Adding Time Diversification to Risk Diversification, the Case for Equalization reserves for Natural Catastrophes

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Regulators and Accountants

- Regulators want insurers to develop *internal models* for risk-adjusted capital (RAC) (Swiss Solvency Test, first and second pillar of Solvency II)
- Accountant standard setters want insurers to *mark-to-market* their assets (IAS 39) and eventually their liabilities through *mark-to-model* valuation
- Most of those rules are inspired by the bank regulations and accounting.
- The purpose is to protect the policyholders (regulators) and to bring *more transparency* in the value creation of the industry (accountants)
- Is the industry ready for these challenges?

Challenges and Questions Ahead

- First of all, the insurance industry still needs to adopt *a common language* and disseminate best practices to build models
- Are we able to model the *complexity* of the business and the risks to a good level of accuracy? Do we have the methods and data in place?
- Is the requirement for transparency (Pillar III of Solvency II and IFRS) going too far and introducing *artificial volatility*?
- Is the principle of *conservatism in accounting* still followed: “anticipate no profit but anticipate all losses”, when using probabilities or NPVs in balance sheets?
- Despite their obvious similarities, have we really considered the *major differences* between banking and insurance?
- In insurance *reserving is crucial and very difficult*. Insufficient reserves account for two third of insurance insolvencies

Equalization reserves an old debate closed by US-GAAP, IFRS and the regulators

- Reserving for natural catastrophes (CAT Reserving) is a good example of the problems that face the insurance industry in applying the IFRS and US-GAAP accounting rules
- US-GAAP and the new IFRS* rules do not allow to carry over reserves for *future business*. If no loss has occurred during the year then the reserves must be released: equalization reserves are not allowed anymore
- Two main arguments speak for the introduction of those rules:
  1. It is in the interest of shareholders to diminish the amount of free cash flows at the disposal of managers for *fear of misuse*
  2. Moreover, the tax authorities want to avoid artificial reserve increases that *diminish tax payment*

**) In our model we mention the company without reserves the US-GAAP firm since IFRS was inspired by that regulation.*

Premiums and Claims

- Insurance premiums are computed on the basis of the *expected loss* adding to it risk loading and expenses:

  Premium = Expected Loss + Cost of Capital + Expenses

- It is in the nature of CAT business that most of the time the claims will be *much below expectation*
- Once in a while though, a catastrophe will occur with claims *much above expectation* and the yearly premiums would not suffice to cover the liabilities
- To survive such situations, insurance companies have learned to *diversify their risks*

Mitigating Catastrophic Risks

- Diversification is usually thought in terms of *geography* and of *type* of risks
- For instance a reinsurance company would reinsure European windstorm and Japanese earthquakes as well as American hurricanes
- Given this type of risk, geographical diversification *will not suffice* to avoid large fluctuations in the results, as we have seen recently
- *Uncertainty* in the results is *penalized* by investors. They will require higher reward for their investments
- This will, in turn, *increase the cost* of insurance policies

Time Diversification Helps

- Traditionally, insurers have built *equalization reserves* to *dampen the effects* of natural catastrophes on their balance sheet.
- This is nothing else than diversifying the risk *over time*.
- Some countries particularly exposed to catastrophic risks even require their insurance companies to hold equalization reserves e.g. Japan.
- The idea is simple: the years without natural disaster are used to *build up reserves* for the years where such a catastrophe occurs.
- Since the probability of occurrence is low, it is possible on average to build substantial reserves before large claims happen.

Capital or Reserves, That is the Question!

- The argument against equalization reserves is that capital is here to be used when the premiums do not cover the claims
- If not actively invested, analysts would argue that capital should be given back to shareholders and again raised only when it is needed
- Unfortunately, if an insurance company tries to tap the market when it is known to have several hundred million dollars of claims to pay, it finds:
  - That there is *less cash available* from the market; and
  - That the cash that can be found is much *more expensive* than keeping it on the balance sheet

Time Diversification is Good for Long-Term Investors

- Clearly, it is to the *benefit of the policyholders* to keep an extra cushion
- Is it also true for shareholders?
  - For short-term investors: the chances of getting high returns is bigger, if reserves are released at the end of the year
  - For long-term investors: the volatility incurred by an insurer that releases its CAT reserves every year is high
- The extra-cash kept in the reserves differs from the capital:
  1. it is *not rewarded* at the cost of capital but at the risk free rate
  2. *no new risk* is written against it

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The Case of Reserving for Natural Catastrophe

- US-GAAP and the new IFRS rules do not allow to carry over reserves for future business:
  - If no loss occurs during the year → reserves are released as profit to the shareholders
- We want to verify if the arguments put forward against equalization reserves hold and demonstrate that
  - Equalization reserves bring additional value to shareholders
  - The amount of taxes the company pays is lower when reserves are put aside

A Simple Model

Model of the financial statement of 2 firms with *same risks*

One carrying over reserves for future business (time-diversified)

One applying the new accounting rules (US-GAAP)

- *Same initial capital* (100'000) for which we use a $\mathrm{VaR}_{99\%}$ (maximum authorized capital)
- Risk taken and consequent losses the same for both companies over a *30 years* period
- 2 typical distributions to simulate the losses (Monte Carlo simulation):
  - *Lognormal* distribution
  - *Fréchet* distribution
- The accounting model defines:
  - The dividends given to shareholders Z
  - The capital left after paying the losses
  - The shareholders' wealth M
  - Taxes (and deferred tax assets when the company writes a loss)

How Does Companies Deal with a Loss ?

- When a large claim happens:
  - Time-diversified company
    - covers the loss with the *premium received for the risk plus the reserves put aside* for this purpose (equalization reserves) and if not enough with the *capital*
  - US-GAAP company
    - covers the loss with the *premium received for the risk*, and, if not enough, with the *capital*
- Consequences:
  - When capital is partially used, *rebuild it* → very *expensive* (cost of raising capital). The capital is rebuilt up to the acquired wealth of the shareholder
  - If the capital is not fully refurbished the company is only allowed to take on risk proportionate to its remaining capital
  - When the whole capital is used by the claim: the company is bankrupted and can no longer write business

Business Cycles and Cost of Capital

- We introduce *business cycles* by assuming *softening* of the market if the previous loss ratio is below 60%. The price is then reduced by 20% for the next year. The price will keep going down up to the expectation
- The *hardening* of the market is modeled by a price increase of 200% if the previous loss ratio has reached 150%
- The *cost of raising new capital* is put at 5% of the sum raised, which corresponds to the usual investment bank fees. We neglect other costs due to distress
- The company is allowed to keep equalization reserves up to an amount equivalent to the *expected loss minus the paid losses*. The cumulated reserves are not allowed to exceed the VaR(99%), i.e. 100,000

The Stochastic Models

- We model the risk (loss, X) with a *lognormal distribution*:

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma x} e^{-(\ln x - \mu)^2 / 2\sigma^2}$$

- The parameters μ and σ are chosen so that the Value-at-Risk (VaR) at the 99% level *always equals* 100,000, assuming that this is the risk-adjusted capital (RAC).
- We *vary the coefficient of variation*, CV= σ/μ , allowing for various tails to the distribution but keeping the same VaR.
- The *initial premium* is computed according to the *technical price*:
  Expected Loss + 15% of the RAC + Expenses
- *Expenses* are taken to be 5% of the *expected loss*.

The Stochastic Model (Fréchet Distribution)

- We use also a *fat-tailed* distribution, the Fréchet distribution:

$$\Phi_{\alpha,s}(x) = \begin{cases} 0, & x \le 0 \\ \exp\left(-\left(\dfrac{x}{s}\right)^{-\alpha}\right), & x > 0 \end{cases}$$

- We compute the expectation: $E\left[\Phi_{\alpha,s}\right] = s \cdot \Gamma\left(1 - \dfrac{1}{\alpha}\right)$

- And the expected shortfall: $ES\left[\Phi_{\alpha,s}; r\right] = s \cdot \Gamma(1 - \dfrac{1}{\alpha}, -\ln r) \cdot \dfrac{\Gamma(1 - \frac{1}{\alpha})}{1 - r}$

- Where $\Gamma(a,z)$ is the incomplete gamma function: $\dfrac{\int_0^z x^{a-1} e^{-x} dx}{\int_0^\infty x^{a-1} e^{-x} dx}$

Influence of the Tails on the Expected Shortfall

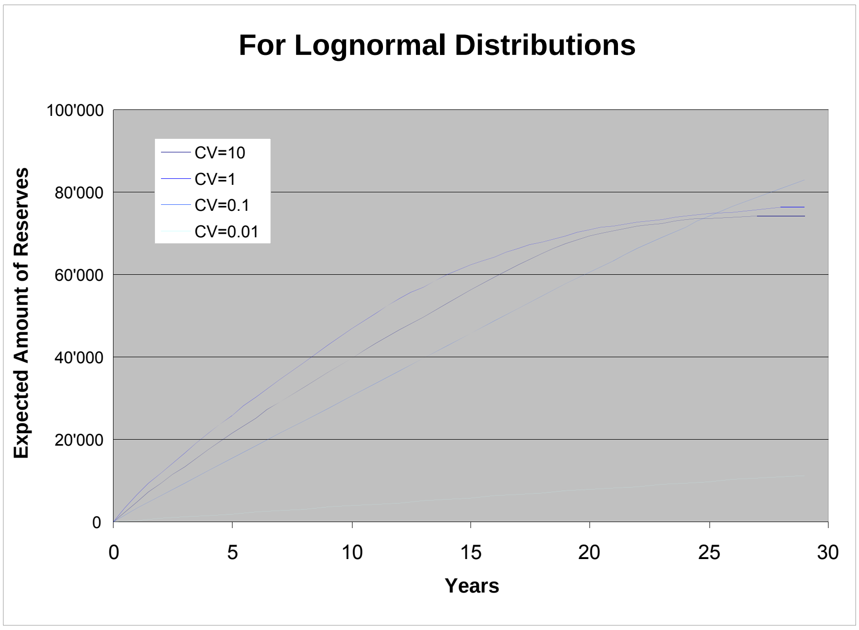
- Lognormal distribution
- For all parameters the VaR at 99% is 100'000

CV	Expectation	ES
10	6'787	192'346
1	20'388	135'788
0.1	79'686	104'288
0.01	97'705	100'430

- Fréchet distribution
- For all parameters the VaR at 99% is 100'000

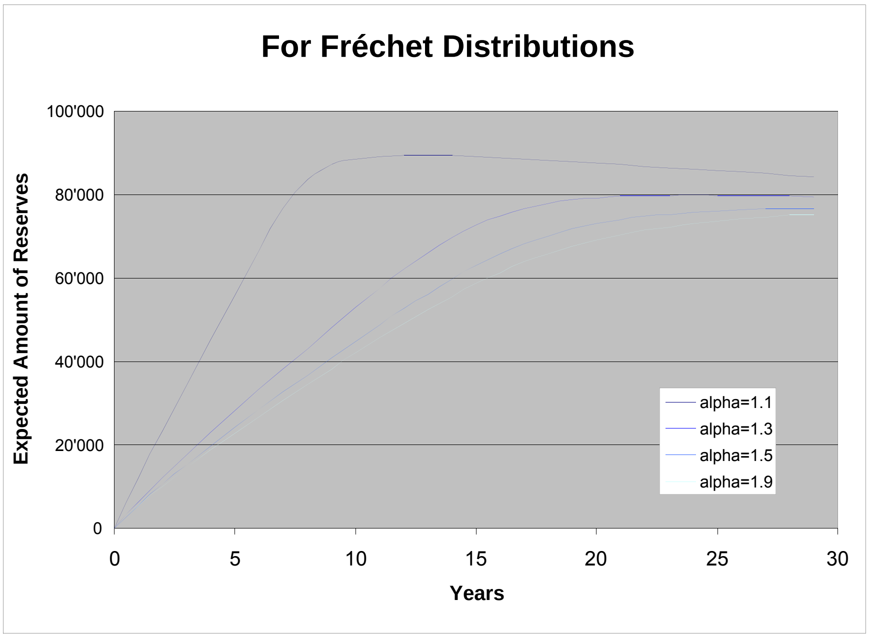
Alpha	Expectation	ES
1.1	16'041	1'104'613
1.3	11'465	434'696
1.5	12'476	300'755
1.9	16'607	211'490

Buildup of the Reserves Over Time (Lognormal)



- We use 10,000 simulations of the claims over 30 years
- The equalization reserves are accumulated using the previously proposed rule: the difference between the expected claim minus the actual payment is carried over to the next year

Buildup of the Reserves Over Time (Fréchet)



The CAT reserves' buildup behavior is complex and depends on the fatness of the tails of the distribution (limit 100,000)

Simulation Results for the Buildup of Reserves

- We simulate 10,000 times a period of *30 years* and look how the respective balance sheets evolve
- We see that the company can, on average, *build up sufficient equalization reserves* if the tails are sufficiently fat
- The fatter the tails the faster the equalization reserves buildup for both stochastic processes but it is more pronounced with Fréchet distributions
- We see that for low fluctuations (CV=0.01) it is not possible to build sufficient equalization reserves

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Performance Measures for the Shareholders Wealth (1/2)

Pure performance measures:

- IRR (Internal Rate of Return):

$$\sum_{t=1}^{T} \frac{Z(t)}{(1+\mathrm{IRR})^t} - \rho_0(X) = 0$$

where $Z(t)$ is the dividends the shareholders receive at time t and $\rho_0(X)$ is the initial investment (equal to the RAC)

- PI (Profitability Index):

$$\mathrm{PI} = \frac{\mathrm{NPV}(Z)}{\rho_0(X)}$$

where NPV is the Net Present Value of shareholders' dividends

Performance Measures (2/2)

Risk-adjusted performance measures:

- Sharpe ratio:

$$S = \frac{\mathrm{E}[R(t) - r]}{v}$$

where $R(t)$ is the yearly return ($R(t)=Z(t)/\rho_{t-1}(X)$)
r the risk free rate
v the volatility of the yearly return

- Value of the call option based on the Merton model*):

$$C_T = \frac{\mathrm{E}[\max(M(T) - \rho_0(X), 0)]}{(1+r)^T}$$

where M is the shareholders' wealth at maturity T (dividends + interests)

**) We use the concept of real option which has been inspired by the financial option (Black Scholes and Merton)*

Discussion on the Performance Measures

- *IRR and PI are not appropriate* performance measures
  - do not treat the risk component of the cash flows
  - Because of discounting, they lead to the belief that a shorter life project with earlier cash inflows (dividends and interests earned) is preferable than a longer one

- Additional disadvantage of IRR
  - Returns an error value when changing signs in cash flows. Thus, negative outcomes are not included in the average IRR

- Sharpe ratio and value of the call option based on Merton model are *risk-adjusted measures*

Summary of the Results

	Sharpe Ratio				Merton Model			
CV	**0.1**	**1**	**10**	**20**	**0.1**	**1**	**10**	**20**
Lognormal US-GAAP	1.1032	0.4321	0.4229	0.4483	262'617	269'568	144'140	141'828
Lognormal Time div.	1.4300	0.6090	0.4761	0.4790	262'707	279'980	146'104	142'987
Alpha	**1.9**	**1.5**	**1.3**	**1.1**	**1.9**	**1.5**	**1.3**	**1.1**
Fréchet US-GAAP	0.4106	0.4298	0.4676	0.6466	196'910	175'657	171'323	230'331
Fréchet Time div.	0.5378	0.5413	0.5744	0.9383	203'269	180'126	175'064	235'678

- Both measures: Sharpe Ratio and Merton Model give an advantage to the time diversified firm with regard to the US-GAAP firm
- Lognormal and Fréchet behave similarly except for the Sharpe ratio where the Fréchet gets better results for fatter tails

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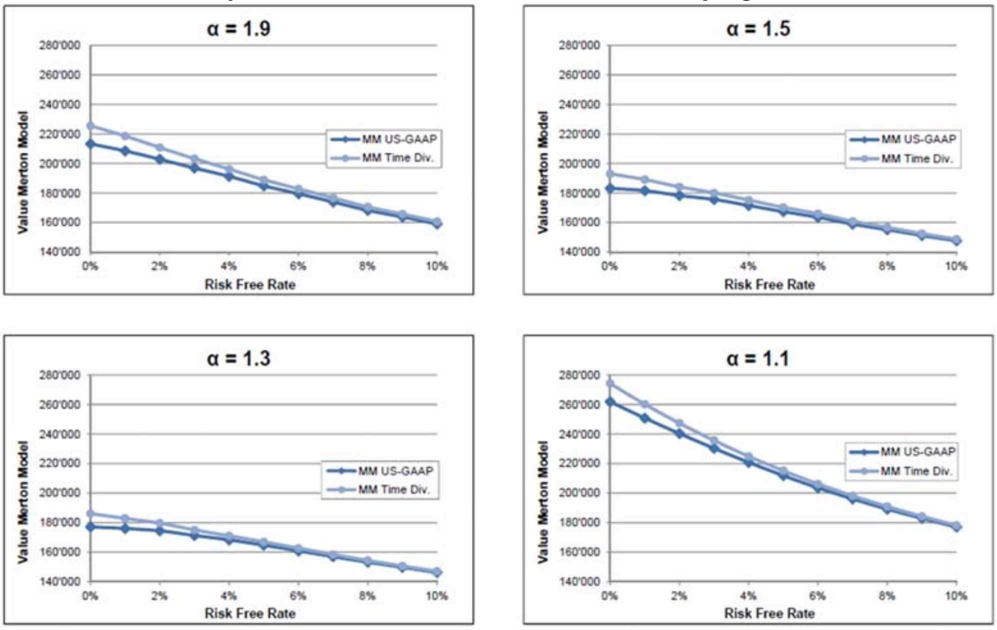
Variation of the Parameters

- Results for the performance of the shareholders wealth obtained by simulating the losses Lognormal and Fréchet distributed
- Comparison between US-GAAP and time-diversified firms using:
  - Sharpe ratio
  - Call option's value (Merton model)
- For each performance measure, we vary the following parameters:
  - Risk free rate : between 0 and 10%
  - Cost of raising capital : between 0 and 80%
  - Hardening of the market : between 0 and 500%
  - Softening : between 0 and 20%
- What is the effect of the tail? So we vary :
  - the coefficient of variation (CV) for the Lognormal distribution (0.1, 1, 10, 20)
  - the α-parameter of the Fréchet distribution (1.9, 1.5, 1.3, 1.1)

Impact of the Risk Free Rate (1/2)

Value of the call option based on Merton model while varying the risk free rate.*)



- The higher the risk free rate, the lower the value of the call option for both companies
- The time-diversified company performs better than the US-GAAP firm
- The heavier the tail, the lower the performance (except for $\alpha = 1.1$)

**)The losses are here Fréchet distributed.*

Impact of the Risk Free Rate (2/2)

- Why these behaviors?

  Expected payoff at maturity discounted with the risk free rate

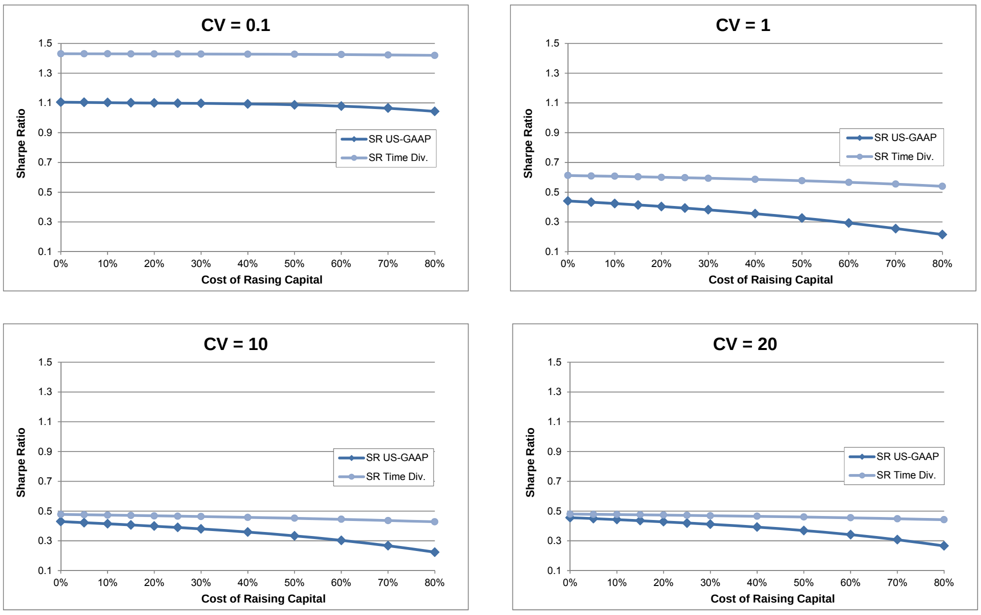
  When the *risk free rate rises*, the value of the *call option decreases* in comparison to the gain made in investing risk free (taking risk becomes less attractive)

- If there is a huge loss:
  - The *US-GAAP* company pays it with its *capital* and rebuild it right after with the dividend and interest given to shareholders (adding a cost) ➡ *Shareholders' wealth falls down* and the call option's value as well
  - The *time-diversified* company pays it with its *equalization reserves* and rarely need to use its capital or to a lower extent

- The *heavier the tail*, the less probability to have a big loss, but if there is one, it is very big:
  - *Performance decreases*
  - Number of *bankruptcies grows*

Impact of the Cost of Raising Capital (1/2)

Sharpe ratio while varying the cost of raising capital*)



- The higher the cost of raising capital, the lower the Sharpe ratio
- The time-diversified company performs better than the US-GAAP company
- The Sharpe ratio of the US-GAAP firm falls down faster than the one of the time-diversified firm
- The higher the coefficient of variation (CV), the smaller the interval between the 2 companies

*)The losses are lognormal distributed.

Impact of the Cost of Raising Capital (2/2)

- Why these behaviors?

  When a large loss occurs:

  - The US-GAAP company covers it with its own capital
  - The time-diversified firm withdraws the reserves put aside for this purpose (equalization reserves)

- Then, the US-GAAP firm rebuilds the capital by buying back the dividends distributed to shareholders adding some cost (cost of raising capital)

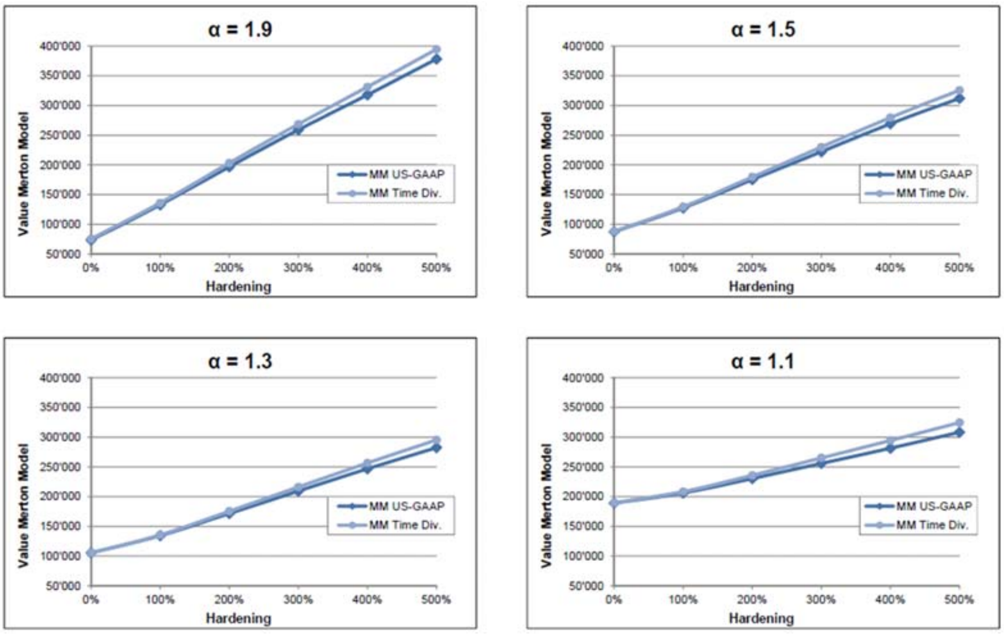
- Another disadvantage for the US-GAAP company:

  Higher probability to go bankrupt ➡ Out of the market and no possibility to enter a new business when market is hardening

- When the *CV is high* both companies are subject to *a high level of bankruptcies* ➡ Performance of both firms get closer

Impact of the Hardening (1/2)

Value of the call option based on Merton model when affected by the hardening of the market cycle.*)



- The higher the hardening of the market, the higher the value of the Merton model
- The time-diversified firm has a higher value than the US-GAAP firm
- The higher the hardening of the market, the larger the interval between the 2 companies

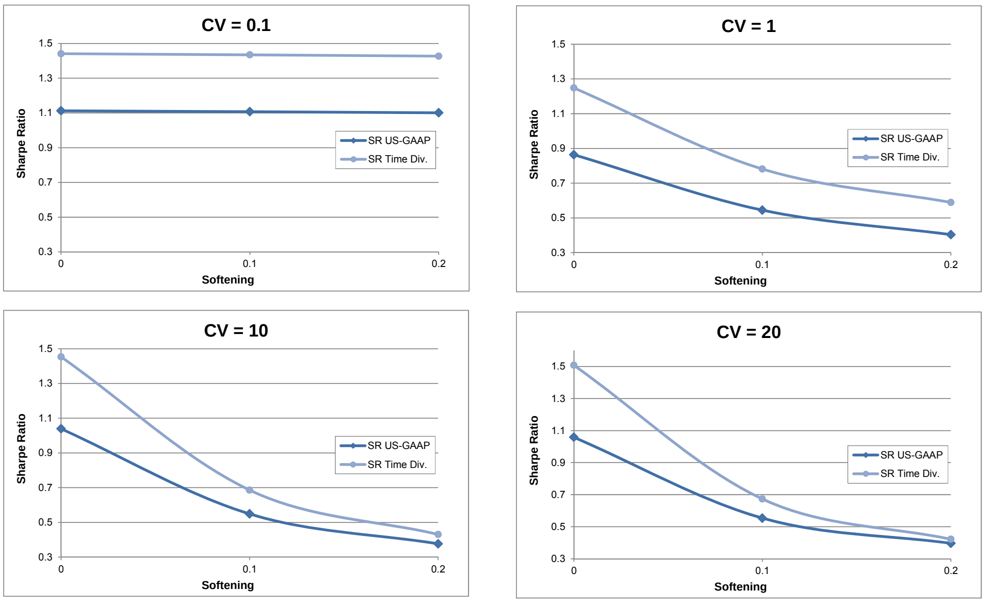
*)The losses are Fréchet distributed.

Impact of the Hardening (2/2)

- Why these behaviors?
  - After a large claim, the market hardens ➡ *increase of premiums*
  - When premiums increase, the *profit grows* ➡ more dividends for shareholders ➡ shareholder's wealth continues to grow and the value of the call option as well
- If a big loss occurs:
  - The US-GAAP company has to pay the loss with its capital in account and rebuild it with additional costs
  - The time-diversified company has its equalization reserves and rarely needs to use its capital
- The *higher the α-parameter*, the *higher the number of bankruptcies* particularly for US-GAAP

Impact of the Softening (1/2)

Sharpe ratio when influenced by the softening of the market.*)



- The higher the softening, the lower the performance (except for $\mathrm{CV} = 0.1$)
- Company with equalization reserves performs better than the one following US-GAAP
- The higher the softening, the thinner the interval between the 2 companies

**)The losses are lognormal distributed.*

Impact of the Softening (2/2)

- Why these behaviors?
  - After a year with low level of loss, premiums decrease and profit too. The performance of the company decreases ➡ less dividends for the shareholders
- When softening high
  - Both companies struggle to pay incurred losses
  - The time-diversified firm has not enough equalization reserves in account. It gets closer to the US-GAAP firm performance
- When $\mathrm{CV} = 0.1$:
  - almost no fluctuation of the losses
  - *zero probability of default* ➡ flat performance through the softening range

Impact of the number of bankruptcies

- When there is a bankruptcy ➡ *not possible to enter in a new business*

- US-GAAP has *more probability of default* than the time-diversified firm

	Lognormal	
CV	US-GAAP	Time Div.
0.1	0	0
1	1030	399
10	2243	1517
20	2305	1594

- One of the reason why time-diversified firm performs better in general
- Keeping reserves in order to limit the losses has a good influence on the well-being of the company

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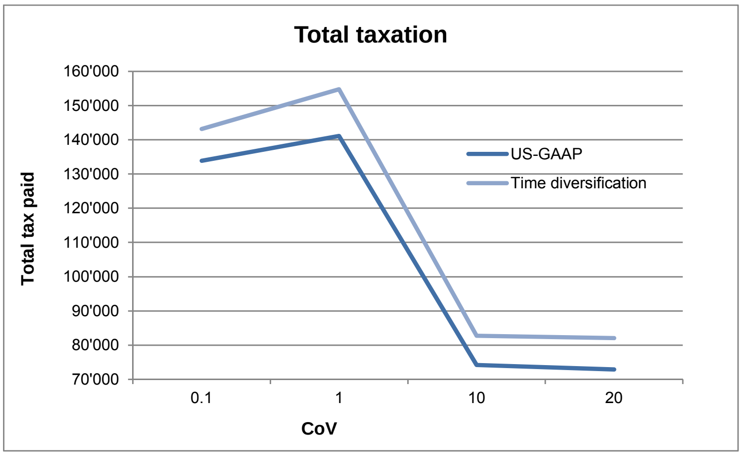
Tax Payments

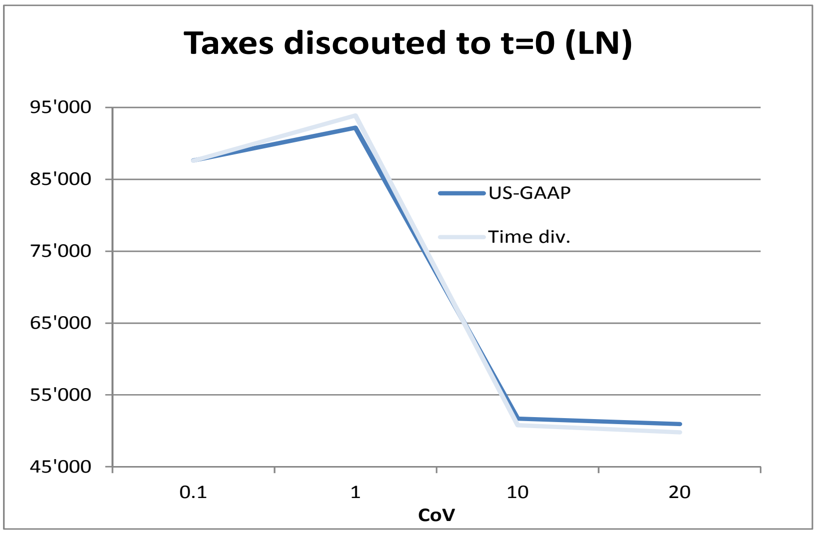
- ❑ Verification of what tax authorities said: “Firms keep equalization reserves to reduce taxes.”
- ❑ In our model:
  - ➤ Tax paid while varying the CV*)
  - ➤ Comparison between US-GAAP and time-diversified companies of the tax paid during 30 years



*)The losses are lognormal distributed.

Discounted Tax Payments

- ❑ Even when the tax payments are discounted to t_0 the two companies pay about the same amount of taxes on average



Equalization Reserves do not mean Escaping Tax

- The time-diversified company *pays more taxes* than the one following US-GAAP and about the same amount discounted

- Reason:
  - *Less bankruptcies* when the firm has equalization reserves
  - At maturity, *accumulated reserves are released* and added to profit
    Taxes are paid on this amount

- The fatter the tail, the lower the tax because:
  - Possible losses are higher
  - More bankruptcies

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Conclusion

- Our simple model allows us to *look beyond the one year horizon* and to analyze complex feedback effects
- We see that arguments that seem to hold in a Gaussian framework do not in a more complex one: time diversification is *good both for shareholders and tax authorities* as long as it is done within a transparent and reasonable framework
- The conclusions of our study do not depend crucially on the heaviness of the tails but rather on *the existence of fat tails*
- To mitigate risks insurers need all the diversification they can get including *time diversification*
- *New technology* allows for more *transparency* without abandoning some old prudent habits (equalization reserves)
- The integration of risk management, however, will demand more and more solutions that should imply a *strong cooperation* between *insurances, banks and academics*