanson et al. (2006) and Opera et al. (2007) examine variants of the Plott and Sunder design with the modification that a subset of traders were motivated to bias market prices in a particular direction. Results in both papers indicate that

[14] Another branch of the experimental asset market literature, initiated by Smith, Suchanek, and Williams (1988), considers the capacity of traders to track the underling fundamental value of a relatively long-lived asset that yields stochastic returns. Results indicate a persistent propensity for speculative pricing bubbles. This result appears resilient to a variety of conditions, including brokerage fees, short selling or subjects drawn from subpopulations of corporate managers or professional stock traders (see, e.g., King et al., 1993, Lei, Noussair, and Plott, 2001). Common experience with the trading institution appears to minimize the propensity toward speculative pricing. However, recent research by Hussam et al. (2008) indicates that other factors, such as dividend uncertainty and a capacity to sell short can reignite bubbles even with very experienced traders.

even a sizable number of manipulators find altering prices in a desired direction difficult. Nevertheless, as in the related research, prices often failed to reflect underlying value.

Our research questions require some substantial deviations from these information-aggregation designs. We are interested in examining a market where the fundamental value is unknown to the monitor and revealed only through trading. Further, to avoid "no trade" predictions we must induce some heterogeneity in asset values. At the same time, however, we seek a baseline context where traders aggregate information sufficiently to make market prices reflect reasonably well the underlying fundamental. Satisfying these design constraints requires us to deviate somewhat from the theoretical environments used by *BGP* and *SW*. Although our design does not precisely implement either environment, it does provide useful insight into the interrelationship between various conversion mechanisms and market prices.

3.2. Experiment Design. The experiment consists of a *BASE* condition and three treatment regimes: a *Regulator* regime where a price-informed monitor makes conversion decisions, a *Fixed Trigger* regime where the monitor is replaced with a trigger, and a *Prediction Market* regime, where the results of a prediction market supplement price information. In each regime we conduct treatments with value-increasing conversions and value-decreasing conversions. All treatments are extensions of the *BASE* condition, which we explain first.

3.2.1 BASE Condition. The base condition consists of 10 traders and 3 monitors. Each period traders are endowed with two units of an asset, and a cash endowment of E =\$16 lab. Six of the traders realize an underlying fundamental asset value θ_1 drawn from a uniform distribution *U[\$2.00, \$8.00]*. The remaining four traders are endowed with assets valued 60 cents lower, e.g., $\theta_2 = \theta_1$ -60¢. The value distribution, the relation between high and low values, and the aggregate number of high- and low-value units are provided as common knowledge to traders. Traders, however, do not know if their fundamental value draw for the period is low or high.

In this market trade accomplishes a very simple information aggregation task: units flow from the low- to the high-value traders, and in the process reveal θ_1. Aggregating value realizations, as shown in Figure 3 reveals a substantial excess demand for high-value units, providing considerable incentive for prices to rise to the "market" fundamental θ_1.

The market is organized as a standard, open book double auction (similar to the rules used on the NYSE), and traders may trade their endowments of cash and asset units as they see fit.[15] Trading periods last 110 seconds. At the end of each period, payoffs for each trader of type *k* are determined as the sum of residual cash, and the fundamental value of all units owned at the end of the period, or

$$Payoff_k = E - \sum_{i=1}^{n_b} p_i + \sum_{j=1}^{m_s} p_j + \theta_k \times (n_b - m_s + 2) \qquad (1)$$

where n_b units are bought at prices p_i, $i=\{1,\ldots,n_b\}$ and m_s units are sold at prices p_j, $j=\{1,\ldots,m_s\}$.

Finally, in the *BASE* condition the three monitors are shown the median transaction price at the close of each period and then guess θ_1.[16] Monitors make decisions simultaneously, and once all decisions are complete the actual θ_1 is revealed. Monitors earn \$3 lab if their guess is within 20¢ of θ_1, \$1 lab if their guess is within 50¢ of θ_1, and zero otherwise. Absent the possibility of intervention, markets in *BASE* periods should aggregate information effectively. Operationally, this should mean that the deviation between median prices and the market fundamental θ_1 should be consistently small. Defining *informational efficiency* as the extent to which the median price reflects the underlying market fundamental, and *allocative efficiency* as the percentage of total available gains extracted from exchange we form a first conjecture.[17]

Conjecture 1*: In the BASE condition, markets are both informationally and allocationally efficient.*

3.2.2 The Regulator Regime. Conditions for the *Regulator* treatments duplicate those for the *BASE* condition with the following differences. First, in addition to assessing θ_1 for the

[15] Organizing the market as a simultaneous move institution, such as a call market, would be procedurally simpler. Overall, call markets perform quite favorably relative to double auctions (see, e.g., Cason and Friedman, 2008, and Kagel, 2004). However, a number of experimental studies indicate that simultaneous move institutions like the call market are susceptible to information cascades (Anderson and Holt, 1997) and the winner's curse (Kagel and Levin, 1986), and are thus less desirable as information aggregation mechanisms. See, e.g., Plott (2001), or, for information aggregation problems in a context that is in some respects related to the one examined here, Duffy and Fisher (2005).

[16] We elected to provide a single price-based measure of market activity both for simplicity and for purposes of parallelism with relevant natural contexts, where market assessments focus primarily on summary price measures. Alternative possible price-based measures include the closing price and the average of the final several contracts in a period. Concerns about traders trying to manipulate prices in order to convince monitors to intervene or not guided our decision to use the median price, rather than a potentially more manipulable measure of final trading activity, such as the closing price.

[17] We calculate allocative efficiency as the percentage of units held by high-value traders at the end of each trading period. The maximum gain from efficient portfolio reallocation is \$4.80 lab: 60¢ each from the movement of the eight units held by "low-value" traders (with values of θ_2) to "high-value" traders (with value of θ_1).

period, monitors must also make a conversion decision under the condition that conversion is desirable if the market fundamental θ_1 is less than $\hat{\theta} = \$5.00$. The monitor earns \$10 lab for a correct decision. The relatively large payment for correct conversion decisions was imposed to reflect incentives for regulators in natural contexts, where the bulk of their returns are determined by making socially optimal decisions.

After all decisions are complete, θ_1 is revealed to the monitors, and the action of one of the three monitors is selected at random and implemented. In the case of a value-increasing scenario the value of assets increases by \$2.00 in the case of a conversion, so for high-value traders the value is $\theta_1+2.00$ and for low-value traders it is $\theta_1-0.60+2.00$. Based on the nonexistence finding of *BGP*, we conjecture that the experimental environment will have similar problems that will be reflected by informational and allocative inefficiencies for the traders and difficulty for monitors in making conversion decisions.

Conjecture 2. *The possibility of a value-increasing conversion by monitors will cause informational and allocative efficiency to fall relative to the BASE condition. Monitors will make errant conversion decisions.*

Sessions in a value-decreasing scenario are structured in exactly the same way as the value-increasing scenario except that a conversion transfers value away from rather than to incumbent equity owners. As discussed above, in the *BGP* model value-decreasing conversions do not interrupt the monotonic relationship between fundamentals and price and the markets are fully efficient. This gives a third conjecture.

Conjecture 3: *The possibility of a value-decreasing conversion by monitors will not affect the informational or allocative efficiency of markets relative to the BASE condition. Monitors should commit few conversion errors.*

3.2.3. Fixed Trigger Regime. To evaluate the performance of markets operating with a trigger, we replace the monitor, with a mandatory conversion that occurs if the median price in a period falls below \$5. As discussed in section 2, *SW* find that in a value-increasing scenario no equilibrium exists in the *Fixed-Trigger* regime for fundamental realizations between \$3.00 and \$5.00. For this reason, our fourth conjecture is that there will be informational and allocative inefficiencies, as well as a significant numbers of conversion errors.

Conjecture 4: *In the case of a value-increasing conversion the trigger will cause informational and allocative efficiency to fall relative to the BASE condition. Monitors will make errant conversion decisions.*

In a value decreasing scenario the use of a trigger creates both high and low price Nash equilibria for each fundamental realization in the [$5.00, $7.00] range. Based on the findings in *SW*, we anticipate that the creation of this second Nash equilibrium would tend to reduce informational efficiency relative to *BASE* markets, and as a consequence generate allocative efficiency losses and conversion errors. This is a fifth conjecture.

Conjecture 5: *In the case of a value-decreasing conversion the use of a trigger will cause informational and allocative efficiency to fall relative to the BASE condition. Monitors will make errant conversion decisions.*

3.2.4 Prediction Market Regime. To examine the corrective capacity of prediction markets, we conduct a pair of treatments that parallel the initial *Regulator* treatments, except that at the beginning of each period traders are endowed with one conversion likelihood ticket. The ticket is worth $1 (lab) at the end of the period if the monitor intervenes following the close of trade and $0 otherwise. Prior to the onset of equity trading each period, traders are given the opportunity to exchange tickets by submitting both maximum bid to purchase a second ticket and a minimum offer to sell their ticket.[18] A call market is used to determine a market ticket price as well as the number of tickets that change hands: bids are ranked from highest to lowest, offers are ranked from lowest to highest, and a crossing is found. The market price of a ticket is determined as half the distance between last "inside" bid and offer.[19] All "inside" units exchange, with tickets passing from sellers to buyers at the market price. Following the ticket exchange, trading proceeds as in the initial *Regulator* treatment, except that the market price of a ticket is displayed to all traders and monitors.

The potential information-correcting role of the prediction market in the *BGP* model produces a sixth conjecture.

[18] Bids and offers are submitted under the conditions that the maximum offer cannot exceed $1 (since that is the ticket's maximum value), and that each trader's offer must exceed his or her bid (so that the trader does not sell to himself or herself).

[19] That is, the last ranked bid and offer pair where the bid is no greater than the offer. In the case that no offer exceeds a bid, the price is set as half the distance between the lowest offer and the highest bid.

Conjecture 6*: Addition of a prediction market to markets in the Regulator regime will yield informational and allocative efficiency levels comparable to those observed in the BASE condition. Few conversion errors will occur.*

3.3 Experiment Procedures. The experiment was conducted in two temporally distinct phases. In an initial phase, our primary focus was on examining the consequences of having a monitor make conversion decisions. In a temporally subsequent second phase we conducted treatments that (a) added a prediction market to the experiments with a monitor and (b) replaced the monitor and prediction market with the fixed trigger rule. The initial phase consisted of a series of 16 twenty-period market sessions. At the outset of each session participants were randomly seated at visually isolated PCs. An experiment administrator then read aloud a common set of instructions, which explained incentives for traders and for monitors in the *BASE* condition, as well as how to make decisions on the computer interface used in the experiment.[20] The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). To facilitate participant understanding, screen shots were projected onto a wall at the front of the lab. Following the instructions, participants completed a short quiz of understanding, which the experiment administrator reviewed publicly. Finally, participants completed a practice period for which they were not paid. At any time during the instructions, quiz, and practice period, participants were encouraged to ask questions by raising their hands. Questions were answered privately. Following completion of the practice period, the session commenced.

After five periods in the *BASE* condition the session was paused and additional instructions were distributed. In the *Regulator* treatments, instructions regarding the intervening monitor were distributed to participants. An experiment administrator read aloud these instructions. Following a second short quiz of understanding, a second 15-period portion of the session commenced. After period 20 these initial phase sessions ended.

The second experiment phase consisted of 12 additional 13-participant sessions conducted to examine the *Prediction Market* regime, and six 10-participant sessions that examine the *Fixed Trigger* regime. Procedures for the *Prediction Market* treatments were identical to those for the *Regulator* treatments, except that following the *BASE* condition periods, we conducted only five periods in a value-increasing or value-decreasing *Regulator* regime. Following these initial 10

[20] Instructions are available at http://www.people.vcu.edu/~dddavis.

periods, a third set of instructions was passed around that explained to participants the market for conversion likelihood tickets. Following instructions, a short quiz and practice with the ticket auction, a third 10-period sequence began in which trading and monitor decisions were informed by results of the ticket auctions. These sessions also terminated after period 20.

In the *Fixed Trigger* regime, no monitors were present. Following 5 *BASE* condition periods, instructions regarding a trigger in a value-increasing (or value-decreasing) scenario were distributed to the 10 traders and read aloud by an experiment administrator. Following a short quiz of understanding, a second 10-period segment of the session commenced. The second segment was followed by a similarly introduced third 10-period sequence in the value-decreasing (value-increasing) scenario not conducted in the second segment. The *Fixed-Trigger* sessions ended after period 25.[21]

In total 424 undergraduate student volunteers participated in this experiment. In the initial phase, 208 volunteers participated in 16 *Regulator* market sessions (eight in a value-increasing scenario and eight in a value-decreasing scenario). In the second phase, 216 volunteers participated in 12 *Prediction Market* sessions (six in a value-increasing scenario and six in a value-decreasing scenario), and in six *Fixed-Trigger* sessions (yielding six 10-period sequences in a value-increasing scenario and six 10-period sequences in a value-increasing scenario). Participants were upper-level math, science, engineering, and business students enrolled in courses at Virginia Commonwealth University in the spring semesters of 2010 and 2011. No one participated in more than one session. Lab earnings were converted to U.S. currency at $12 lab =$1 U.S. rate. Participant earnings for the 90-120 minute sessions ranged from $14 to $32.25 and averaged $23.25 (inclusive of a $6 appearance fee).

4. Experiment Results

We present the results in terms of a series of findings that evaluate Conjectures 1 to 6. In a second subsection we offer some observations regarding performance across different conversion rule regimes.

4.1 Evaluation of Conjectures. A first finding pertains to *BASE* condition results.

[21] To facilitate the comparison of outcomes across treatments, a common set of fundamental realizations were used in all *Regulator* sessions However, alterations in the number of sequences and the total number of periods forced us to use a slightly different set of fundamental realizations in the *Fixed-Trigger* and *Prediction Market* treatments. Values for each treatment are displayed in appendix A.

***Finding 1**. BASE condition markets are both informationally and allocationally quite efficient: median contract prices deviate from the fundamental by an average of 21¢ and trading extracts 95% of the available surplus.*

Figure 4 plots median contract prices against underlying market fundamental realizations for the *BASE* condition periods. Notice in the figure that for each fundamental realization median prices (indicated by circles) cluster tightly about the fundamental (noted as a line). Quantitatively, the absolute deviation of contract prices from underlying fundamentals averages 21¢. Using the 60¢ gap between θ_1 and θ_2 as a reference, our *BASE* markets extract roughly two-thirds of the underlying information. While imperfect, performance in our *BASE* periods is fairly impressive, relative to other information aggregation experiments (e.g., Plott and Sunder, 1988, Forsythe and Lundholm, 1990, Hansen et al., 2006, or Oprea et al., 2007).[22]

Beyond informational efficiency, we observe that our *BASE* condition markets were also quite allocatively efficient. As reflected by the horizontal dashes hovering close to the 100% line at the bottom of Figure 4, units flow from low- to high-value traders quite effectively in the *BASE* condition periods. Overall, allocative efficiency averages 95%, a level that parallels results of many double auction experiments.■

4.1.1 The Regulator Treatments

Our second and third findings regard the effects of the *Regulator* treatments. Consider first the value increasing scenario.

***Finding 2**: In a value-increasing scenario, monitor conversion decisions result in significant informational and allocative efficiency losses relative to the BASE condition. Although the largest efficiency losses occur in the ambiguous [$3.00, $7.00] range, sizable losses occur even for fundamentals that do not yield ambiguous price signals. In the ambiguous range conversion, errors occur in almost 25% of periods.*

The upper panel of Figure 5 summarizes results of *Regulator* markets in the value-increasing scenario. The active monitor markedly affects informational efficiency, particularly for market fundamentals below $5.00. In this range, prices "bubble up" very incompletely from

[22] It is difficult to draw an explicit standard of comparison across these different experiments. However, the authors in each case regard information aggregation as "highly incomplete" and price variations are very large.

the *ex ante* fundamental to the *ex post* level that includes the value of the conversion. Despite this incomplete adjustment, median prices increasingly exceed $5.00 as the *ex ante* fundamental approaches the conversion cutoff, which in turn complicates the monitor's task of assessing underlying fundamental values in the neighborhood of $5.00.

Looking at the bottom of the upper panel, observe further that this informational inefficiency also importantly impacts allocative efficiency. Allocative efficiencies for the *Regulator* markets in the value-increasing scenario hover at about 75%, a level both markedly lower than in the *BASE* condition, and startlingly low for markets organized under double auction trading rules.[23]

The ambiguity of price information also generates numerous conversion errors. This can be seen by the light gray, dark gray and black fillings for the median price circles, which indicate, respectively, instances of one, two, and three intervention errors in a trading period. Although errors occur throughout the ambiguous [$3.00, $7.00] range of fundamental realizations, the highest concentration of conversion error occur for fundamentals close to the $5.00 efficient conversion cutoff.

We more formally assess performance in the value-increasing scenario of the *Regulator* treatment relative to the *BASE* condition with a series of simple regressions. For informational and allocative efficiency we pool *BASE* and value-increasing *Regulator* periods, and regress each efficiency measure against two dummy variables, (i) D_{Active}, which takes on a value of 1 in periods when the monitor conversion regime is in effect, and 0 otherwise, and (ii) D_{Ambig} , which takes on a value of 1 in *Active* periods when the fundamental realization is in the [$3.00, $7.00] ambiguous range and 0 otherwise. Thus, the coefficient on D_{Active} captures the incremental effect of the active monitor regime on informational or allocative efficiency, while the coefficient on D_{Ambig} captures the incremental effect of an ambiguous fundamental realization given an active monitor. For the conversion error rate regression, observe that conversion errors arise only when the monitor is active. For this reason, we exclude the *BASE* periods from the conversion error rate regression and estimate the incremental effect of ambiguous fundamental realizations in *Active* monitor periods. The intercept for this regression reflects the conversion error rate in

[23] For example, in a very demanding double auction design with inexperienced traders where each period supply and demand receive random shocks and where relative cost and value assignments are reshuffled among sellers and buyers, respectively, Cason and Friedman (1999) observe mean trading efficiencies of 88.4%. In a similar eight-seller design, also with inexperienced traders, Kagel (2004) observes average trading efficiencies of 95%.

Active monitor periods for fundamentals outside the ambiguous range. In all regressions we cluster data by markets and use a robust (White "sandwich") estimator to control for possible unspecified autocorrelation or heteroskedasticity

Columns (1) to (3) in the left side of Table 1 report results for *Regulator* markets in the value-increasing scenario. As can be seen from the coefficients on D_{Active} in row *(ii)* the possibility of conversion significantly reduces both informational and allocative efficiency. Relative to *BASE* condition periods, absolute median price deviations for *Active* periods increase by 29¢, thus reducing information transmission to roughly one-sixth of the spread between θ_1 and θ_2. Similarly, allocative efficiency falls by 11 percentage points, as traders with *ex post* high values sell units to low value traders. As indicated by the asterisks, both of these effects are significant at a 5% significance level. Notice further in column (3), however, that despite these unpredicted efficiency losses, the presence of an active monitor does not importantly undermine the capacity of monitors to assess when conversion is appropriate, when fundamental realizations are outside the ambiguous range. Intervention errors occur in only 3% of periods with "unambiguous" fundamental realizations.

Row *(iii)* of Table 1 summarizes the incremental effects of ambiguous fundamental realizations in the *Active* monitor periods. As seen in columns (1) and (2) of row *(iii),* ambiguous fundamental realizations increase absolute median price deviations by 26¢, for a cumulative total of 76¢ - a difference that exceeds the 60¢ difference between θ_1 and θ_2. Similarly, allocative efficiency falls another 10 percentage points, for a cumulative level of 74%. Perhaps most prominently, conversion error rates in the *ambiguous* range increase by a significant 22 percentage points, for a cumulative total of 25%.■

Finding 3: *In the case of a value-decreasing conversion, the presence of an active monitor reduces both informational and allocative efficiency relative to BASE condition. Further, monitors commit a significant number of conversion errors.*

Results for the value-decreasing scenario of the *Regulator* regime, shown in the lower panel of Figure 5, suggest that, contrary to our expectations, substantial informational efficiency losses also arise here. For market fundamentals below $5.00, median prices do not always drop from the *ex ante* fundamental to the *ex post* efficient level, as traders incompletely incorporate into prices the value of what should be an anticipated conversion. On the other hand, for market fundamentals in excess of $5.00, traders in several instances assume (pessimistically) that the monitor will make a conversion, causing prices to drop. Combining the effects of incomplete capitalizations of anticipated conversions and trader pessimism regarding the likelihood of unnecessary conversions, monitors see a large number of prices in the [$3.00, $5.00] range, where no price is consistent with an equilibrium.

Looking at the bottom of the lower panel, observe further that allocative efficiency in the *Regulator* treatment with a value-decreasing scenario suffers relative to the *BASE* condition. For most fundamental realizations, traders extract only about 75% of the possible gains from trade. Finally, as indicated by the light grey, dark grey and black fillings, median prices in the [$3.00, $5.00] range cause numerous conversion errors, the majority of which occur for fundamentals in excess of $5.00. Generally speaking, monitors appear to interpret prices in the [$3.00, $5.00] range as traders incompletely incorporating the value of what should be an anticipated conversion. As indicated by the high frequency of dots with colored fillings to the right of $5.00, in those instances where traders do pessimistically adjust for a socially unnecessary conversion, conversion errors arise frequently.

Regression results in columns (4) to (6) of Table 1, allow a more formal support for Finding 3. These regressions parallel those for the value-increasing scenario of the *Regulator* regime except that we exclude the D_{Ambig} dummy, because no ambiguous range exists in the value-decreasing scenario. Looking at the entries in row *(ii)* observe that in a value-decreasing scenario an active monitor significantly reduces both informational and allocative efficiency. Median absolute price deviations increase by 42¢ over the *BASE* condition, and allocative efficiency falls by 16 percentage points. Both changes are statistically significant. Notice further from column (6) that conversion errors occur in 8% of instances.■

4.1.2 The Fixed Trigger Treatment

The next pair of findings evaluate Conjectures 4 and 5 pertinent to the fixed-trigger regime. We start with the value-increasing scenario.

Finding 4: *In the case of a value-increasing conversion, a fixed trigger results in significant informational and allocative efficiency losses relative to the BASE treatment, with particularly large losses in the [$3.00, $5.00] range. In this range, conversion errors occur in 38% of instances.*

Figure 6 summarizes results of the fixed trigger regime. In the case of a value-increasing conversion, shown in the upper panel, dispersion from *ex post* efficient price illustrates considerable informational inefficiency relative to the *BASE* condition. For fundamentals in the [$3.00, $5,00] range, prices cluster about $5.00, as the trigger prevents traders from incorporating into prices the value of a socially beneficial conversion. Traders fail to balance their individual interests in purchasing units at prices below value against the group interest in keeping the median price below the trigger. This in turn prompts frequent conversion errors.

The regression results summarized in columns (1) to (3) of Table 2 provide more formal support of Finding 4. These regressions parallel those for the value-increasing *Regulator* treatment in Table 1, except that, consistent with *SW*, we restrict the ambiguous range of fundamental realizations to the [$3.00, $5.00] range. Starting with the incremental effects of an active trigger, in row *(ii)*, observe first that the addition of a trigger does not importantly affect either informational efficiency, as indicated by the small (but significant) 6¢ entry in column (1), or the incidence of conversion errors, as indicated by the 3% entry in column (3) . However, the trigger does exert sizable and significant allocative inefficiencies, as reflected in the -11% entry in column (2). Parallel to the value-increasing *Regulator* treatment, many traders appear to encounter some difficulties in efficiently reallocating their portfolios.

Turning to results for the ambiguous [$3.00, $5.00] range, summarized in row *(iii),* observe that the consequences of the trigger here increase markedly: absolute price deviations increase by 107¢ (to a cumulative level of 154¢), allocative efficiency falls by another 11 percentage points (to a cumulative level of 73%), and the incidence of conversion errors increases by 35 percentage points (to a cumulative level of 38%).■

Finding 5*: In the case of a value-decreasing conversion, use of a trigger results in sizable informational and allocative efficiency losses relative to the BASE condition. Substantial informational efficiency losses occur in the [$5.00, $7.00] range, where the fixed-trigger creates multiple equilibria. In this range, conversion errors occur in 33% of instances, though most of these are close to the trigger value.*

The bottom panel of Figure 6 illustrates results of a trigger in the case of a value-decreasing scenario. As indicated by the fairly small differences between median prices and the *ex post* efficient price, for fundamentals outside the [$5.00, $7.00] range, prices track underlying fundamentals quite well (at least relative to the value-decreasing treatment of the *Regulator* regime). Nevertheless, the multiple equilibria in the [$5.00, $7.00] range, impact negatively on informational efficiency, as indicated by the median price dots trailing down from the *ex post* efficient fundamental. Notice further from the black fillings for those dots, these prices triggered a large number of socially unnecessary conversions. Also, allocative efficiencies cluster about the 75% level, which is less than in the *BASE* condition.

The regression results, listed in columns (4) to (6) of Table 2 summarize these observations quantitatively. Looking first at row *(ii)*, observe from the small and statistically insignificant 7¢ coefficient on D_{Active} that for fundamental realizations outside [$5.00, $7.00] a trigger does not significantly affect informational efficiency relative to the *BASE* condition. Further, as seen by the 0 entry in column (6), for fundamentals outside [$5.00, $7.00] traders commit no conversion errors. Thus, traders appear better able to cause a market adjustment for the anticipated conversion with the trigger. Nevertheless, the price adjustment process fails to force the smooth flow of units from low- to high-value traders. As seen in column (5), trading efficiency with an active trigger falls by 20 percentage points (to a cumulative level of 74%).

Turning to incremental effects for the [$5.00, $7.00] range, summarized in row *(iv)*, observe that, as predicted by *SW*, the fixed trigger negatively and importantly affects performance: Absolute mean price deviations almost double (increasing by 25¢), and conversion errors occur in one-third of instances, as pessimistic traders coordinate frequently on prices below $5. Curiously, for fundamentals in the [$5.00, $7.00] range notice that trading efficiency increases by 10 percentage points. This improvement is likely driven by traders in most instances not needing to incorporate the value of a conversion into prices.■

4.1.2 The Prediction Market Treatments. A sixth finding regards results of the prediction market regime.

Finding 6*: Prediction markets fail to resolve the efficiency losses and conversion errors induced by the presence of an active monitor.*

The scattergrams plotting median prices against fundamentals for the *Prediction Market* treatments are shown as Figure 7. Viewing Figure 7 in light of Figure 5 suggests that prediction markets do exert some ameliorative effects. In particular, for fundamental realizations below $5, median prices "bubble up" more fully in the value-increasing scenario (shown in the upper panel) and "sink" more completely in the value-decreasing scenario (shown in the lower panel).

Nevertheless, relative to *BASE* condition prediction markets suffer in all dimensions. Prices do not cluster about efficient fundamentals with anything close to the precision observed in the *BASE* condition, with deviations being particularly pronounced for fundamental realizations close to the $5.00 cutoff. As indicated by gray and black fillings for many median price dots, conversion errors also occur with some frequency. Observe finally that allocative efficiencies do not approach the 95% levels observed in the *BASE* condition.

Regression results summarized in Table 3, quantify the failure of prediction markets to restore trading performance observed in the *BASE* condition. For the value-increasing treatments, summarized in columns (1) to (3), observe that absolute median price deviations roughly double (increasing by 19¢). Similarly, allocative efficiency falls by 19 percentage points and conversion errors occur in 12% of trading periods. Parallel results arise in the value decreasing treatments, summarized in columns (4) to (6). Relative to the *BASE* condition, mean absolute price deviations increase by 26¢, allocative efficiency falls by 12 percentage points, and conversion errors occur in 12% of all periods.■

4.2 Cross-Treatment Comparisons. In evaluating the different trigger mechanisms, we compare the *Fixed-Trigger* and *Prediction Market* treatments with the *Regulator* treatment, since empowering a regulator with discretionary authority represents perhaps the default method for implementing conversions.

For the analysis that follows, we evaluate performance with a finer grid of fundamental realizations than in our earlier analysis. Specifically, we segment the range of fundamental realizations into six parts. The first pair of segments consist of the ranges [$4.40, $4.99] and [$5.00, $5.59]. These segments are of interest because the fundamental is closest to the trigger point, where presumably the most confusion will occur. The second pair of segments capture the remainder of what we defined as the ambiguous range in the value-increasing scenario of *Regulator* treatment, [$3.00, $4.39] and [$5.60, $6.99]. Efficiency losses and conversion errors in these segments would capture any failure to accurately reflect underlying fundamentals not already reflected in the segments closest to the conversion cutoff. The final pair of segments consists of fundamental values below $3.00 and $7.00 or above. These ranges are furthest from the trigger, so presumably would have less efficiency losses and conversion errors.

The histograms in Figure 8 allow assessment of the incremental effects of the *Fixed Trigger* and *Prediction Market* regimes relative to the *Regulator* regime. (We exclude allocational efficiencies from Figure 8 because they do not vary importantly across regimes.) [24] Comparing first the *Fixed Trigger* and *Regulator* regimes, shown respectively as black and white bars, notice first that in a value-increasing scenario, both regimes exhibit very similar patterns of mean absolute price deviations. As market fundamentals approach the $5.00 cutoff from below, the spread between median prices and the efficient *ex post* fundamental increases markedly, with traders becoming progressively more reluctant to strike contracts that reflect the *ex post* fundamental value. Above $5.00, however, concerns about incorporating the value of a conversion disappear, and absolute price deviations fall to or even below the average level in the *BASE* condition (shown as a dashed line) in both regimes.

Continuing down the left column of Figure 8, observe that despite the similarity of price patterns in the two regimes, the shift from *Regulator* to *Fixed Trigger* regimes does affect conversion error rates. In the *Regulator* regime, conversion errors are distributed throughout the [$2.00, $8.00] range of possible fundamental realizations, but with a mode just above the efficient cutoff, in the [$5.00-$5.59] range, implying that monitors mix errors of omission and commission, but tend to commit more errors of commission (that is, make more socially undesirable conversions). In the *Fixed Trigger* regime, by way of contrast, the incidence of conversion errors drops significantly relative to the *Regulator* regime for the [$5.00, $5.59] and [$5.60-$6.99]. Nearly all errors in the *Fixed Trigger* regime occur in the segment just below $5.00, implying that this regime almost exclusively yields acts of omission (e.g., foregoes socially desirable conversions), and only when the market fundamental is very close to the cutoff for efficient intervention.

Switching to the value-decreasing scenario, observe that mean absolute price deviations for the *Fixed Trigger* regime fall below their *Regulator* regimes counterpart in every segment, suggesting that the *Fixed Trigger* regime improves informational efficiency. Continuing down the column observe further that in a value-decreasing scenario, the *Fixed Trigger* regime

[24] Notice in the upper panels of Figure 8 that the mean absolute price deviation for the *BASE* condition is drawn as a horizontal line, reflecting the overall average for all segments. In fact, as a careful review of Figure 4 suggests, mean absolute price deviations increased very slightly with increases in the underlying fundamental. The frequencies in Figure 8 are developed from regressions of Mean Absolute Price Deviations and Conversion Error rates on a series of indicator variables that separate outcomes by treatment and segment. The *BASE* condition is the intercept in these regressions. Regression results appear in Appendix B.

concentrates conversion errors entirely in the [$5.00, $5.59] range (where socially undesirable conversions occur). In that range, the conversion error rate for the *Fixed Trigger* regime is an almost pervasive 58%. We summarize these as the following comment.

Comment 1: *Substituting a monitor with a trigger improves informational efficiency in the value-decreasing scenario. Further, in both value-increasing and value-decreasing scenarios, use of a trigger consolidates the range of fundamental realizations that prompt conversion errors to the segment either just below the efficient conversion cutoff (in the value-increasing scenario), or just above the cutoff (in the value-decreasing scenario).*

Comparison of the white and gray bars in the panels of Figure 8 allows assessment of the incremental effects of the *Prediction Market* regime. Starting with the value-increasing regime, observe that the *Prediction Market* regime considerably improves informational efficiency for fundamental realizations below $5.00. For each of the three segments below $5.00, mean absolute price deviations in the *Prediction Market* regime are much lower that their *Regulator* regime counterparts. Above $5.00, however, the *Prediction Market* regime does not importantly affect informational efficiency.

Continuing down the left side of Figure 8, observe that associated with the informational efficiency improvements for fundamentals below $5.00 is a sizable reduction in conversion error rates. In both the [$3.00, $4.39] and [$4.40, $4.99] segments conversion errors for the *Prediction Market* regime fall almost to zero. The incidence of conversion errors also falls for fundamentals in the [$5.00, $5.59] range. Nevertheless, the distribution of conversion errors retains the strong mode of almost 40% observed in the *Regulator* regime, implying that while the *Prediction Market* regime shifts the type of conversion errors almost exclusively to acts of commission (e.g., socially undesirable conversions), it does not importantly affect the frequency of such errors.

The right panels of Figure 8 illustrate incremental effects of the *Prediction Market* regime in a value-decreasing scenario. As seen in the upper right panel of Figure 8, the *Prediction Market* regime tends to modestly improve informational efficiency. Mean absolute price deviations are at least marginally smaller than their *Regulator* regime counterpart for every segment except [$5.00, $5.59]. These informational efficiency improvements, however, fail to generate any noticeable changes in conversion error rates. The distribution of conversion error rates for the *Prediction Market* and *Regulator* regimes are quite similar. We summarize the above observations regarding the incremental effects of the Prediction Market regime as a second and final comment.

Comment 2: *The addition of a Prediction Market helps traders and monitors disentangle underlying fundamental values from the ex post value of conversion, particularly for fundamental realizations below $5.00. Nevertheless, use of a prediction market does not reduce the strong tendency for monitors to make many socially undesirable conversions for fundamental value realizations close to, but above $5.00.*

As noted in the introduction, prediction markets have been used to elicit group perceptions with remarkable accuracy in a variety of contexts ranging from election outcomes to new product adoption rates. The limited success of prediction markets here merits some reflection. We cannot dismiss the possibility that limitations in the structure of our simple prediction markets keep prices from reflecting the underlying market fundamental with more accuracy. By the standards of field markets, our prediction markets are quite thin (with only 10 participants) and traders' capacities to affect the market prices is quite limited, since they can buy or sell only a single unit. Perhaps with a larger ticket endowment, or a capacity to purchase more than a single ticket, our prediction market prices might reflect more fully the high-value fundamental. The effectiveness of larger prediction markets in this context certainly merits investigation.

We observe, however, that we are perhaps asking more of prediction markets in this context than they can reasonably be expected to deliver. Traders, after all buy and sell tickets on the basis of their *ex ante* assessment of the probability of a monitor intervention, that is, they predict not what is socially efficient, but what actually *will* happen. In a value-decreasing condition, for example, for market fundamentals only slightly above $5.00, pessimistic traders may quite rationally sell tickets at prices close to $0.00 if they assume that a monitor interprets median prices in the [$3.00, $5.00] range as warranting an intervention. Other traders, uncertain as to the relative optimism of traders may post ticket prices close to 50¢. Crossing bids and offers in this case can quite legitimately generate ticket prices that produce little useful information. Similarly in the case of a value-increasing conversion, when market fundamentals only slightly exceed $5.00 some traders will not know *ex ante* whether or not a conversion is efficient, and others (with values only slightly in excess of $5.00) may be uncertain as to whether or not near $5.00 prices will convince a monitor to not intervene (and in any case, these traders would prefer that a conversion does occur). Again, these forces combine to provide relatively uninformative ticket prices. The listing of mean ticket prices by fundamental segment in Table 4 illustrates this point quite clearly. In both value-increasing and value-decreasing conditions, mean ticket prices exceed 75¢ for fundamentals below $5.00 and are less than 33¢ for fundamentals $5.60 and above. However, in the $5.00-$5.59 range, mean ticket prices are essentially uninformative at 52¢ and 62¢ for the value-increasing and value-decreasing conditions respectively.

5. Concluding Comments

This paper reports an experiment conducted to evaluate various price-dependent rules for triggering contingent capital conversions. We find that if conversion decisions are based on equity prices, the endogeneity between conversion actions and equity value creates an important informational problem for a regulatory authority. In the case where a conversion increases value for incumbent equity holders, our results are consistent with predictions by Bond, Goldstein and Prescott (2010) and we observe informational inefficiencies that result in allocative inefficiencies and numerous conversion errors. Not predicted by *BGP*, we also observe sizable inefficiencies and conversion errors in the case of a value-decreasing conversion. These results suggest that the use of regulators to make conversion decisions can create severe informational problems.

We also explore two alternatives to a simple regulatory regime. One alternative replaces the regulator with a fixed threshold that triggers a conversion. Use of a trigger improves informational efficiency in the value-decreasing conversion scenario, and narrows considerably the range of fundamental values that yield conversion errors. Nevertheless, (and consistent with predictions by Sundaresan and Wang, 2011) we observe sizable informational inefficiencies and conversion error rates for fundamental realizations just above the conversion trigger (in the value-increasing scenario), and just below the conversion trigger (in the value-decreasing scenario). In fact, in these narrow segments, the incidence of conversion errors appears to actually increase relative to the case of a regulator.

As a second alternative, we supplemented agents' information sets in a regulatory regime with results of a prediction market. For fundamental realizations below the efficient conversion cutoff, prediction markets do markedly improve informational efficiency in both value-increasing and value-decreasing conversion scenarios. Similar to the fixed trigger treatment, use of a prediction market also tends to concentrate the range of fundamental realizations where conversion errors occur. Nevertheless, allocative efficiencies remain low, and conversion errors arise frequently for fundamental realizations just above the efficient conversion cutoff.

In sum, our results suggest that contingent capital creates significant informational inefficiencies when the regulator bases conversion decisions on market prices. Further, replacement of a regulator either with a fixed-conversion trigger or supplementing agents' information sets with results of a prediction market improves market performance, but does not eliminate the incidence of conversion errors.

We do, however, observe that in all regimes the range of fundamental realizations that results in frequent conversion errors tends to be more narrowly concentrated about the efficient conversion cutoff than theoretical models by either *BGP* or *SW* would suggest. Further both fixed-trigger and prediction-market treatments have the effect of narrowing this range almost entirely to fundamentals just above or just below the efficient conversion cutoff. In fact, in both the fixed trigger and prediction-market treatments, conversion errors are largely confined to the range of fundamentals where some traders are uncertain about the underlying market fundamental prior to trading.

In evaluating contingent-capital proposals, our results imply that if the region in which conversion errors occur is small enough, then these mechanisms may be reasonable, assuming that the allocative inefficiencies are not too costly. In the context of the values used in our laboratory markets, our judgment is that these costs are significant. Whether these costs remain significant in the pertinent natural contexts is an open question. What is clear from the experiments, however, is that the feedback between prices and actions reduces the informational content of prices, which reduces the efficiency of allocations and makes conversion decisions less effective.

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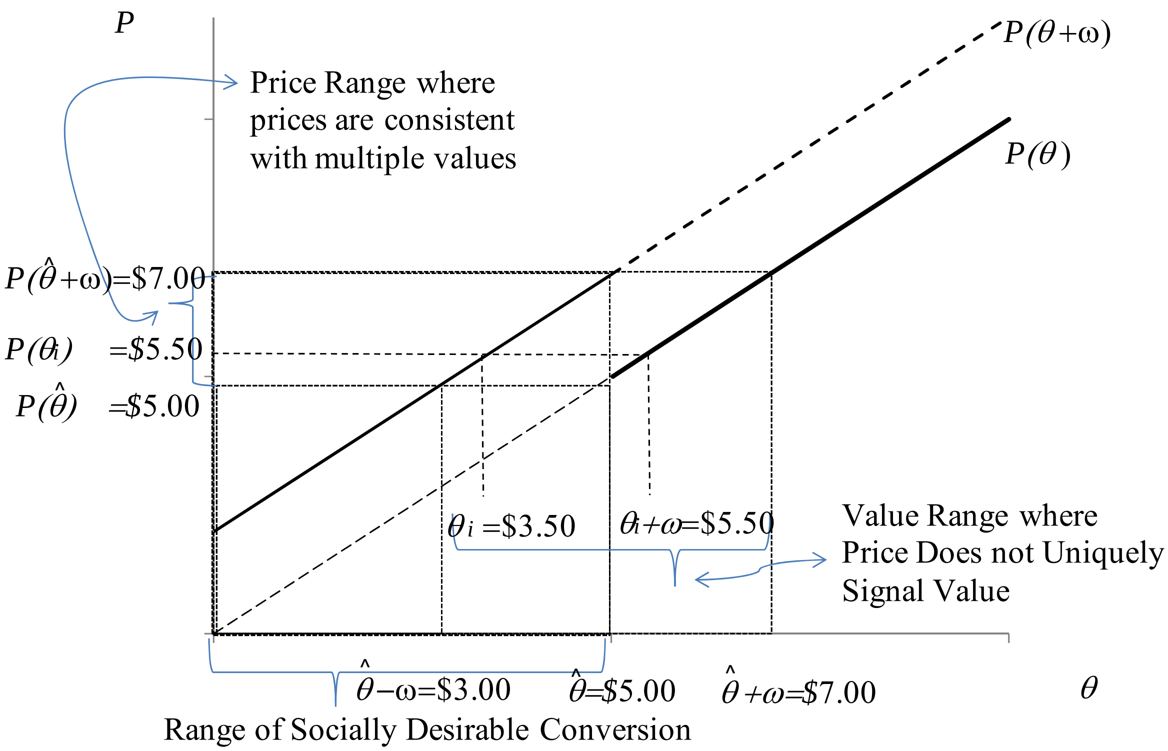


Figure 1. Prices and Fundamentals Given the Possibility of a Value-Increasing Conversion.

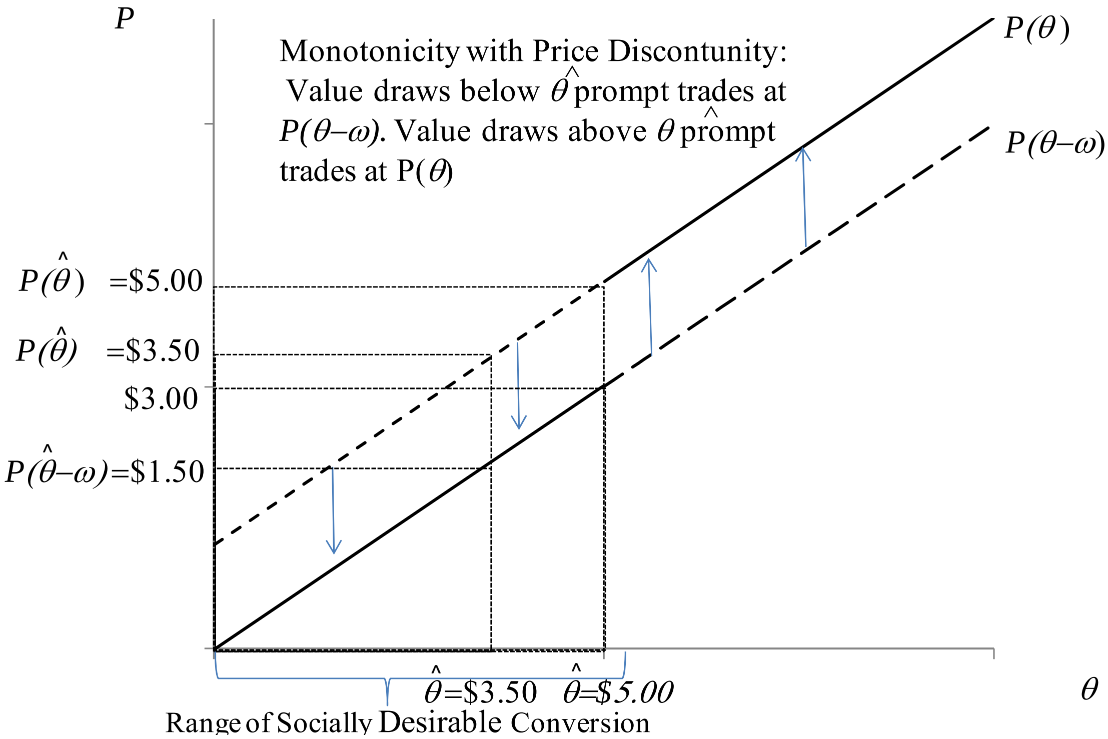


Figure 2. Prices and Fundamentals, Given the Possibility of a Value-Decreasing Conversion

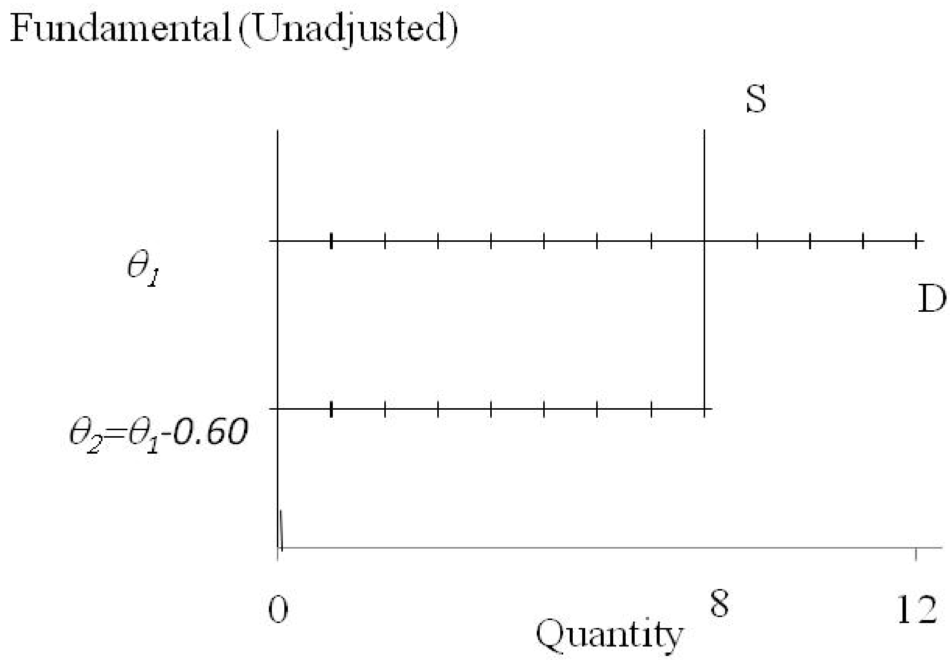


Figure 3. Market Supply and Demand, Given a Market Fundamental θ_1.

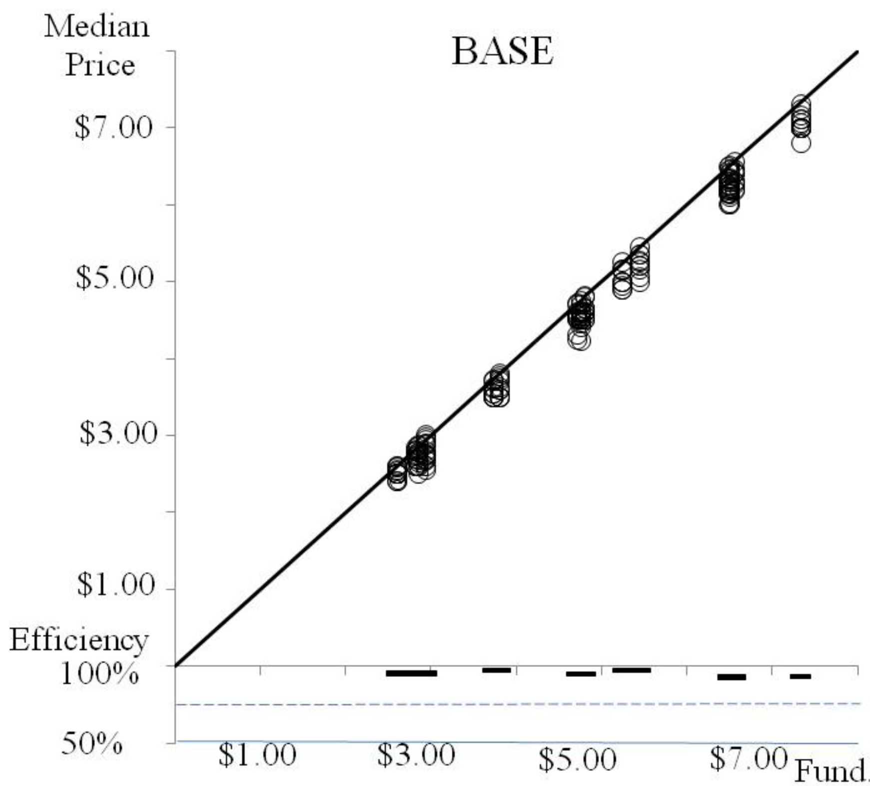


Figure 4. Median Contract Prices vs. Fundamental Realizations in the *BASE* Condition.
Key: Circles indicates median contract prices. Horizontal bars at the bottom of the figure indicate mean allocative efficiencies.

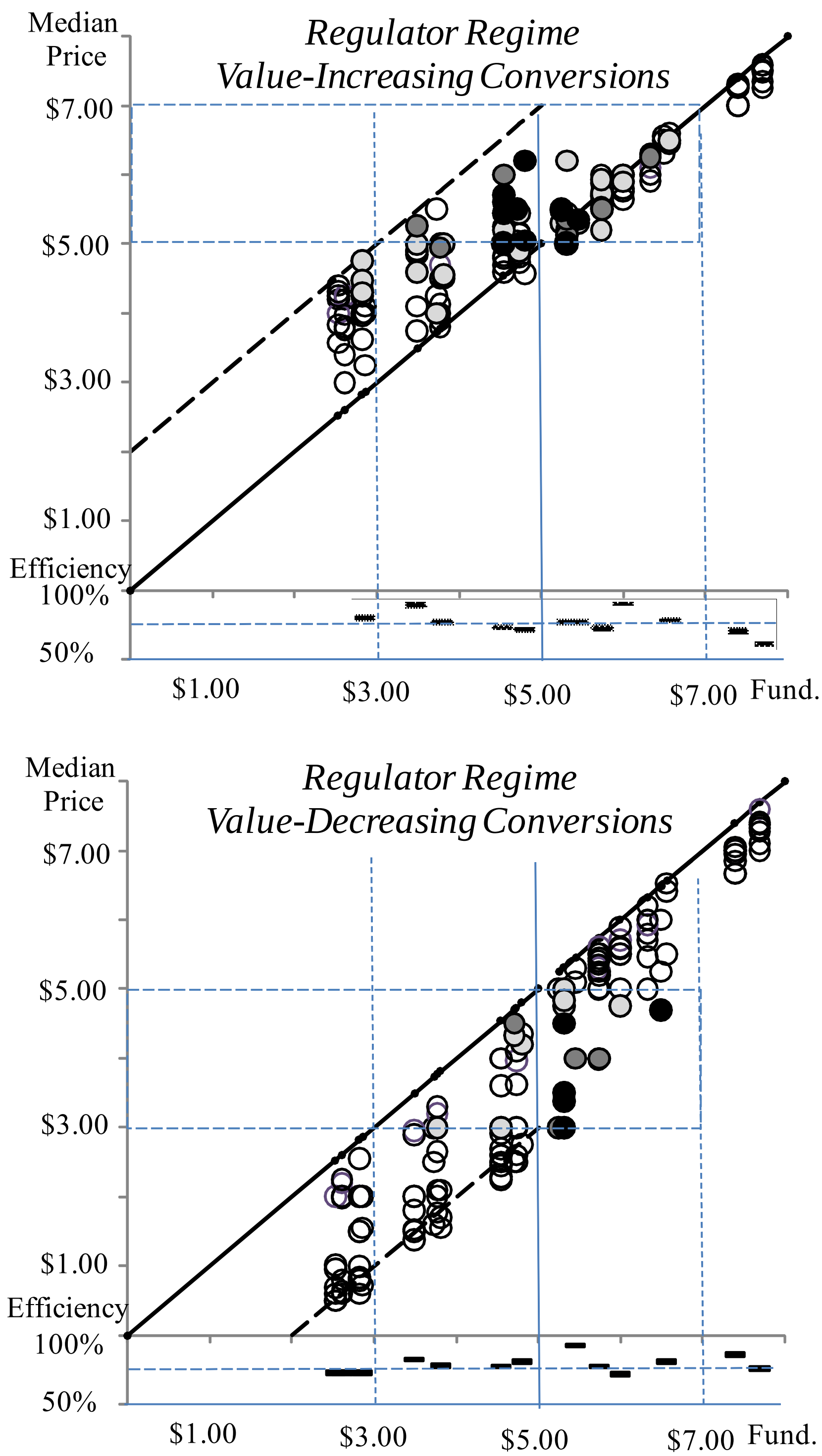
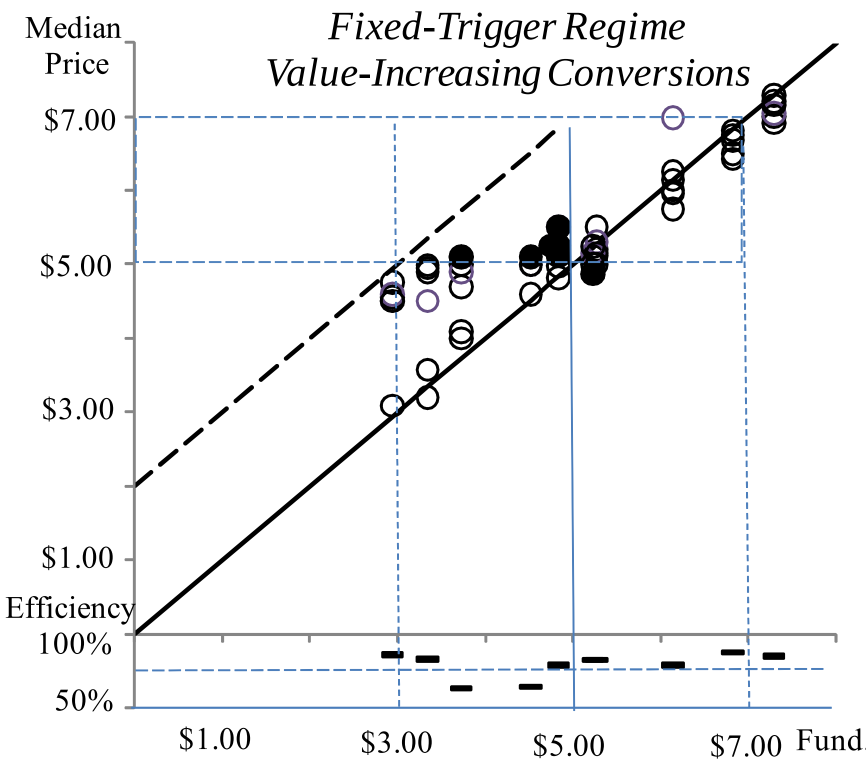


Figure 5. Median Contract Prices vs. Fundamental Realizations in the *Regulator* treatments. *Key*: Dots indicate median contract prices. Light gray, dark gray and black dots indicate instances of 1, 2 and 3 intervention errors, respectively. Bars indicate mean allocative efficiency.



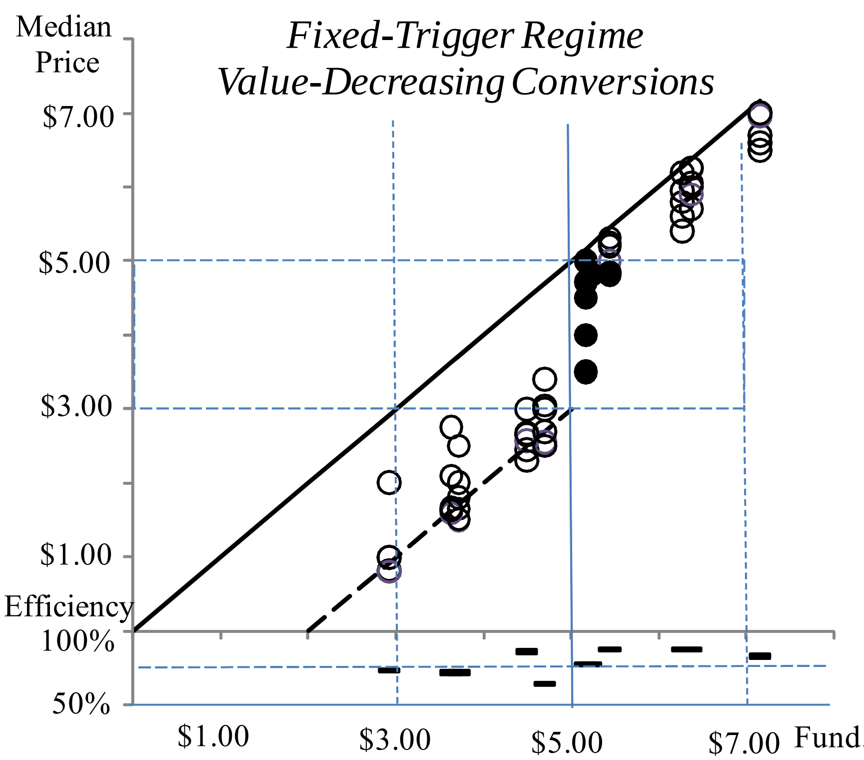
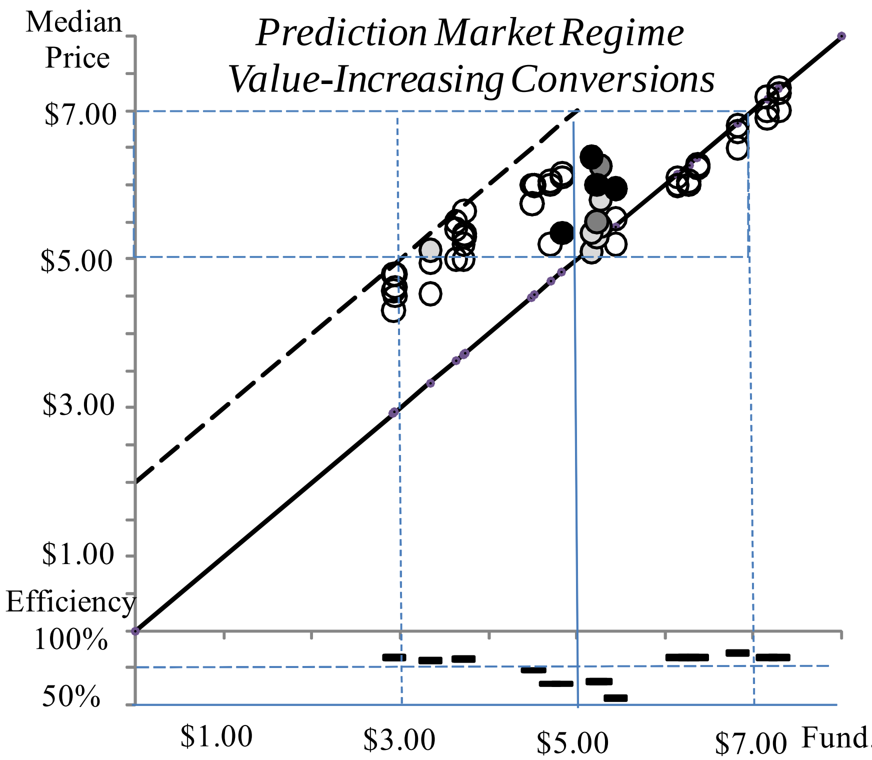


Figure 6. Median Contract Prices vs. Fundamental Realizations in the *Fixed Trigger* treatments. *Key*: Hollow dots indicate median contract prices. Black fillings indicate instances of intervention errors. Bars at the bottom of the page reflect mean allocative efficiencies.



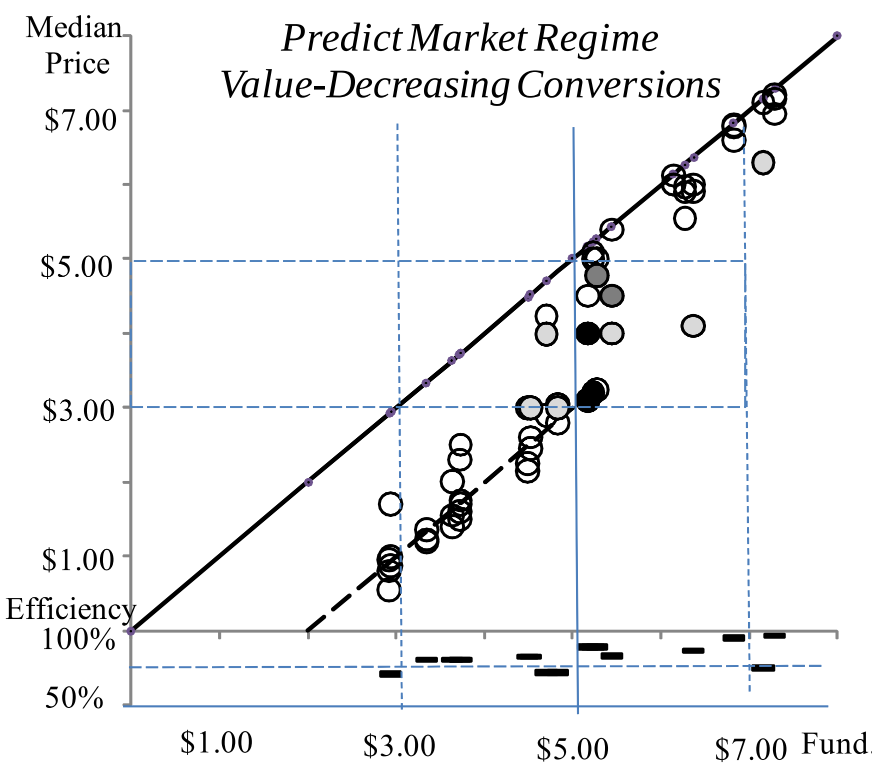


Figure 7. Median Contract Prices vs. Fundamental Realizations in the *Prediction Market* treatments. *Key*: Dots indicates median contract prices, light gray, dark gray and black dots indicate instances of 1, 2 and 3 intervention errors. Bars indicate mean allocative efficiency.

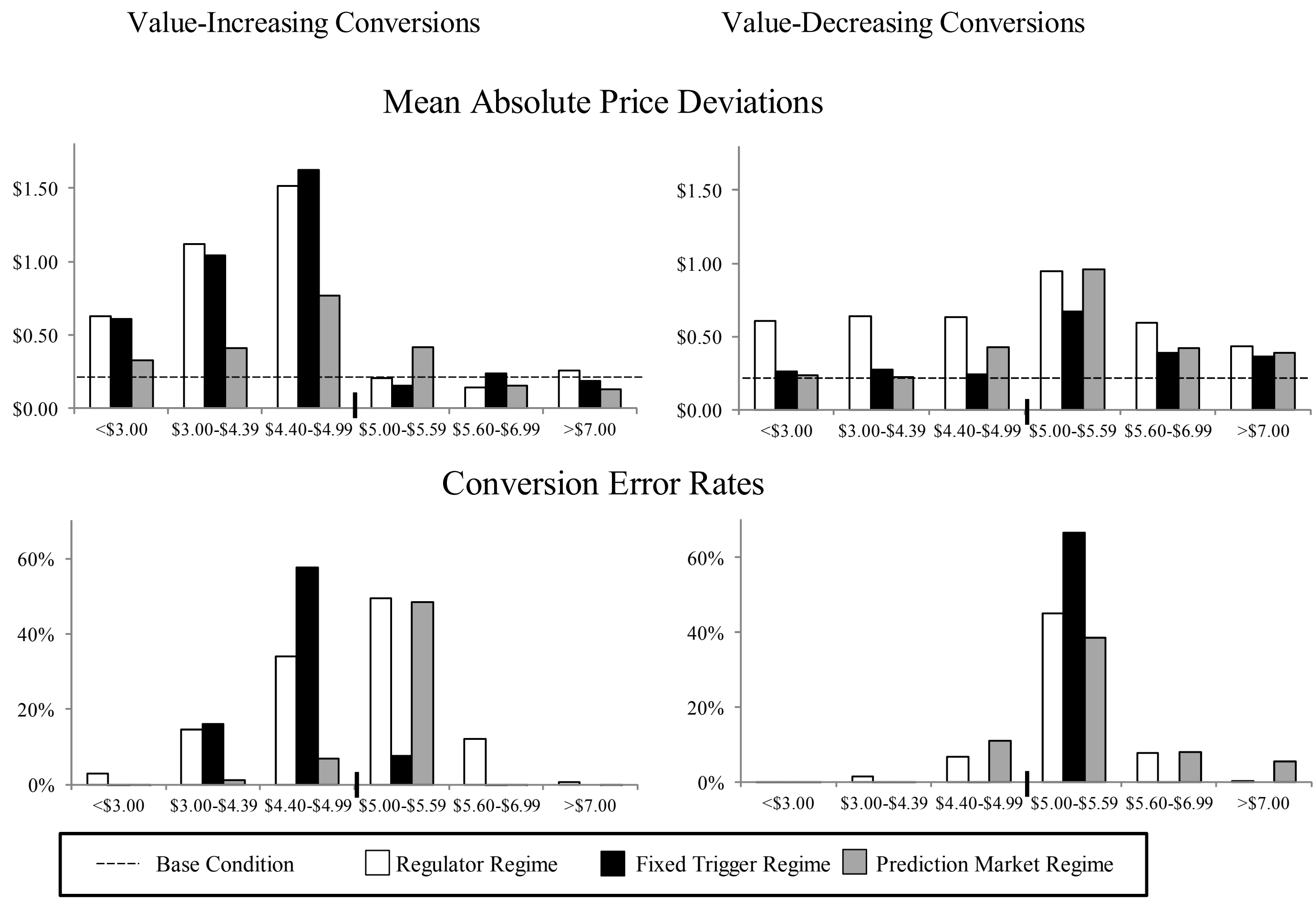


Figure 8: Mean Absolute Price Deviations and Conversion Error Rates by Segments

Table 1. Regulator Treatments, Incremental Effects

	Value-Increasing Conversions			*Value-Decreasing Conversions*		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\lvert P_{med} - P_{fx} \rvert$:	Allocative Efficiency	Conversion Error Rate	$\lvert P_{med} - P_{fx} \rvert$:	Allocative Efficiency	Conversion Error Rate
(i) Cons	21¢*	95%*		21¢*	95%*	
(ii) Active	29¢*	-11% *	3%†	42¢*	-16%*	8%*
(iii) Ambig	26¢*	-10%*	22%*			
N	320	320	150	320	320	150
Wald χ^2	121.2*	162.1*	29.18*	36.4*	154.8*	

Key: * and † indicate rejection of the null that the coefficient equals zero, *p*<.05 and *p*<.10, respectively (2-tailed tests).

Table 2. *Fixed Trigger* Treatments, Incremental Effects.

	Value Increasing Conversions			*Value-Decreasing Conversions*		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\lvert P_{med} - P_{fx} \rvert$:	Allocative Efficiency	Conversion Error Rate	$\lvert P_{med} - P_{fx} \rvert$	Allocative Efficiency	Conversion Error Rate
(i) Cons	21¢*	95%*		21¢*	95%*	
(ii) Active	6¢*	-11% *	3%	7¢	-20%*	0
(iii) Ambigft	107¢*	-11%*	35%*			
(iv) MultiEq				25¢*	10%*	33%*
N	230	230	60	230	230	60
Wald χ^2	96.77*	60.95*	8.7*	13.26*	81.74*	

Key: * and † indicate rejection of the null that the coefficient equals zero, *p*<.05 and *p*<.10, respectively (2-tailed tests).

Table 3. *Prediction Market* Treatments, Incremental Effects.

	Value Increasing Conversions			*Value Decreasing Conversions*		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\lvert P_{med} - P_{fx} \rvert$:	Allocative Efficiency	Conversion Error Rate	$\lvert P_{med} - P_{fx} \rvert$:	Allocative Efficiency	Conversion Error Rate
(i) Cons	21¢*	95%*		21¢*	95%*	
(ii) Active	19¢*	-19%*	12%*	26¢*	-12%*	12%*
N	230	230	60	230	230	60
Wald χ^2	37.05*	783.61*	--	6.41*	7.18*	-

Key: * and † indicate rejection of the null that the coefficient equals zero, p<.05 and p<.10, respectively (2-tailed test)

Table 4. *Prediction Markets*: Mean Ticket Prices (Standard Deviation)

	Fundamental					
	<$3.00	$3.00-$4.39	$4.40-$4.99	$5.00-$5.59	$5.60-$7.00	>$7.00
VIC	93¢ (3¢)	85¢ (16¢)[a]	77¢ (10¢)	52¢ (18¢)	14¢ (10¢)	10¢ (6¢)
VDC	94¢ (2¢)	82¢ (19¢)[b]	83¢ (9¢)	62¢ (20¢)	32¢ (19¢)	20¢ (21¢)

[a] Elimination of 2 low priced outliers changes entry to 92¢ (5¢)
[b] Elimination of 3 low priced outliers changes entry to 93¢ (6¢)

Appendix A
Sequences of Fundamental Realizations

Table A1. Sequence of Fundamental Value Realizations Initial *BASE/Regulator* Sessions

BASE Condition								
Period	1	2	3	4	5			
Fundamental	$2.94	$7.33	$4.76	$2.61	$6.50			
Regulator Periods								
Period	6	7	8	9	10	11	12	
Fundamental	$5.73	*$3.77*	$2.61	$7.39	$5.99	*$3.49*	$5.74	
Period	13	14	15	16	17	18	19	20
Fundamental	*$4.54*	$7.69	$2.82	*$4.73*	$6.33	$2.53	$5.31	*$4.54*

Table A2. Sequence of Fundamental Value Realizations — Second Sessions

Period:	1	2	3	4	5	6	7	8	9	10
Sequence					Fundamental					
A5	6.56	4.80	2.86	5.55	3.73					
B5	6.49	3.81	5.45	2.82	4.71					
A10	6.82	3.34	4.83	6.14	5.23	2.92	5.44	7.16	4.70	3.72
B10	2.94	4.52	7.29	5.27	3.73	4.49	6.27	3.63	6.37	5.17

Table A3. Fundamental Realization Sequences for *Prediction* and *Fixed Trigger* Markets

Prediction Market				
BASE	*Regulator*	Value-Increasing Conversion	Value-Decreasing Conversion	Sessions
A5	B5	A10		3
B5	A5	B10		3
A5	B5		A10	3
B5	A5		B10	3
Fixed-Trigger				
A5		A10	B10	3
B5		B10	A10	3

Appendix B

Performance by Segment in the *Regulator* Treatments. Incremental Effects of *Fixed Trigger* and *Prediction Market* Treatments.

	Value-Increasing Conversions			Value-Decreasing Conversions		
(1) Range	(2) $\lvert P_{med} - P_{fx} \rvert$	(3) Allocative Efficiency	(4) Conversion Error Rate	(5) $\lvert P_{med} - P_{fx} \rvert$	(6) Allocative Efficiency	(7) Conversion Error Rate
			Base			
$2.00 - $8.00	21¢*	95%*		21¢*	95%*	
			Regulator			
>$7.00	25¢	88%*	1%	43¢*	85%*	0%
$5.60-$7.00	15¢*	83%*	12%*	59¢*	79%*	8%†
$5.00-$5.59	21¢	71%*	49%*	94¢*	90%*	45%*
$4.40-$4.99	151¢*	63%*	34%*	64¢*	77%*	7%†
$3.00-$4.39	112¢*	73%*	15%*	64¢*	74%*	1%
<$3.00	63¢*	81%*	3%†	61¢*	77%*	0%
			Fixed Trigger – Regulator			
>$7.00	-6¢	-3%	-1%	-7¢	-2%	0%
$5.60-$7.00	10¢	0%	-13%*	-20¢	9%*	-8%†
$5.00-$5.59	-5¢	11%*	-42%*	-27¢	-8%	21%
$4.40-$4.99	11¢	8%†	24%	-39¢*	-2%	-7%†
$3.00-$4.39	-8¢	1%	1%	-36¢†	-2%	-2%
<$3.00	-2¢	5%	-4%†	-34¢	-4%	0%
			Prediction Market – Regulator			
>$7.00	-12¢*	-6%	-2%	-4¢	1%	5%
$5.60-$7.00	1¢	-1%	-14%*	-17¢	10%*	0%
$5.00-$5.59	21¢	-8%	-1%	2¢	-3%	-6%
$4.40-$4.99	-74¢*	5%	-27%*	-21¢	0%	4%
$3.00-$4.39	-71¢*	8%	-13%*	-41¢*	6%	-2%
<$3.00	-30¢*	1%	-5%†	-37¢*	-6%	0%
N	440	440	270	440	440	270
Wald χ^2	--	--	--	--	--	--

Key: * and † indicate rejection of the null that the coefficient equals zero, $p<.05$ and $p<.10$, respectively (2-tailed tests).