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Contingent Capital: The Trigger Problem

Edward Simpson Prescott

Contingent capital is long-term debt that automatically converts to equity when a trigger is breached. It is a new and innovative security that many people are proposing as part of a reform in bank capital regulations.[1] The security is most associated with Flannery (2005), but with the recent financial crisis many others, including Flannery (2009); Huertas (2009); Albul, Jaffee, and Tchistyi (2010); Plosser (2010); Squam Lake Group (2010); Calomiris and Herring (2011); McDonald (2011); Pennacchi (2011); and Pennacchi, Vermaelen, and Wolff (2011), have also advocated its adoption.[2] Furthermore, the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 mandated a study of contingent capital, while the Independent Commission on Banking's report (2011) on banking in the United Kingdom recommended that bank capital structure include loss-absorbing debt like contingent capital.

Contingent capital has four appealing properties. First, it increases a bank's capital when a bank is weak, which is precisely when it is hardest for a bank to issue new equity. In doing so, contingent capital reduces the "debt overhang" problem, which is the inability of a bank to raise funds to finance new loans because their return partially accrues to existing debtholders. During the recent financial crisis, many U.S. banks were forced to raise new equity. If they had had contingent capital securities, this process would have been much easier. Second, contingent capital automatically restructures part

The views expressed here are those of the author and not necessarily those of the Federal Reserve Bank of Richmond or the Federal Reserve System. E-mail: edward.prescott@rich.frb.org.

[1] There are already several changes to bank capital requirements, like increasing capital levels and making them more procyclical, that have already been implemented or are in the process of being implemented.

[2] See Calomiris and Herring (2011) for a more detailed list of the various contingent capital proposals. An early analysis is contained in Raviv (2004). Finally, there are also related proposals like Hart and Zingales (2011) that require banks to raise more equity when price triggers are breached.

of a bank's capital structure, reducing the chance it fails and is put in resolution or bankruptcy.[3] Many people think that the abrupt nature of Lehman's bankruptcy was very disruptive to financial markets, so a pre-bankruptcy reorganization of a financial firm may be valuable. Third, it is a way to force regulators to act, at least when the trigger is tied to an observable variable, like the price of a bank's equity. Fourth, it "punishes" equityholders by diluting existing equityholders. Some proposals argue that the threat of this dilution will give a bank an incentive to take less risk (e.g., Calomiris and Herring 2011).

All four of these properties have varying degrees of merit, but the purpose of this article is not to analyze these benefits.[4] Instead, it is to discuss a cost of implementing contingent capital. All contingent capital proposals rely on a trigger to implement conversion. Many of the proposals advocate the use of a market-price trigger (e.g., Flannery 2005, 2009), but some of them rely on accounting numbers (e.g., Huertas 2009), and others also include a role for regulators. For example, Squam Lake Group (2010) advocates as a trigger the use of accounting numbers at the firm level plus a regulatory declaration that there is a systemic crisis.

This article argues that the trigger is the weak point of contingent capital and, more specifically, a trigger based on a market price, be it a fixed trigger or a signal for a regulator to act, suffers from an inability to price contingent capital. This inability will be more precisely defined later, but the problem arises because asset prices incorporate the possibility of conversion and the way in which contingent capital conversion is triggered makes this feedback problematic. In practice, this will mean conversion could occur when it is not desired. Unless the price trigger can be designed in a way to overcome this problem, contingent capital with a price trigger will not work.

An alternative to a price-based trigger is an accounting-based one. This article does not focus on this type of trigger except to note that accounting measures of a bank's quality seem to lag its actual condition. For example, the prompt corrective action provision (PCA) of the Federal Deposit Insurance Corporation (FDIC) Improvement Act of 1991 is an accounting-based regulatory trigger system. It does not convert debt to equity like with contingent capital, but it requires regulators to restrict the activities of a bank and even shut the bank down if regulatory capital drops below certain thresholds. The motivation behind PCA was to force regulators to act before a bank's losses got too big. In the recent crisis, losses to the deposit insurance fund have been very high despite the existence of PCA (Government Accountability Office

[3] It is worth noting that even though converting debt to equity raises the book value of equity, it does not bring new cash into a firm (other than indirectly by eliminating interest payments on the converted debt) like a new issuance of equity would.

[4] This is not entirely true. The Appendix contains a discussion of why the incentive effects of contingent capital are not the major benefit of contingent capital.

2011). For example, FDIC losses on banks and thrifts (excluding Washington Mutual) that failed over the period 2007–2010 have been 24.62 percent of the assets of these failed institutions.[5] Based on this experience, caution about the timeliness of accounting measures seems warranted.

Underlying the use of price triggers in contingent capital is the fundamental idea that prices aggregate information, so regulation should be able to use them to make decisions. Indeed, one of the most robust findings in financial economics is that prices are efficient in the sense that prices incorporate all available information (Fama 1970). A striking example is found in Roll (1984), who documents that the price of orange juice futures better predicts variations in Florida weather than National Weather Service forecasts. Indeed, the empirical banking literature surveyed in Flannery (1998) documents that bank security prices can predict changes in supervisory ratings.[6]

This article uses a simple model to illustrate how the usual theoretical and empirical properties of financial prices break down for contingent capital with a price trigger. The model is based on a small theoretical literature that has found that the discrete jump in security prices resulting from conversion interferes with the ability of prices to aggregate information.[7] This problem with contingent capital was discovered by Sundaresan and Wang (2011), who found that contingent capital with a trigger based on an equity price could not be priced because there did not necessarily exist a unique set of prices. When conversion heavily diluted equity, they found that there were multiple equilibria. When conversion raised the value of equity, they found that there were no equilibria.

Birchler and Facchinetti (2007) and Bond, Goldstein, and Prescott (2010) studied the related problem of a regulator who could intervene in the operations of a bank and thus affect the value of the bank. In both articles, the regulator did not know the fundamental value of the bank, but instead had to infer it from the prices of the traded bank securities. Instead of using a price-trigger rule, the regulator had trigger-like preferences in that he wanted to intervene only when the fundamental quality of the bank was below some threshold. The

[5] Washington Mutual is excluded for two reasons. First, including it skews the average because it had about $300 billion in assets and the FDIC took no loss on it when they arranged a sale through receivership to J.P. Morgan Chase. The high average on the rest of the failed banks illustrates that there were a lot of banks for which the accounting numbers substantially lagged their actual condition, otherwise losses would have been much smaller. Second, Washington Mutual was not shut down because of a violation of PCA triggers, but rather because of liquidity problems. Indeed, it was well capitalized by PCA standards as of September 25, 2008 (Offices of Inspector General 2010), so it is further evidence that accounting numbers can lag actual condition.

[6] Motivated by this logic, there is an older set of proposals (e.g., Stern 2001) that advocate that bank supervisors use market prices to supplement their surveillance of banks.

[7] One concern raised about the use of market price triggers is that traders will manipulate prices to generate conversion when it would be advantagous to them. While this is a legitimate concern, the analysis in this article shows that there are problems with using market prices as a trigger even in the absence of these concerns.

effect of the intervention decision is mathematically similar to the effect from a price trigger—there is nonexistence of equilibrium when the regulator cannot commit to an intervention rule, though in the simplest environments there is a unique equilibrium when there is heavy dilution. Indeed, the implication of their work is that when prices are used as a trigger, prices need *not* aggregate all available information.

Almost all the analysis of contingent capital is theoretical because there is no financial market evidence. Sundaresan and Wang (2011) report only four issuances of contingent capital, all of which were within the last few years. Furthermore, none of these issuances purely rely on market prices. For example, Credit Suisse (2011) issued a contingent-capital security in 2011 that used as its trigger the equity capital ratio and allowed the regulator to trigger conversion if it was determined that customary measures to improve capital adequacy were inadequate to keep Credit Suisse viable.

To overcome this lack of data, Davis, Korenok, and Prescott (2011) ran market experiments to study the effect of using a market price as a contingent capital trigger. Market experiments are small scale economies run in laboratories with human subjects who trade in a market. They found that conversion increased the volatility of prices, reduced the efficiency of allocations, and led to conversion errors with some frequency. A summary of their findings is provided.

Section 1 illustrates the pricing problem with a simple theoretical model. Section 2 discusses possible ways around the pricing problem. Section 3 briefly discusses the experimental results. Section 4 concludes, and the Appendix contains an argument for why contingent capital will only partially reduce risk-taking incentives.

1. THE MODEL

There is a bank that is financed by one unit of equity and one unit of debt. Debt is scheduled to pay one and there is one share of equity. The value of the bank, that is, the amount of cash it has to distribute, is $\theta > 0$.

The bank's equity is traded in a market by risk-neutral traders. These traders know the value of θ and use that information plus their expectation of whether debt will be converted to equity to trade the equity. The price of equity depends on θ and is written $p(\theta)$.

For simplicity, this article only considers conversion rules in which all the debt is converted to equity. This assumption is not important for the results. The *conversion rule* is $\alpha(p)$, which at price p converts the single unit of debt into α shares of equity. As with the trigger rule proposals, the conversion depends on the price of equity. There are a lot of possible conversion rules, but the most common ones are to convert the debt to a fixed number of shares.

In particular, they take the form

$$\alpha(p) = \begin{cases} \alpha > 0 & \text{if } p \leq \hat{p} \\ 0 & \text{if } p > \hat{p} \end{cases},$$

where $\hat{p}$ is some fixed trigger. The idea is that as a bank gets closer to insolvency, its share price will drop and that is when it is best to automatically convert debt to equity.

Definition 1 *Given a trigger rule, $\alpha(p)$, an equilibrium is a price of equity, $p(\theta)$, such that $\forall\theta$*

$$p(\theta) = \begin{cases} \frac{\theta}{1+\alpha(p(\theta))} & \textit{if } \alpha(p(\theta)) > 0 \\ \theta - 1 & \textit{if } \alpha(p(\theta)) = 0 \end{cases}. \tag{1}$$

Equilibrium requires that prices, $p(\theta)$, be consistent with the conversion rule. As we will see, for some conversion rules no $p(\theta)$ will satisfy (1) and for others multiple $p(\theta)$ will.

No Conversion Benchmark

As a benchmark, consider the case of no conversion of debt. In this case, the price of equity is

$$p(\theta) = \begin{cases} 0 & \text{if } \theta \leq 1 \\ \theta - 1 & \text{if } \theta > 1 \end{cases}.$$

When $\theta \leq 1$, all the firm's payments go to the debtholders and there is nothing left for equityholders. When $\theta > 1$, the debtholders get the full payment of one and the equityholders get what is left.

Decreased Value of Equity

Most contingent capital proposals advocate setting conversion so as to heavily dilute equity in order to "punish" the owners of the bank.[8] The problem with a trigger rule that heavily dilutes equity is that there are multiple equilibria. To illustrate the problem, consider the trigger rule that if the price of equity is less than or equal to 1.5 then the debt is converted to one share of equity, so there are two shares of equity total. Formally,

$$\alpha(p) = \begin{cases} 1 & \text{if } p \leq 1.5 \\ 0 & \text{if } p > 1.5 \end{cases}. \tag{2}$$

Under this trigger rule, an equilibrium exists. One of them is

$$p(\theta) = \begin{cases} \theta/2 & \text{if } \theta \leq 3 \\ \theta - 1 & \text{if } \theta > 3 \end{cases}.$$

[8] See the Appendix for a discussion of incentives for equity owners.

To see this, if, at $\theta \leq 3$, the traders assume that there will be conversion, then the price is less than or equal to 1.5, which is consistent with the conversion rule. Similarly, for $\theta > 3$, if the traders assume that there is no conversion, then the price is $\theta - 1 > 1.5$, which is also consistent with the conversion rule.

A second equilibrium is

$$p(\theta) = \begin{cases} \theta/2 & \text{if } \theta \leq 2.5 \\ \theta - 1 & \text{if } \theta > 2.5 \end{cases}.$$

At $\theta \leq 2.5$, if traders assume there will be conversion, then the price will be less than or equal to 1.25, which is consistent with the conversion rule. Similarly, for $\theta > 2.5$, if the traders assume that there is no conversion, then the price is $\theta - 1 > 1.5$, which is also consistent with the conversion rule.

As should be apparent, any price function in which traders assume that there will be conversion for values of θ below any cutoff between 2.5 and 3.0 will be an equilibrium. But actually, the multiple equilibria problem is even worse than this. There are *lots* of other price functions that are equilibria, some of which are rather strange. For example,

$$p(\theta) = \begin{cases} \theta/2 & \text{if } \theta \leq 2.5 \\ \theta - 1 & \text{if } 2.5 < \theta \leq 2.6 \\ \theta/2 & \text{if } 2.6 < \theta \leq 3 \\ \theta - 1 & \text{if } \theta > 3 \end{cases}$$

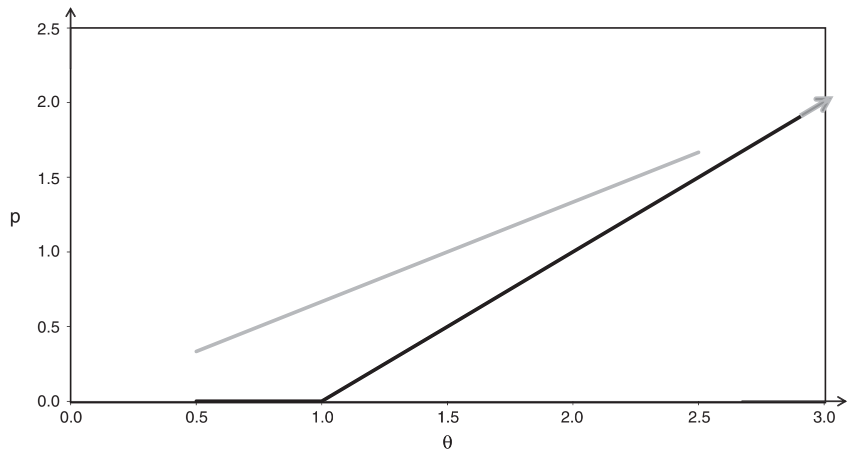
is also an equilibrium!

Multiple equilibria is a serious problem for contingent capital because it is unclear what its price will be. As we will see, a variety of prices occur in the experimental evidence. In terms of the proposal this means that conversion need not happen when it is desired or it may happen when it is undesired.

Increased Value of Equity

The proposals do not advocate conversion to increase the value of equity, but this case still has to be studied for two reasons. First, there may very well be states of the world where the price of equity is low, but conversion would increase the value of equity. For example, imagine a very high probability that θ will be less than 1, the amount owed to debtors. Equity does not have much value in this case, but if the debt is converted to equity, then the price of equity may very well go up even if it is heavily diluted. After all, a high probability of a small payment can be more valuable than a low probability of a high payment. Second, the proposals for regulators to use prices to take regulatory actions, like replacing management or doing something similar, could very well *increase* the value of the bank. This was the scenario studied in Birchler and Facchinetti (2007) and Bond, Goldstein, and Prescott (2010).

Figure 1 Increased Value of Equity Case



Notes: The black line shows the price of equity assuming that the debt is not converted to equity. The gray line shows the price of equity assuming that it converts to equity when $\theta \leq 2.5$. The gray line is non-monotonic, which is suggestive as to why there is no equilibria when the price trigger is set at 1.5. For θ just below 2.5, the price drops below 1.5 without conversion and increases above 1.5 with conversion. Neither possibility is consistent with the trigger rule.

If the value of equity increases from a conversion then the problem is not one of multiple equilibria, but instead that no equilibrium even exists. To see this, consider the same price trigger level as above, but now convert debt into 0.5 shares, that is,

$$\alpha(p) = \begin{cases} 0.5 & \text{if } p \leq 1.5 \\ 0 & \text{if } p > 1.5 \end{cases} . \tag{3}$$

Under this trigger rule, no equilibrium exists. To see this, consider what the price can be if $\theta = 2.5$. If traders assume there will be conversion, then there is no debt and 1.5 shares of equity. The price of equity would then have to be $\frac{2.5}{1.5}$, but that is greater than the 1.5 trigger, so there cannot be conversion. Alternatively, if traders assume that there will not be conversion then the price of equity is 1.5 without conversion, but that violates the trigger rule of converting when the price is less than or equal to 1.5.[9]

Figure 1 illustrates the problem. The gray line shows what prices would be *if* conversion could be tied directly to the fundamental value θ. The problem

[9] This is not just a problem right at the trigger point. The same logic applies to a range of fundamentals below 2.5, in this example, down to 2.25.

here is that a conversion rule that increases the price of equity requires a price function that is above the trigger value for a range of θ values below $\theta = 2.5$. This non-monotonicity in prices around the trigger implies that the trigger rule, as commonly proposed, cannot distinguish between values of θ for which conversion is desirable and values for which it is not.

2. SOLUTIONS?

The lack of existence of a unique equilibrium is a serious challenge to implementing contingent capital proposals. Certainly, triggers of the form analyzed above would not work. There are, however, alternative ways to structure the trigger that avoid these problems. Below, some possible solutions are described and assessed.

Getting the Conversion Ratio Just Right

If conversion is set so that the value of equity does not change at conversion, then there is a unique equilibrium. In the example above, a trigger rule that works is at a price of 1.5, convert the debt to $\frac{2}{3}$ a share. Under this rule, if conversion occurs at $\theta = 2.5$, then the price of equity is 1.5, just like if there is no conversion. Figure 2 illustrates.

More generally, the conversion ratio that generates a unique equilibrium is the one that generates a continuous monotonic price function. With a conversion rule that converts all the debt to α shares of equity (like in the examples above), α needs to be set so that at the desired conversion point, $\hat{\theta}$, the prices of equity under conversion and non-conversion are the same, that is,

$$\hat{\theta} - 1 = \frac{1}{1+\alpha}\hat{\theta}$$

or

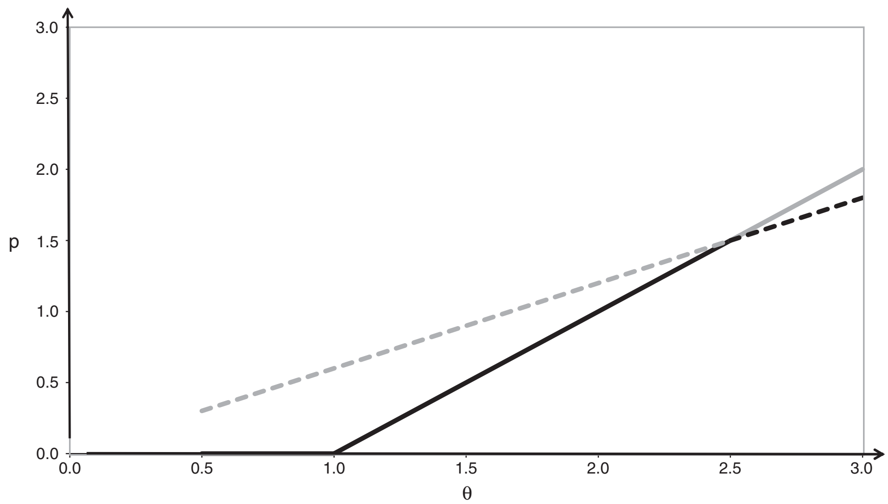
$$\alpha = \frac{1}{\hat{\theta} - 1}.$$

This means that the trigger price in turn needs to be

$$\hat{p} = \frac{1}{\alpha}.$$

While this conversion rule is simple and works in this one-period model, it need not work in a dynamic model with uncertainty. Sundaresan and Wang (2011) show that, in a dynamic model, even if the conversion ratio is set so that at maturity there is no change in the value of equity from conversion that is no guarantee that the same conversion ratio will not change the value of equity in earlier periods. Basically, a simple trigger rule is not robust enough to cover the wide variety of paths of uncertainty.

Figure 2 No Change in the Value of Equity at Conversion



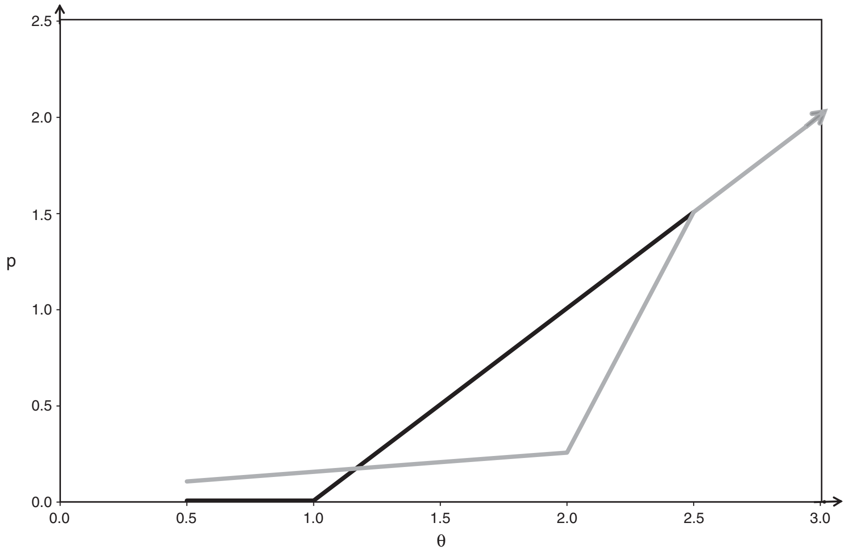
Notes: The solid line shows the price of equity assuming that the debt is not converted to equity. The dashed line shows the price of equity assuming that the debt always converts to equity. The portions of the lines in gray show the price of equity when the conversion ratio is set so that there is no change in the value of equity at the trigger. This price function is the only equilibrium.

Finally, in order to prevent a jump in the value of equity, this conversion rule actually helps the original equity owners, at least relative to no conversion. As Figure 2 illustrates, for values of θ less than 2.5, the price of a share is more than it would be without conversion. With this conversion rule, equity owners are actually not punished, which is one of the motivations behind contingent capital.

Sliding Conversion Rules

One way to "get the conversion ratio just right" without rewarding equity owners is to use a "sliding conversion rule." The idea is to make the amount of dilution vary so that as θ declines, the price continuously decreases. The monotonicity is needed for existence and the continuity is needed for uniqueness. Birchler and Facchinetti (2007) use a similar concept in their regulatory action model to get existence when there is a value-increasing action.

Figure 3 Trigger Rule with Unique Equilibrium that Punishes Equityholders



Notes: The black line shows the price of equity with non-convertible debt. The gray line shows the price of equity with debt that converts to equity using the sliding conversion rule in the text. The price function is continuous and monotonically increasing. Relative to non-convertible debt, it hurts original equity owners for medium values of θ, but helps them for low values of θ.

For this example, assume that the lower bound on θ is 0.5. A conversion function that generates a unique price function is

$$\alpha(p) = \begin{cases} (9p - 0.5)/p & \text{if } 0.10 \leq p \leq 0.25 \\ (4.75 - 1.5p)/2.5p & \text{if } 0.25 < p \leq 1.5 \\ 0 & \text{if } p > 1.5 \end{cases} .$$

Figure 3 shows the price function that results from this conversion rule. It is the piecewise linear gray line, and it is straightforward to show that it is the unique price function. There are three things to note about this function. First, the continuity prevents the multiple equilibria that arose in the heavy dilution example. Second, the monotonicity prevents the discrete drop in price at and above a trigger point, which was the source of nonexistence in the increased value example. Third, the price schedule punishes equity owners for a range of values of θ below the trigger. For the lowest values of θ, equityholders are actually made better off by conversion, but this feature is only there to keep the price of equity above zero. With a trigger and a conversion rule that wipes out old equity—bankruptcy can be thought of a conversion rule with $\alpha = \infty$—the price of equity is zero under conversion, so there is a really severe form of multiple equilibria, namely, for *any* value of θ there is an equilibrium where the price of equity is zero! Keeping the price of equity positive under conversion prevents this perverse problem.

Use Other Information

Another possible solution is to make the conversion depend on the total value of the firm (e.g., Raviv [2004] and Pennacchi [2011]). In the example, the total value of the firm is simply the value of equity plus the value of contingent capital. If the trigger were set so that the total value of the firm is less than or equal to 2.5, then a unique equilibrium would exist. The reason is that the value of equity plus debt is simply the value of the firm, that is, the cash flow θ, and that does not change with conversion.

The obvious concern with this solution is that markets for bank debt (not to mention bank deposits) are far less liquid than those for equity, so good measures of the value of the firm will not be readily available. But even if this issue could be overcome, the deeper issue is whether conversion affects the value of a firm. The firm-value trigger works in this example because the model is a Modigliani-Miller environment in that the capital structure does not affect the value of the firm. However, implicit in many of the arguments for contingent capital is that a debt-to-equity conversion will *improve* the value of the firm by reducing debt overhang. But if there is a debt overhang problem then the environment is *not* a Modigliani-Miller one, so a change in the capital structure would create a discrete change in the value of the firm and there would be the same problems with equilibrium that we analyzed above.[10]

Price Restrictions

A simple way to deal with the multiple equilibria is to forbid exchanges of equity at certain prices. In the decreased value of equity example above, if equity were forbidden to trade over the range $(1.25, 1.5]$ then the only equilibrium would be the one where conversion occurs for $\theta \leq 2.5$. The other equilibria discussed above simply cannot occur.

Even if it were feasible to prohibit trading at certain prices, this solution would still require a lot of information to set up. The amount of the drop in the price of equity will depend on the aggregate state (something that was not in

[10] The Birchler and Facchinetti (2007) and Bond, Goldstein, and Prescott (2010) studies were precisely worried about regulatory interventions that changed, and more specifically improved, the value of the bank.

the model above). That requires a lot of information on the part of regulators to set up.

Prediction Markets

Another possible solution is to introduce prediction markets in whether or not there is conversion and use that information as part of the trigger. Bond, Goldstein, and Prescott (2010) show that in the regulatory action with an increased value of equity case, when prediction markets are added, a unique equilibrium exists. Here, we show that with a price trigger rule that also depends on the price of the prediction security, a unique equilibrium exists for both the decreased and increased value examples.

The prediction market is a market in a security that pays one if there is conversion and zero otherwise. The same traders who trade equity also trade the prediction security. The price of the prediction security is $q(\theta)$ and the trigger rule now depends on both prices, that is, $\alpha(p, q)$. A price of one means that traders expect conversion and a price of zero means they do not.

Definition 2 *Given a trigger rule, $\alpha\,(p, q)$, an equilibrium is a price of equity, $p(\theta)$, and a price of the prediction security, $q(\theta)$, such that $\forall\theta$*

$$p(\theta) = \begin{cases} \frac{\theta}{1+\alpha(p(\theta),q(\theta))} & \text{if } \alpha\,(p\,(\theta)\,, q\,(\theta)) > 0 \\ \theta - 1 & \text{if } \alpha\,(p\,(\theta)\,, q\,(\theta)) = 0 \end{cases}$$

$$q(\theta) = \begin{cases} 0 & \text{if } \alpha\,(p\,(\theta)\,, q\,(\theta)) = 0 \\ 1 & \text{if } \alpha\,(p\,(\theta)\,, q\,(\theta)) > 0 \end{cases}.$$

For the example studied earlier, where the value of equity declines with conversion, consider the following modification to the trigger rule (2):

$$\alpha(p, q) = \begin{cases} 1 & \text{if } p \leq 1.25 \\ 1 & \text{if } 1.25 < p \leq 1.5 \text{ and } q = 0 \\ 0 & \text{if } 1.25 < p \leq 1.5 \text{ and } q = 1 \\ 0 & \text{if } p > 1.5 \end{cases}.$$

The price function

$$p(\theta) = \begin{cases} \theta/2 & \text{if } \theta \leq 2.5 \\ \theta - 1 & \text{if } \theta > 2.5 \end{cases}$$

$$q(\theta) = \begin{cases} 1 & \text{if } \theta \leq 2.5 \\ 0 & \text{if } \theta > 2.5 \end{cases}$$

is an equilibrium. For $\theta \leq 2.25$, conversion has to happen, while for $\theta > 3$, conversion cannot happen. Where the prediction security gets used is for the range of θ where multiple equilibria were an issue without the prediction security. First, consider the range $2.25 < \theta \leq 2.5$. If traders assume that there will be no conversion, then $1.25 < p \leq 1.5$ and $q = 0$, but by the trigger rule there will be conversion. If traders assume there will be conversion, then $p \leq 1.25$, and there is conversion (and $q = 1$), which is consistent with the trigger rule. Second, consider the range $2.5 < \theta \leq 3$. If traders assume that there will be conversion, then $1.25 < p \leq 1.5$ and $q = 1$, but by the trigger rule there will not be conversion. In contrast, if traders assume there will not be conversion, then $p > 1.5$, and there is no conversion (and $q = 0$), which is consistent with the trigger rule. This trigger rule eliminates the multiple equilibria by making it impossible for prices to fall in the range between 1.25 and 1.5, which prevents conversion at values of $\theta > 2.5$. Essentially, this solution uses the trigger rule to restrict the prices in the same way that the analysis of the price-restriction solution did earlier.

In the case where the value of equity increases, where existence of equilibrium was the problem earlier, the prediction market gives the trigger rule enough extra information to recover existence. Consider the modification to the earlier trigger rule (3):

$$\alpha(p, q) = \begin{cases} 0.5 & \text{if } p \leq 1.5 \\ 0.5 & \text{if } 1.5 < p \leq 1\frac{2}{3} \text{ and } q = 1 \\ 0 & \text{if } 1.5 < p \leq 1\frac{2}{3} \text{ and } q = 0 \\ 0 & \text{if } p > 1\frac{2}{3} \end{cases} .$$

The price function

$$\begin{aligned} p(\theta) &= \begin{cases} \frac{2}{3}\theta & \text{if } \theta \leq 2.5 \\ \theta - 1 & \text{if } \theta > 2.5 \end{cases} \\ q(\theta) &= \begin{cases} 1 & \text{if } \theta \leq 2.5 \\ 0 & \text{if } \theta > 2.5 \end{cases} \end{aligned}$$

is a unique equilibrium. To see this, first consider $\theta \leq 2.5$. If traders assume conversion, then $p \leq 1\frac{2}{3}$ and $q = 1$, which is consistent with the trigger rule. If traders assume no conversion then $p \leq 1.5$, but that requires conversion according to the trigger rule, so that is not a possibility. Now consider $\theta > 2.5$. If traders assume that there is no conversion, then $p > 1.5$ and $q = 0$, which is consistent with the trigger rule. However, if traders assume conversion, then $p > 1\frac{2}{3}$, which by the trigger rule requires no conversion, so that is not a possibility.

A prediction market security of the form discussed above does not exist right now. Nevertheless, credit default swaps are very close in that they are essentially insurance contracts that pay out in the event of a default. If a credit default swap was designed so that conversion was the triggering "default" event, then the swap could be used as the prediction security. Of course, the usual concerns about liquidity and market manipulation would apply.

3. EVIDENCE

As was discussed earlier, there is very little empirical evidence on the effectiveness of contingent capital. The only source of evidence that I am aware of is from the laboratory experiments reported in Davis, Korenok, and Prescott (2011). Laboratory experiments are games played by subjects (typically college students) for real stakes. The experiments can be used to study individual decisionmaking or more complex group interactions.

Davis, Korenok, and Prescott (2011) ran experiments where the subjects used a standard open book double auction to trade an asset that could change in value if a price trigger were breached. The price trigger worked just like the examples above. If breached, the underlying value of the asset jumped up in some of the experiments and dropped in others.

As predicted by theory, they found that the fixed-price trigger created informational inefficiencies in the sense that prices deviated from fundamentals and were more volatile. This was true in experiments where the value of equity was increased and those where it was decreased. The problems were worse, however, in the case where the value increased.[11]

Compared with a no-conversion baseline, they also found that conversion made the allocation less efficient in the sense that assets ended up less frequently in possession of the traders who valued them the most. Finally, they also found the trigger was frequently breached when the fundamentals did not warrant conversion and it was sometimes not breached when fundamentals warranted conversion. For some ranges of fundamentals, these errors occurred most of the time. There were some caveats to their findings. In particular, conversion errors in the decreased-value experiments were concentrated in the range of fundamentals just above the trigger, which may be tolerable from a cost-benefit perspective, but for increased-value experiments conversion errors were dispersed over a wider range of fundamentals.

They also ran experiments where, instead, a regulator made the decision of whether or not to convert. The regulator was given a reward structure that rewarded him if he converted when the fundamental was below the trigger or if he did not convert when it was above the trigger. Compared with the fixed-price trigger, performance by a regulator tended to be worse. In particular, it seemed that the additional source of uncertainty for traders, namely, guessing how the regulator would interpret the price, made prices more volatile. Furthermore, the regulator made conversion errors over a wider range of fundamentals than in the fixed-trigger experiments. They also ran experiments with a prediction market in whether the regulator would convert. The additional information from the prediction market improved the efficiency of

[11] This was the case where an equilibrium did not exist in the model.

prices and allocations as well as the performance of the regulator, but substantial inefficiencies remained.[12]

For more details see the article, but overall they concluded that the inefficiencies and frequency of conversion errors are a significant cost to using contingent capital with a price trigger.

4. CONCLUSION

This article illustrates the potential pitfalls of using a market-price trigger in contingent capital. The multiple equilibria and nonexistence results are problematic for these proposals. Indeed, in the closest thing we have to empirical evidence—the market experiment data—the use of a trigger made prices and allocations less efficient, increased volatility, and led to numerous conversion errors.

In my view, any contingent capital proposal that uses market-based prices needs to confront these problems. A viable proposal needs to find a trigger that is not subject to multiple equilibria and nonexistence or, alternatively, one that leads to few conversion errors, minor inefficiencies, and reasonable levels of price volatility.

APPENDIX: A DIGRESSION ON INCENTIVES

Many of the proposals advocating contingent capital emphasize the value of "punishing" the equity owners by diluting equity (e.g., Calomiris and Herring 2011) in order to improve equity owners' ex ante incentives. Structuring bank capital to improve incentives is an idea with a long tradition in the banking literature. The banking literature that came out of the savings and loan crisis emphasized the risk-shifting incentives that bank equity owners have under a legal and regulatory system that includes limited liability and deposit insurance (e.g., White 1991).

This perspective is one that I am sympathetic with, but if incentives are the motivation behind contingent capital, then the analysis is better served by directly using an incentive model with an explicit treatment of moral hazard. The standard approach to analyzing incentives is to use a moral hazard model where bank equity owners have limited liability and can choose the amount

[12] They did not run experiments where a prediction market was combined with a fixed-price trigger.

of risk the bank takes.[13] Interestingly, in this class of models, Marshall and Prescott (2001, 2006) found that the most effective way to discourage a bank from taking excessive risk was to, counterintuitively, "punish" the bank when it did well! (In their context, punishment meant requiring that the bank's capital structure include warrants with a high strike price that essentially reduced the upside gain to the bank. For a summary of their argument, see Prescott [2001].) The reason for their surprising result was that very high returns were more likely when a bank took an excessive amount of risk than an appropriate amount, so reducing equityholders' payoffs in these states was desirable. In their model, it was also desirable to "punish" the equityholders when the bank did poorly, but limited liability reduced the amount of punishment that could be provided in this case.

The point of this digression is to argue that bank incentives need to be viewed from a broad perspective that may well put little emphasis on "punishing" equityholders when a bank does poorly, or more accurately, that the incentive implications of a heavy dilution are only a part, and possibly a small part, of the total incentives created by a bank's capital structure. For this reason, I think recapitalization effects rather than any incentive effects are what is potentially most valuable about contingent capital.

REFERENCES

Albul, Boris, Dwight M. Jaffee, and Alexei Tchistyi. 2010. "Contingent Convertible Bonds and Capital Structure Decisions." Manuscript, University of California at Berkeley.

Birchler, Urs, and Matteo Facchinetti. 2007. "Self-Destroying Prophecies? The Endogeneity Pitfall in Using Market Signals as Triggers for Prompt Corrective Action." Manuscript, University of Zurich.

Bond, Philip, Itay Goldstein, and Edward Simpson Prescott. 2010. "Market-Based Corrective Actions." *The Review of Financial Studies* 23 (February): 781–820.

Calomiris, Charles W., and Richard J. Herring. 2011. "Why and How to Design a Contingent Convertible Debt Requirement." Wharton Financial Institutions Center Working Paper 11-41 (April).

[13] Implicitly, these models assume that bank managers act in the best interest of equity owners. That assumption is, of course, debatable.

Credit Suisse Group. 2011. "Buffer Capital Notes Information Memorandum." Available at www.credit-suisse.com/investors/doc/buffer_capital_notes_information_memorandum.pdf.

Davis, Douglas, Oleg Korenok, and Edward Simpson Prescott. 2011. "An Experimental Analysis of Contingent Capital Triggering Mechanisms." Federal Reserve Bank of Richmond Working Paper 11-01R.

Fama, Eugene. 1970. "Efficient Capital Markets: A Review of Theory and Empirical Work." *Journal of Finance* 25 (May): 383–417.

Flannery, Mark J. 1998. "Using Market Information in Prudential Bank Supervision: A Review of the U.S. Empirical Evidence." *Journal of Money, Credit and Banking* 30 (August): 273–305.

Flannery, Mark J. 2005. "No Pain, No Gain? Effecting Market Discipline via 'Reverse Convertible Debentures.'" In *Capital Adequacy Beyond Basel: Banking, Securities, and Insurance,* edited by Hal S. Scott. Oxford: Oxford University Press, 171–96.

Flannery, Mark J. 2009. "Stabilizing Large Financial Institutions with Contingent Capital Certificates." Manuscript, University of Florida.

Government Accountability Office. 2011. "Bank Regulation: Modified Prompt Corrective Action Framework Would Improve Effectiveness." Washington, D.C.: GAO-11-612 (June).

Hart, Oliver, and Luigi Zingales. 2011. "A New Capital Regulation for Large Financial Institutions." *American Law and Economics Review* 13 (Fall): 453–90.

Huertas, Thomas F. 2009. "Too Big to Fail, Too Complex to Contemplate: What to do about Systemically Important Firms." Paper presented at the Financial Markets Group, London School of Economics, September 15.

Independent Commission on Banking. 2011. "Final Report Recommendations." Available at http://bankingcommission.s3.amazonaws.com/wp-content/uploads/2010/07/ICB-Final-Report.pdf.

Marshall, David A., and Edward Simpson Prescott. 2001. "Bank Capital Regulation with and without State-Contingent Penalties." *Carnegie-Rochester Conference Series on Public Policy* 54 (June): 139–84.

Marshall, David A., and Edward Simpson Prescott. 2006. "State-Contingent Bank Regulation with Unobserved Actions and Unobserved Characteristics." *Journal of Economic Dynamics and Control* 30 (November): 2,015–49.

McDonald, Robert L. 2011. "Contingent Capital with a Dual Price Trigger." Manuscript, Northwestern University.

Offices of Inspector General. 2010. "Evaluation of Federal Regulatory Oversight of Washington Mutual Bank." Report No. EVAL-10-002. Washington, D.C.: Federal Deposit Insurance Corporation (April).

Pennacchi, George. 2011. "A Structural Model of Contingent Bank Capital." Manuscript, University of Illinois.

Pennacchi, George, Theo Vermaelen, and Christian C. P. Wolff. 2010. "Contingent Capital: The Case for COERCs." INSEAD Working Paper 2010/55/FIN.

Plosser, Charles I. 2010. "Convertible Securities and Bankruptcy Reforms: Addressing Too Big to Fail and Reducing the Fragility of the Financial System." Paper presented at the Conference on the Squam Lake Report, New York, N.Y., June 16.

Prescott, Edward Simpson. 2001. "Regulating Bank Capital Structure to Control Risk." Federal Reserve Bank of Richmond *Economic Quarterly* 87 (Summer): 35–52.

Raviv, Alon. 2004. "Bank Stability and Market Discipline: Debt-for-Equity Swaps versus Subordinated Notes." Available at http://129.3.20.41/eps/fin/papers/0408/0408003.pdf.

Roll, Richard. 1984. "Orange Juice and Weather." *American Economic Review* 74 (December): 861–80.

Squam Lake Group. 2010. *The Squam Lake Report: Fixing the Financial System*. Princeton, N.J.: Princeton University Press.

Stern, Gary H. 2001. "Taking Market Data Seriously." *The Region* Federal Reserve Bank of Minneapolis (September).

Sundaresan, Suresh, and Zhenyu Wang. 2011. "On the Design of Contingent Capital with Market Trigger." Federal Reserve Bank of New York Staff Report 448 (November).

White, Lawrence J. 1991. *The S&L Debacle*. New York: Oxford University Press.