Costly External Financing and the Capital Shock Theory of the Insurance Cycle

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Abstracts: The costly external financing assumption in capital shock theories of insurance cycles are conventionally attributed to Myers and Majluf (1984). Contrary to conventional belief, we argue that the Myers and Majluf model is not appropriate to justify the capital shock theories, since (i) it does not justify price increases at the time of information symmetry; (ii) given information asymmetry, its results imply that an insurer that is severely affected by a shock can always raise capital; and (iii) it does not consider liability that is a main concern of insurers. We consider a modified version of the Myers and Majluf model, by introducing liability. When a shock is small, the results are similar to Myers and Majluf. However, when a shock is large, a pooling equilibrium always exists, in which all insurers cannot raise capital. Interpreting no financing as price increases, this result justifies the argument that costly external financing leads to price increases. Therefore, our model provides a justification for the link between costly external financing and price increases.
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I. Introduction

The insurance cycle (or underwriting cycle) refers to the cyclical behavior in which a so-called hard market and a soft market follow each other. In general, a hard (soft) market is characterized by price increases (decreases) and the low (high) availability of insurance coverage. Among academic efforts to explain the cycles, capital shock theories explain a hard market by the occurrence of capital shocks and costly external financing (see Section II for more details, and Harrington and Niehaus, 2000 for a review). When a large capital shock such as a catastrophic event hits an insurer, the insurer will need to raise capital in order to, for example, preserve its franchise value. If external financing is costly, the insurer may opt not to raise capital from the capital market. Instead, it may finance internally by increasing prices, which will lead to a hard market.

Explicitly or implicitly, costly external financing, a key element in capital shock theories, is attributed to Myers and Majluf (1984). In their model, external financing costs are incurred because a firm may pass up a good investment opportunity due to information asymmetry between the firm (its manager) and outside investors.

The purpose of this paper is to revisit the Myers and Majluf model and to propose an alternative model that better fits capital shock theories. Contrary to the conventional belief, we argue that the Myers and Majluf model is not appropriate to justify the capital shock theories, since (i) it does not justify price increases at the time of information symmetry; (ii) given information asymmetry, its results imply that an insurer that is severely affected by a shock can always raise capital; and (iii) it does not consider liability that is a main concern of insurers.

By introducing liability, we consider a modified version of the Myers and Majluf model. We assume that a capital shock causes an insurer to suffer from a large liability (bad state of nature) or a small liability (good state of nature). However, the realized state of nature is observed only by the insurer (its manager), not by outside investors. In this setup, insurers seek external financing and investors should also make decisions on investing in insurers. We find that a large shock produces different results from a small shock. In the small shock case, the results are similar to Myers and Majluf. In equilibrium, insurers in both states can raise capital, or only the insurer in the bad state can raise capital. However, the large shock case provides an important outcome that cannot be obtained in Myers and Majluf. In this case, a pooling equilibrium always exists, in which all insurers cannot raise capital. Interpreting no financing as price

increases, this result justifies the argument that costly external financing leads to price increases. Therefore, our model provides a justification for the link between costly external financing and price increases.

The rest of the paper is organized as follows. Section II provides a literature review. Section III presents assumptions of the model and an illustrating example. Section IV develops a formal model. Section V discusses the implications of our results, and Section VI concludes.

II. Literature Review

Insurance markets in diverse countries are believed to exhibit insurance cycles in which underwriting profits and loss ratios are changing in cyclical patterns (Chen, Wong, and Lee, 1999; Cummins and Outreville, 1987; Doherty and Kang, 1988; Lamm-Tennant and Weiss, 1997; Venezian, 1985). Insurance literature has suggested diverse explanations for the insurance cycle. For example, insurance cycles may result from irrational pricing practices affected by the past loss experience such as extrapolation of past claim costs (Venezian, 1985). Cummins and Outreville (1987) argue that data collection lags, regulatory lags, and accounting practice may well cause insurance cycles under rational expectations. Interest rate change can result in insurance price

and underwriting profit changes, since interest rates are used as discounting rates in insurance pricing (see Doherty and Kang, 1988; Doherty and Garven 1995).

However, the strand of literature that has received most attention is so-called capital shock theories, which is also the concern of this paper. Capital shock theories are focused on capital constraints after capital shocks such as catastrophes or unexpected increases in liability claims. When capital shocks hit, insurers are exposed to capital constraints. As long as external financing costs are low, the problem of capital constraints will disappear. However, if external financing is costly, firms may opt not to raise capital from the capital market. Instead, they may finance internally by increasing insurance prices. Therefore, capital shock theories explain hard markets by capital shocks and costly external financing. Let us briefly review this strand of literature.

Given the capital size of an insurer fixed, insurance sales will be limited by its concerns regarding insolvency risks and/or by insolvency regulations. When firms cannot raise capital externally due to costs, capital shocks will lead the insurer to increase prices, in order to avoid aggravating insolvency risks or to comply with regulatory requirements (Winter, 1991, 1994; Gron, 1994a, b).

Doherty and Garven (1995) link interest rate changes to capital shock models.

While interest rate changes affect insurance prices under discounting process, they will also affect the values of assets, liabilities, and thus capital. When interest rate changes severely deplete the value of capital, it will then increase insurance prices, given costly external financing.

While most of the above mentioned studies are focused on supply-side rationales, several studies consider both demand side and supply side reactions (Cagle and Harrington, 1995; Cummins and Danzon, 1997; Lai, et. al., 2000). For example, if insurance demand is more elastic with respect to price and capital, then the price increase following a negative capital shock will be lowered (Cagle and Harrington, 1995). Changes in expectations about the parameters of firm profits may also contribute to the increase of prices given a negative capital shock (Lai, et. al., 2000). When expectations about the mean and variance of losses increase, they may aggravate mismatches between supply and demand by increasing demand and reducing supply and by making both demand and supply more inelastic. Cummins and Danzon (1995) emphasize the insolvency risk from the policyholder's view. Insolvency risks of insurers may increase after a capital shock. Concerned with the increased insolvency risks, policyholders will require price reduction, reflecting the increase in insolvency risks. Therefore, insurance prices may decline after a capital shock,

unlike in most papers mentioned above.

Capital shock theories are generally supported by empirical findings (Winter, 1994; Gron, 1994a, b; Doherty and Garven, 1995; Lai, et. al., 2000). Recent empirical evidence also finds that price changes are affected by policyholders' concerns with insolvency risks (Cummins and Danzon, 1997; Weiss and Chung, 2004).

III. Revisiting the Myers and Majluf Model

Obviously from the previous section, capital shock theories are built up on the assumptions of costly external financing. Explicitly or implicitly, the capital shock theories refer to Myers and Majluf (1984) as a main rationale for this assumption. However, a closer look at the model of Myers and Majluf reveals that their model is not appropriate to justify the capital shock theories. There are at least three issues that should be addressed in order to apply Myers and Majluf to the capital shock theories for insurance cycles: (i) presence of information asymmetry, (ii) no costs to insurers in the bad state, and (iii) no consideration of liability.

Before addressing these issues, let us first briefly outline the Myers and Majluf model by their example. Suppose that a firm is facing equally probably states of nature: good state and bad state. At the time of financing, the manager of the firm

knows the true state of nature, but outside investors do not. The manager is assumed to work for the old (existing) shareholders. In the good state, the value of the asset-in-place becomes $A_G = 150$, and the NPV of the new investment is $V_G = 20$. In the bad state, the value of the asset-in-place becomes $A_B = 50$, and the NPV of the new investment is $V_B = 10$. The new investment requires 100 to be invested. With no cash, the firm should issue stocks to finance E = 100 to reap the NPV of the new investment. This problem is depicted as a signaling game in Figure 1.

Figure 1

The solid lines in Figure 1 denote the unique (pure strategy) equilibrium of this game. In this equilibrium, the firm in the good state foregoes the new investment opportunity, while the firm in the bad state successfully issue stocks and undertake the investment. The average payoff to the existing shareholders, or the ex ante firm value, becomes P' = (150 + 60)/2 = 105. If the firm has enough cash, then it would undertake investments in both states, leading to the ex ante firm value of (170 + 60)/2 = 115. As a result, there is a loss of 10 in firm value, if the firm has no cash. This loss is the costs of external financing.

It is possible that firms in both states issues stocks and undertake investments

for other values of asset-in place and NPV of the new investment. For example, if V_G = 20 is replaced with 100 in the example, then the equilibrium is pooling on financing in which firms in both states issue stocks and invest. In this case, there is no loss in ex ante firm value. However, note that the firm in the good (bad) state sells stocks for prices lower (higher) than their true values, since investors cannot distinguish between states.

Now, let us go back to the issues raised at the beginning of this section.

(i) Presence of information asymmetry: Given no cash or internal capital, external financing costs are incurred due to the existence of information asymmetry in Myers and Majluf. With no cash, firms may forego good investment opportunities. This emphasizes the importance of internal capital at the time of investment under information asymmetry. However, it does *not* mean that firms should raise that internal capital *internally*. It simply says that firms should not distribute all cash to stakeholders. For example, if information is symmetric after a capital shock, then an insurer can still raise capital externally without costs. In other words, Myers and Majluf do not automatically justify the price increase. In order for insurers to internally raise capital by increasing prices, information asymmetry should exist right after the occurrence of a capital shock. However, this case leads to the following

problem.

(ii) No costs to insurers in the bad state: Given the presence of information asymmetry, the results of Myers and Majluf are rather contradictory to capital shock theories. In Myers and Majluf, the insurer in the bad state can always successfully raise capital without incurring costs, while the insurer in the good state should bear costs. Therefore, the insurer in the bad state does not have to increase prices, while the insurer in the good state may have to do so. If we suppose that the source of information asymmetry is the size of losses following a catastrophic event, then the above result implies that insurers suffering from large losses do not increase prices, while other insurers may do so. This scenario is the only possible result under Myers and Majluf. This result, however, seems to be contradictory to the contentions of capital shock theories that price increases follow large capital shocks.

(iii) No consideration of liability: Myers and Majluf model does not consider the effects of liability changes, while capital shock theories should be related with policyholders' claims, a liability of insurers. As a result, insolvency risks are not properly considered in Myers and Majluf. As seen below, ignoring the liability also contributes to the undesirable result of (ii).

As a result, the Myers and Majluf model does not seem to provide good justification

for capital shock theories, contrary to the conventional belief. This paper attempts to provide a model more fitting to capital shock theories, by introducing liability to Myers and Majluf model. It turns out that introducing liability can resolve the problems regarding the issues mentioned above.

III. Assumptions and Example

We consider a signaling game between an insurer and outside investors. Our model follows Myers and Majluf (1984) except that we also consider existing liability. A starting point is the arrival of a negative shock to capital. The shock deteriorates the insurer's financial strength. First, it may increase the liability of the insurer. Second, it may also decrease the asset values of the insurer, if, for example, the shock is in the form of interest rate increases. In any case, a shock will lead to capital depletion and the increase of the relative liability size. For expository convenience, we assume that the capital shock is a catastrophic loss, affecting only the size of the liability. However, our results are preserved as long as the size of liability is increased relatively to the size of asset after a shock.

Facing capital depletion, the insurer needs to raise capital in order to undertake new investment or preserve its franchise values. We assume that information

asymmetry exists between the insurer (its manager) and investors. For simplicity, we assume that the capital shock also causes information asymmetry between the insurer and outside investors.[1] At the time of financing, investors cannot observe the realized liability size of the insurer, while the insurer can.

The insurer has an asset-in-place A and a future investment with positive net present value (NPV) V. The future investment requires investment of I. There are two states of nature which are completely determined by the size of the liability. The state can be "good (G)" with, a priori, probability p, or "bad (B)" with probability 1 – p. We denote D_S for the liability in state S, where $D_B > D_G$. We will identify the insurer in the good state as a good insurer or a good type, and the insurer in the bad state as a bad insurer or a bad type. The structure of the game is common knowledge.

The signaling game is set up in a two-period setting. In the first period, the insurer observes the realized liability in advance and determines its financing strategy on behalf of old (i.e., existing) shareholders. Following Myers and Majluf, we focus on equity financing, which is denoted by E. We assume that the financing strategy is either fully issuing stocks (E = I) or not issuing (E = 0). In case of issuing stocks, selling prices should also be determined. Given the selling price offered by the insurer, outside

[1] This assumption also is not critical to our results. What we need is the fact that there exists information asymmetry right after the occurrence of a capital shock.

investors will make a decision of accept-it-or-leave-it. Under the assumption of the competitive capital market, investors will invest as long as they can expect a fair return from their investment, which is assume to be zero.

In the second period, the realized state of nature becomes public information. The firm value is distributed to policyholders, old shareholders, and possibly new shareholders (if the insurer raised capital in the first period). If the asset value is less than the liability value, then the insurer will be insolvent. Before proceeding to the formal model, let us consider an example to illustrate our main points.

Example: An insurer is facing a new investment opportunity with NPV, V = 20. The insurer also has the value of the asset-in-place A = 280. A capital shock alters the size of liability. Liability becomes $D_G = 70$ in the good state, and $D_B = 320$ in the bad state. Let us suppose that each state can be realized with probability one half, and the investment opportunity requires I = 100 to be invested. At the time of financing, the insurer observes the realized state of nature, while outside investors do not. This game is depicted in Figure 2.

Figure 2

A separating equilibrium is not possible, unlike in Myers and Majluf (1984). To

see this, suppose that only the bad insurer issues stocks in a separating equilibrium. Note that the insurer value in the bad state after investment becomes 400 (= A +V + E). The remaining value after paying debt is 80 which is less than the invested amount 100. Therefore, rational investors would prefer not to invest in the first place, which is contradictory to equilibrium. It is easy to see that no separating equilibrium is possible, in which only the good insurer issues stocks, since the bad insurer always has incentives to issue stocks in that case. Pooling on issuing stocks is not an equilibrium, since the good insurer will prefer not to issue stocks. For this, note that stocks will be sold at price 105 in this pooling case, leaving the payoff to old shareholders of 169 which is less than 210 under no investment.[2]

The unique equilibrium in this example is the pooling one in which insurers in both states do not issue stocks. This is denoted by solid lines in Figure 2. This equilibrium is supported, for example, by the off-the-equilibrium belief that the issuer is the bad insurer.[3] Under this off-the-equilibrium belief, investors will not buy stocks when stock are issued, since the total value distributable to shareholders, after paying

[2] Undertaking the investment, the total values to shareholders after paying for liability are 330 and 80 in each state. Therefore, selling price P = 105 is calculated from the equation: 100/(P + 100)(1/2)(330 + 80) = 100. The payoff to the old shareholders in the good state is obtained by (105/205)330 = 169.

[3] Note that the equilibrium with this off-the-equilibrium belief satisfies the Intuitive Criteria of Cho and Kreps. This equilibrium is supported as long as investors believe that the probability that the issuer is a good insurer is less than 2/25 (see Proposition 1).

for liability, is 80 (= 280 + 20 + 100 – 320), which is less than the investment amount 100. Therefore, no insurer will deviate from the equilibrium. Being unable to raise capital, the bad insurer will become insolvent, if it cannot raise capital otherwise.

This example highlights the contrast between our model and the Myers and Majluf model. Since no insurer can raise capital externally, insurers should raise capital internally, in order to capture the NPV of the new investment. The costs of external financing are incurred by the bad insurer as well as the good insurer, unlike in Myers and Majluf. Moreover, the effects can be greater to the bad insurer, since it will become insolvent without capital infusion.

IV. A Formal Model

In order to focus on non-trivial cases, we assume that $A < D_B$ and $A+V+I-D_B > 0$. In words, the bad firm value is less than the liability without investment, while it is higher than the liability with financing. We consider two distinguished cases depending on the size of the capital shock. The capital shock can be large ($A+V < D_B$) or small ($A+V \geq D_B$). Under a small (large) capital shock, the true value of the payoff to old shareholders of the bad insurer is (not) high enough to pay for the liability given the investment undertaken. Distinguishing between these two cases is important, since

they produce qualitatively different equilibrium outcomes as shown below. For simplicity, we assume that the true value of the payoff to the old shareholders of the good insurer, given the investment undertaken, is always higher than the liability ($A+V \geq D_G$). Now, let us find equilibrium outcomes in each case.

IV.A. The case of a large capital shock ($A+V < D_B$)

In this case, investors will not want to invest in the bad insurer, if its type is known, since the maximum payoff to new investors ($= A + V + I - D_B$) is less than their invested amount I.[4] This observation rules out the possibility of a separating equilibrium in which only the bad insurer issue stocks. In addition, a separating equilibrium in which only the good insurer issues stocks is not possible, since the bad insurer always has incentives to issue stocks then. The following proposition shows when a pooling equilibrium can exist.

Proposition 1: With a large capital shock ($A+V < D_B$), two equilibria can exist.

(i) Pooling on issuing stocks is an equilibrium if (a) $p \geq \dfrac{D_B - A - V}{D_B - D_G}$, and (b) either (bi) $A - D_G \leq 0$ or (bii) $A - D_G > 0$ and $V \geq V^*$

[4] This is a debt overhang problem (Myers, 1977).

$$= \frac{-(A+I-E(D))+\sqrt{(A+I-E(D))^2+4I(1-p)(D_B-D_G)}}{2}$$, where E(D) = $pD_G + (1-p)D_B$.

(ii) Pooling on not issuing stocks is an equilibrium which is supported by the off-the-equilibrium belief that the issuer is a good insurer with probability r $\leq \frac{D_B - A - V}{D_B - D_G}$.

[proof] See the Appendix.

The results of Proposition 1 can be intuitively explained as follows. For (i), note that investors will invest only if they expect a fair return or more. Since investing in the bad insurer produces a negative return, investors will invest only if there is a high probability that the issuer is the good insurer, which explains (a). On the other hand, (b) provides the incentives for the good insurer to issue stocks. The condition $A - D_G \leq 0$ implies that the good insurer will become insolvent without financing. In this case, the good insurer will prefer to issue stocks. Even if $A - D_G > 0$, the good insurer may have incentives to issue stocks when the value of new investment is high enough. Condition $V \geq V^*$ comes from the requirement that the payoff to the old shareholders in the good insurer with financing is greater than or equal to that without financing. However, note that V is bounded from above by $D_B - A$ for the large capital shock case.

Part (ii) distinguishes our model from the Myers and Majluf model, which was illustrated by the example in the previous section. For (ii), note that, if investors think that the issuer is more likely to be a bad insurer, they will not invest. In this case, insurers cannot issue stocks. The bad insurer cannot raise capital, since the payoff to the investors will be lower than what they invest, which is so-called the debt overhang problem (Myers, 1977). However, the good insurer cannot raise capital due to the information asymmetry, since investors are willing to invest in the good insurer, once its type is known.

Finally, note that the pooling equilibrium on not issuing stocks of (ii) always exists under appropriate off-the-equilibrium beliefs, unlike the pooling equilibrium on issuing stocks of (i). For example, if $p < \frac{D_B - A - V}{D_B - D_G}$, then (ii) is the only possible equilibrium outcome. When a shock is very large and affects many insurers, then p will be small. In this case, (ii) is the unique equilibrium.

IV.B. The case of a small capital shock ($A+V \geq D_B$)

In this case, investors are willing to invest in the bad insurers as long as the stock price is not too high. Since the bad insurer can issue stocks even if its type is revealed, the bad insurer will issue stocks in an equilibrium. Therefore, possible equilibrium

candidates are a separating equilibrium in which only the bad insurer issues stocks, and a pooling equilibrium in which both insurer types issue stocks. The next proposition reports conditions under which each equilibrium can exist.

Proposition 2: With a small capital shock ($A+V \geq D_B$), two equilibria can exist.

(i) Pooling on issuing stocks is an equilibrium if $A - D_G \leq 0$; or if $A - D_G > 0$ and $V \geq V^* = \dfrac{-(A+I-E(D)) + \sqrt{(A+I-E(D))^2 + 4I(1-p)(D_B - D_G)}}{2}$.

(ii) Separating with the bad insurer issuing stocks is an equilibrium if $A - D_G \geq 0$ and $V \leq V^{**} = \dfrac{-(A+I-D_B) + \sqrt{(A+I-D_B)^2 + 4I(D_B - D_G)}}{2}$.

[proof] See the Appendix.

The intuition for (i) is the same as (i) of Proposition 1, except for the condition of probability. Now, we do not need the condition of probability, since investors can earn a fair return even from the bad insurer. For (ii), note that investors consider the issuer a bad insurer. Thus, for this equilibrium, the good insurer should prefer not to issue stocks, given the market value as a bad insurer. If $A - D_G < 0$, then the good insurer will issue stocks, since it will become insolvent otherwise. Therefore, the equilibrium requires that $A - D_G \geq 0$. In addition, the value of the new investment should be low

compared to the loss in the stock prices, so that the good insurer prefer to give up the investment ($V \leq V^{**}$). However, note that V is bounded from below by $D_B - A$ in the small capital shock case.

V. Discussion

Proposition 2 shows that the small capital shock case can be considered as a counterpart of Myers and Majluf, since they produce the same equilibrium types. As a result, the application of Myers and Majluf to the capital shock theory seems to be useful when the capital shock is small. However, as discussed in section III, this case does not seem to be appropriate for the capital shock theories. In equilibrium, both types of insurer successfully raise capital, or only the good insurer does not raise capital. Interpreting raising capital as no need to increase prices, the results imply that insurers do not increase prices or only the good insurer increases prices.

On the other hand, Proposition 1 (ii) shows outcomes that seem to fit the hard market after a large shock.[5] In this equilibrium, a large shock leads to no financing outcomes for both types of insurers, implying that both types of insurers need to

[5] We focus on Proposition 1 (ii), since pooling on not issuing stocks is always an equilibrium under the appropriate off-the-equilibrium beliefs. Note that this equilibrium is more likely to be observed after a large shock, when many insurers are severely affected by the shock (low p).

increase prices. This situation seems to be what most capital shock theories are based on. However, it cannot be observed under the Myers and Majluf model.

While our model is focused on the supply side, it is possible to address the demand side in relation with our model. Let us again consider the pooling on no financing equilibrium under a large shock of Proposition 1 (ii). Our results imply that insurers have to increase prices in order to capture the NPV of the new investment. However, it does not mean that policyholders should passively pay the prices. In general, the willing-to-pay-price of policyholders will reflect insolvency risks. In our setting, critical are the effect of price increases on insolvency risks and the perception of policyholders on insolvency risks.[6] If price increases will allow insurers to keep the insolvency level as low as before, then consideration of insolvency risks does not have to decrease prices.[7] Another possible scenario, however, is that insolvency risks are increased even after the price increases. This case will lead to price decreases, reflecting the higher insolvency risks, as pointed by Cmmins and Danzon (1997).

Clearly, the perception of policyholders on insolvency risks has great impacts on

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[6] Note that our discussion is not rigorous, since we do not explicitly incorporate into the model how price increases lead to capital increases. We attempt to point out possibilities without any rigor.

[7] Obviously, we are ignoring other important factors like the elasticity of demand and claims distribution from new policies (see Cagle and Harrington, 1995). Our discussion is only for outlines of the relationship between insolvency risks and prices.

prices. Interestingly, the perception exhibits a self-fulfilling effect. When policyholders try to lower prices, wary of insolvency risks, it will devastate the financial health of the bad insurer even further. Therefore, it is more likely for the bad insurer to become insolvent. On the other hand, when policyholders pay high prices, ignoring the insolvency risks, it may, in fact, help the bad insurer to be solvent. Note that insurers are not exposed to insolvency risks in any other equilibrium in our model. Therefore, the insolvency concern leads to price decreases after a shock only if the shock is large and the equilibrium is pooling on not issuing stocks.

VI. Conclusion

Capital shock theories are built up on the assumptions of costly external financing. Explicitly or implicitly, capital shock theories refer to Myers and Majluf (1984) as a main rationale for this assumption. However, the Myers and Majluf model does not seem to be appropriate to justify the capital shock theories, since (i) it does not justify price increases at the time of information symmetry; (ii) Given information asymmetry, its results imply that an insurer that is severely affected by a shock can always raise capital; and (iii) it does not consider liability that is a main concern of insurers.

We consider a modified version of the Myers and Majluf model, by introducing

liability. We find that a large shock produces different results from a small shock. In the small shock case, the results are similar to Myers and Majluf. However, the large shock case provides an interesting outcome that cannot be obtained in Myers and Majluf. In this case, there is a pooling equilibrium in which all insurers cannot raise capital. Interpreting no financing as price increases, this result justifies the argument that costly external financing leads to price increases. Moreover, this equilibrium always exists, when a shock is large. We also discuss the possible price decreases after a large shock, when policyholders are concerned with insolvency risks.

While this paper is focused on the effects of information asymmetry on costly financing, it has ignored important factors such as the elasticity of demand, the effects of claims distribution of new policies, and the effects of price increases on insolvency risks, among others. The effects of a shock on price changes will be a function of all these factors as well as information asymmetry (see Cagle and Harrington, 1995). Combining these factors with our model will provide a better understanding of the insurance cycles.

Appendix

Proof of Proposition 1:

Since a separating equilibrium cannot exist as mentioned in the text, we only need to check if a pooling equilibrium can exist. There are two possible types of pooling.

(i) Pooling on issuing stocks: Investors will invest at the price of the payoff to old shareholders $P = p(A + V - D_G) + (1-p)(A + V - D_B) = A + V - E(D)$. For $P \geq 0$, $p \geq \frac{D_B - A - V}{D_B - D_G}$. If p is smaller than this, then pooling on financing cannot be an equilibrium, since investors expect negative profits under any positive P. With $P \geq 0$, a competitive capital market determines P from the equation.

$$(I/(P+I))[p(A + V + I - D_G) + (1-p)(A + V + I - D_B)] = I.$$

It is obvious that the bad insurer will not deviate from the pooling strategy. Now, let us check whether or not the good insurer will deviate from this strategy. The good insurer will not deviate if and only if issuing stocks is preferred to not issuing stocks.

$$(P/(P+I))(A + V + I - D_G) \geq A - D_G. \qquad \text{(A1)}$$

For $A - D_G \leq 0$, (A.1) is always satisfied under our assumptions. For $A - D_G > 0$, simplifying (A.1) provides:

$V^2 + (A + I - E(D))V - I(1-p)(D_B - D_G) \geq 0$, where $E(D) = pD_G + (1-p)D_B$.

Form this inequality, we have $V \geq V^*$

$$= \frac{-(A+I-E(D)) + \sqrt{(A+I-E(D))^2 + 4I(1-p)(D_B - D_G)}}{2}.$$

Note that V should also satisfy $V \leq D_B - A$ for the large capital loss shock.

(ii) Pooling on not issuing stocks: Suppose that insurers in both states opt not to issue stocks. For this to be an equilibrium, insurers should have no incentives to deviate from this strategy. What is important is the off-the-equilibrium belief of investors. Suppose that investors believe that the deviator is a good insurer with probability r. Given this belief, investors will value the deviating insurer as follows:

$P' = r(A + V - D_G) + (1-r)(A + V - D_B) = A + V - E_r(D)$, where $E_r(D) = rD_G + (1-r)D_B$.

For any price $P' > 0$, a bad insurer will issue stocks since $(P'/(P'+I))(A + V + I - D_B) > 0$.

Therefore, pooling on not issuing stocks can be an equilibrium, if and only if $P' \leq 0$, or $r \leq \frac{D_B - A - V}{D_B - D_G}$. With this r, no insurer can raise capital, since investors will not invest with a positive price.[8] ///

Proof of Proposition 2:

It suffices to check for the possibility of a separating equilibrium in which only the bad insurer issues stocks, and a pooling equilibrium in which both insurer types issue stocks.

(i) Pooling on issuing stocks: The analysis is the same as in the large shock case

[8] When $A + V = D_B$, a bad insurer is indifferent between issuing and not issuing stocks. We treat tie cases in favor of the equilibrium existence.

(Proposition 1 (i)), except for the range of V allowing an equilibrium. Note that P is always positive now. This is equilibrium if A - $D_G \leq 0$, or if A –$D_G > 0$, and $V \geq V^* =$

$$\frac{-(A+I-E(D))+\sqrt{(A+I-E(D))^2+4I(1-p)(D_B-D_G)}}{2}.$$

Note that V should also satisfy $V > D_B - A$ for the small capital shock case.

(ii) Separating with only the bad insurer issuing stocks: In this equilibrium, if it exists, the price of the payoff to the old shareholders will be $P' = A + V - D_B$, since its type is revealed. Indeed, the ex post payoff to the old shareholders is $(P'/(P' + I))(A + V + I - D_B) = A + V - D_B$; and the ex post payoff to the investors is $(I/(P' + I))(A + V + I - D_B) = I$, which confirms the price. If the good insurer deviates and issue stock at that price, its payoff becomes $(P'/(P' + I))(A + V + I - D_G)$. Therefore, it will not deviate if and only if

$$A - D_G \geq (P'/(P' + I))(A + V + I - D_G) \qquad \text{(A2)}$$

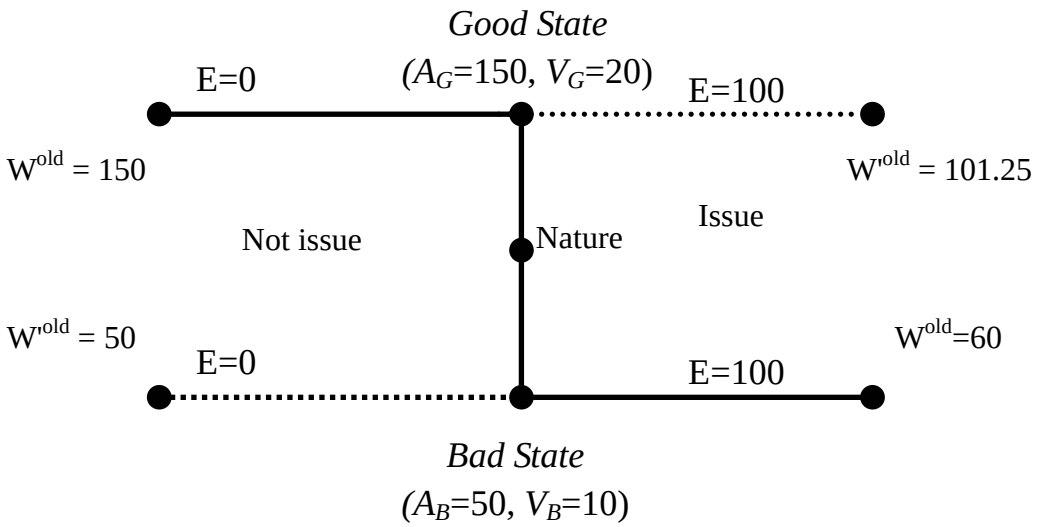
If $A - D_G < 0$, the insurer will always deviate. For $A - D_G \geq 0$, (A2) can be arranged to $V^2 + (A + I - D_B)V - I(D_B - D_G) \leq 0$, which results in $V \leq V^{**}$

$$= \frac{-(A+I-D_B)+\sqrt{(A+I-D_B)^2+4I(D_B-D_G)}}{2}.$$

Note that V should also satisfy $V > D_B - A$ for the small capital loss shock. ///

Figure 1:

The Myers and Majluf example

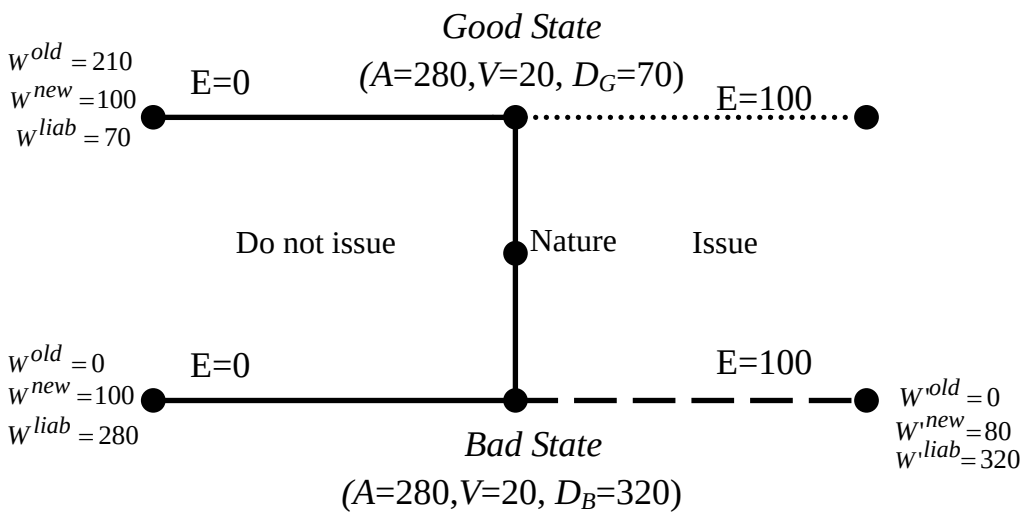


W^{old} : The equilibrium payoff to the old shareholders

W'^{old} : The off-equilibrium payoff to the old shareholders

Figure 2:

The Example with a Capital Shock



W^{old}: The equilibrium payoff to old shareholders

W^{new}: The equilibrium payoff to new investors

W^{liab}: The equilibrium payoff to policyholders

W'^{K}: The payoff to stakeholders K in the bad state given financing, where K = old, new, liab.

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