Nonproportional Reinsurance Pricing Using a Menu of Contracts

Casualty Actuarial Society *Ratemaking, Product and Modeling Seminar* 2023

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Executive Summary

Menu of contracts as a means of overcoming adverse selection

- In a stylized model of aggregate excess of loss reinsurance, it is shown how the reinsurer can insulate itself from adverse selection by offering a menu of contracts
- There are two types of (potential) cedents, one type having a loss distribution with a low mean, and the other type having a loss distribution with a high mean
- The reinsurer is unable to distinguish the type, but knows the two means and the (weighted) average mean (Akerlof, 1970)
- In a signaling game, both types of cedents send out a "low mean" signal, which generates a pooling equilibrium (Spence, 1973)
- The reinsurer offers the cedents a menu of contracts, which generates a screen that provides the cedents an incentive to self-select based on the type (Rothschild and Stiglitz, 1976)
- Both types of cedents transact, and the reinsurer breaks even with both types of cedents[1)]

1) For a sufficiently high frictional-cost parameter, the reinsurer may do better than break-even with low-mean cedents, as they may select a contract priced to the high mean.

Literature:
Akerlof, George A. (1970) "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics* 84: 488-500.
Rothschild, Michael, and Joseph Stiglitz (1976) "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics* 90: 629-49.
Spence, Michael (1973) "Job Market Signaling," *Quarterly Journal of Economics* 87: 355-74.

Information-Theoretic Concepts

Translated into nonproportional reinsurance

- Adverse selection
  - There are two types of (potential) cedents, one type having a loss distribution with a low mean, and the other type having a loss distribution with a high mean
  - The reinsurer is unable to distinguish the type, but knows the two means and its (weighted) average
  - The reinsurer prices the cover at the (weighted) average of means (actuarially fair)
  - The cedents of low mean will not participate (unless the frictional-cost parameter is sufficiently high). Being left with the high-mean cedents, the reinsurer will not break even
- Signaling
  - Low-mean cedents have an incentive to signal that they are of low mean
  - If the high-mean cedents can send out the same signal (that is, can imitate the low-mean type), then the signal does not separate the type and a pooling (as opposed to a separating) equilibrium ensues
- Screening and self-selection
  - The reinsurer installs a screen that provides an incentive for the cedent to self-select into the contract that allows the reinsurer to break even

Origins of Frictional Cost

Reducing volatility around a given mean reduces frictional cost

- Capital constraints
  - Regulatory or rating agency (as opposed to economic) capital may be a binding constraint
  - Mutual insurers face constraints in raising equity capital
- Principal-agent theory
  - High earnings volatility (around a given mean) increases the uncertainty in measuring the performance of the agent—was it bad luck or poor decision-making?
- Costs of financial distress
  - Raising capital in the event of financial distress is costly or unfeasible due to the wealth transfer to policyholders and debt holders from the new equity investors—rights issues mitigate this challenge
  - Financial distress reduces the option set of managerial decisions in the wake of regulatory intervention

Nonproportional (Prospective) Reinsurance

For Retroactive Reinsurance, see Appendix

Tweedie Distribution of Aggregate Loss

Poisson mixture of gamma distributions with an added dispersion parameter

Concept	Parametrization
Exponential dispersion models (EDMs)	Two-parameter family of distributions consisting of a linear exponential family with an added dispersion parameter. Response distribution for generalized linear models
Tweedie models	EDMs with power-mean variance relationship
Mean	$\mu \; (\mu > 0 \; for \; p > 1)$
Power parameter	$p \; (p \notin (0,1))$
Dispersion parameter	φ
Variance function	$\varphi \cdot V(\mu) = \varphi \cdot \mu^p$
Special cases	Normal $(p = 0)$, Poisson $(p = 1)$, gamma $(p = 2)$, inverse Gaussian $(p = 3)$
Collective risk model	Poisson mixture of gamma distributions for $1 < p < 2$
Any factor that increases the frequency of claims without affecting their average size decreases the dispersion and increases the mean	
Any factor that increases the average claim size without increasing claim frequency increases both the mean and the dispersion	

The specification of the Tweedie distribution follows Smyth, Gordon K., and Bent Jørgensen (2002) "Fitting Tweedie's Compound Poisson Model to Insurance Claims Data: Dispersion Modelling," ASTIN *Bulletin* 32(1): 143-57.

Model Parameters

Stylized aggregate excess of loss reinsurance structure

PARAMETER	VALUE
Distribution of aggregate loss	Tweedie
Mean	2 (low) and 4 (high)
Power parameter[1)]	1.725
Dispersion parameter[2)]	200
Expected proportion of zeros, given parameters[3)]	0.9782 (low mean) and 0.9737 (high mean)
Probability of cedent being of low mean	0.5 (50%)
Frictional cost (applies to cedent only)	In proportion to difference between 99.5% value-at-risk (VaR) and mean
Frictional cost proportionality parameter	0.001 (0.1%) and, alternatively 0.005 (0.5%)
Pairs of reinsurance contracts	ATM (at the money), attaching at the mean OTM (out-of-the-money), same exit point as respective ATM, with corridor
Bargaining power	Social surplus (reduction of frictional cost) goes to cedent
Reinsurance pricing	Actuarially fair (expected layer loss)
Pricing to (weighted) average of means	Consideration equals the (weighted) average of expected layer losses across means

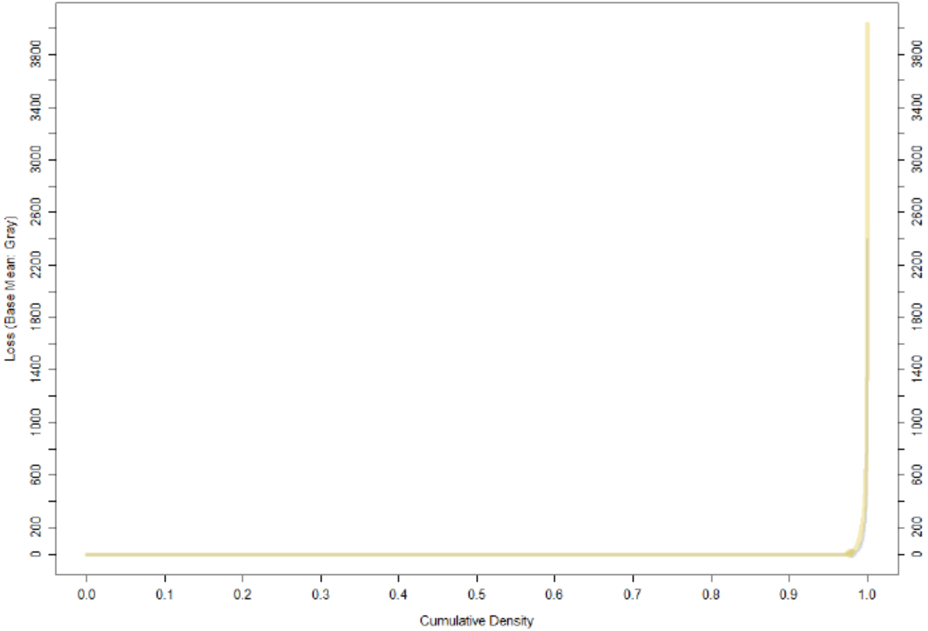
1) The choice of the power parameter is inspired by the empirical study of Swedish auto insurance data presented in Smyth, Gordon K., and Bent Jørgensen (2002) "Fitting Tweedie's Compound Poisson Model to Insurance Claims Data: Dispersion Modelling," ASTIN *Bulletin* 32(1): 143-57.

2) The analysis employs the R package *tweedie*. In this package, for the Tweedie to assume the Poisson, both the power parameter and the distribution parameter must equal unity.

3) The number of zeros approximates the proportion of U.S. registered vehicles that are not involved in accidents in a given calendar year.

Loss Distribution

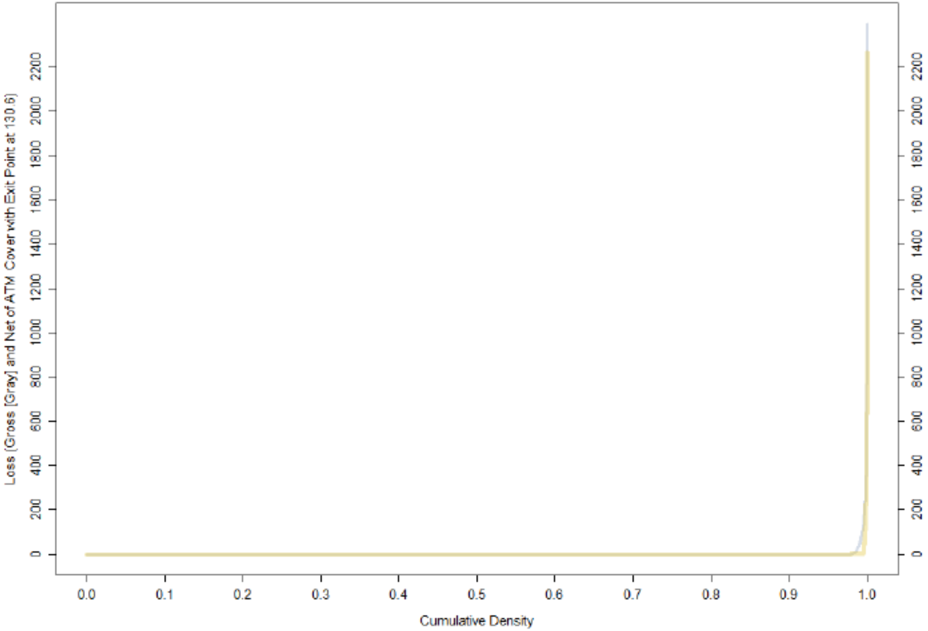
Mean of 2 (gray) and 4 (amber)



The dots indicate the means.

Loss Distribution (Gross vs Net)

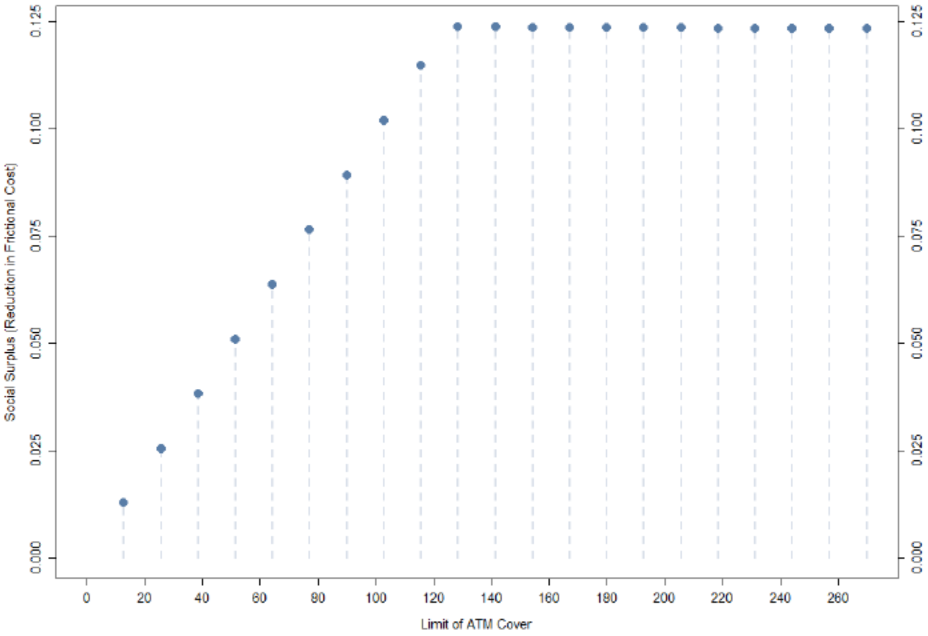
Illustration of ATM



Gray: gross (no reinsurance). Green: net of reinsurance.

Social Surplus

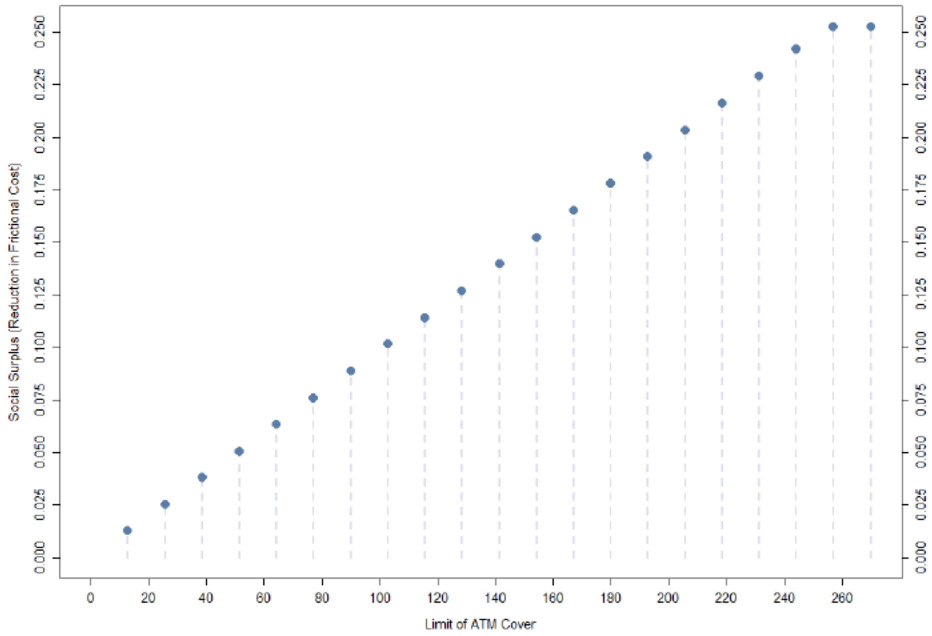
Surplus of reinsurance transaction originates in reduction of frictional cost to cedent



The social surplus is the feasible price range for the reinsurer, defined as the price interval between the cedent's non-participation and the reinsurer's break-even. For simplicity, it is assumed that the social surplus goes to the cedent. The increase in social surplus flattens materially once the 99.5% VaR of the loss net of reinsurance travels through the reinsured layer.

Social Surplus of Reinsuring High-Mean Cedent

Surplus of reinsurance transaction originates in reduction of frictional cost to cedent

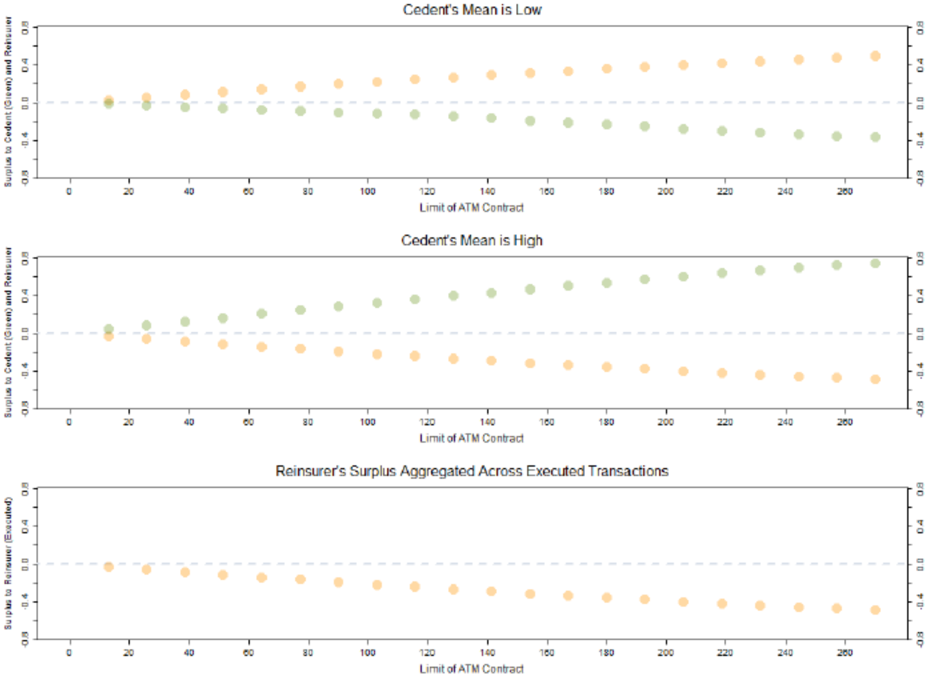


For a sufficiently high limit, the 99.5% VaR of the loss net of reinsurance travels through the reinsured layer. Here, the two right-most exit points are the first two on the grid for which the 95% VaR of the retained loss reaches the attachment point.

Reinsurer Charges Premium Averaged Across Means

Adverse selection (Akerlof, 1970)

Orange: Reinsurer
Green: Cedent



The low-mean cedent does not participate (top panel), whereas the high-mean cedent transacts (middle panel). The reinsurer does not break even (bottom panel).

Menu of Contracts

Reinsurer offers an {ATM, OTM} pair of contracts

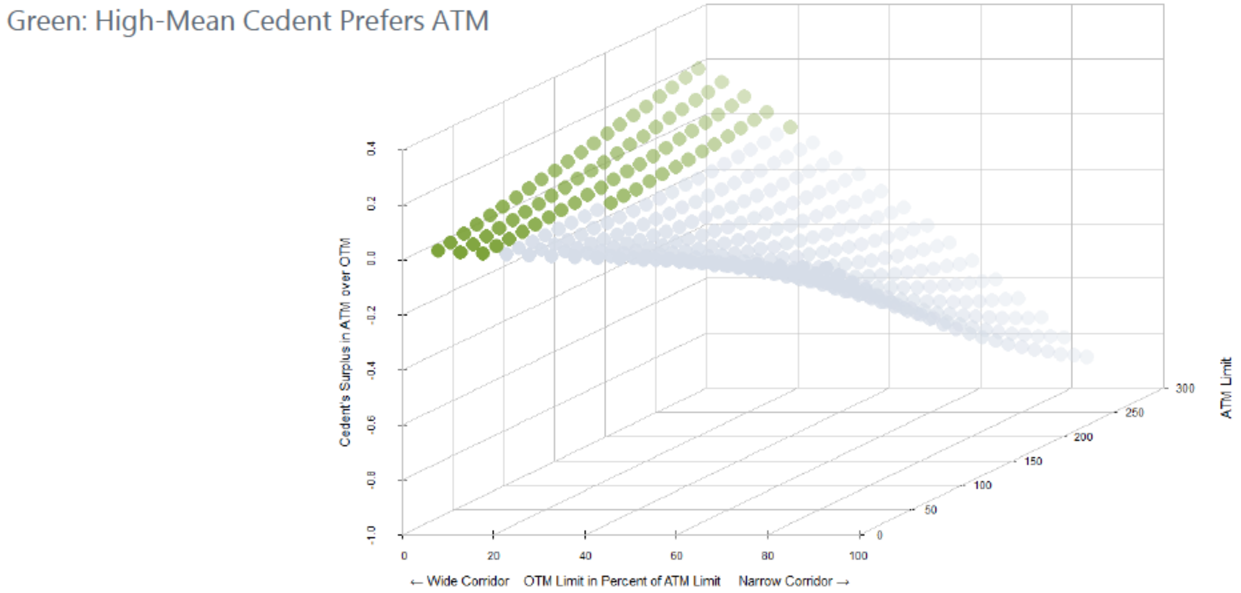
- The ATM (at-the-money) contract is priced to the high mean and has a high limit, generating a large reduction in frictional cost
- The OTM (out-of-the-money) contract is priced to the low mean, has the same exit point as the ATM, and (by definition) has a corridor between the ATM attachment point and its own attachment point (which, here, is the low mean)
- If the ATM limit is sufficiently high and the corridor of the OTM is sufficiently wide, then the high-mean cedent selects the ATM contract and the reinsurer breaks even
- The low-mean cedent selects the OTM contract, in which case the reinsurer breaks even, or (if and only if the frictional cost parameter is sufficiently high) selects the ATM contract, in which case the reinsurer does better than break-even
- Both the high-mean cedent and the low-mean cedent will transact, and the reinsurer will break even (or do better in the case of the low-mean cedent selecting the ATM contract)

Reinsurer Faces No Competition

- Baseline Frictional Cost
- High Frictional Cost

Baseline: The High-Mean Cedent's Contract Choice

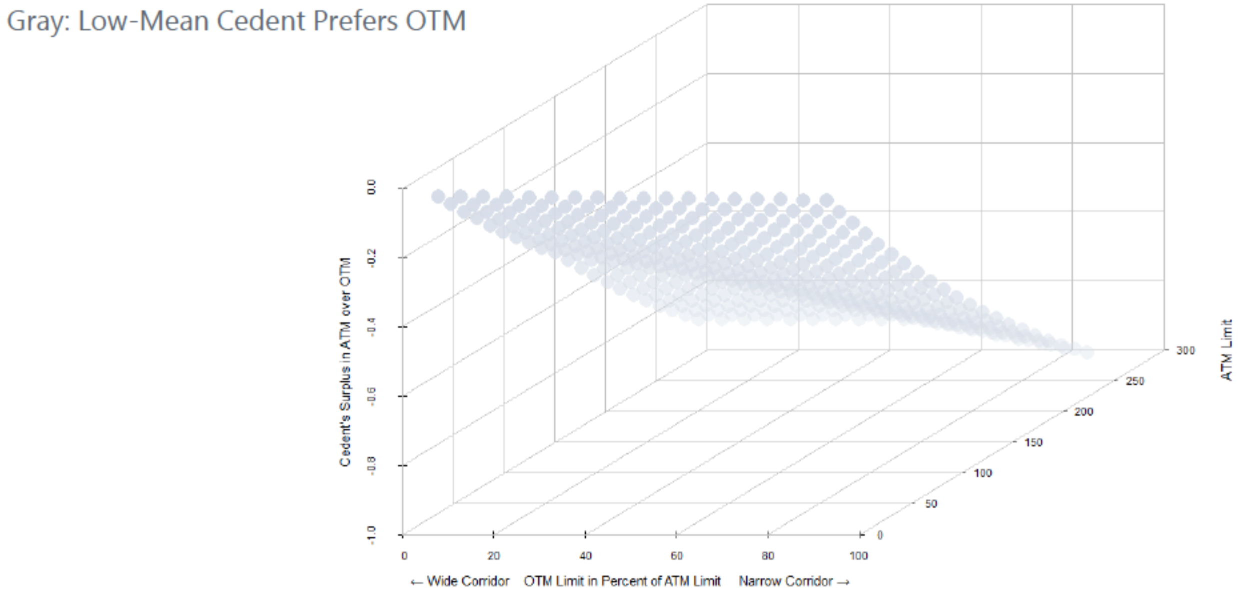
Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type



The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For the high-mean cedent to select into the ATM, the limit must be sufficiently high, and the OTM corridor (distance of ATM attachment point to OTM attachment point) must be sufficiently wide.

Baseline: The Low-Mean Cedent's Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

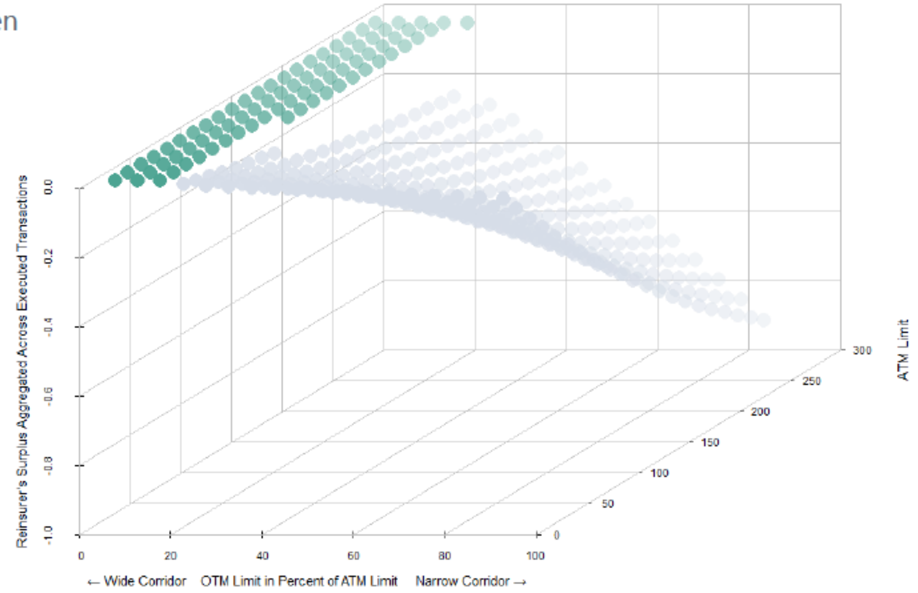


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Here, the low-mean cedent always selects into the OTM (gray dots).**

Baseline: Reinsurer's Surplus Based on Executed Transactions

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Teal: Reinsurer Breaks Even

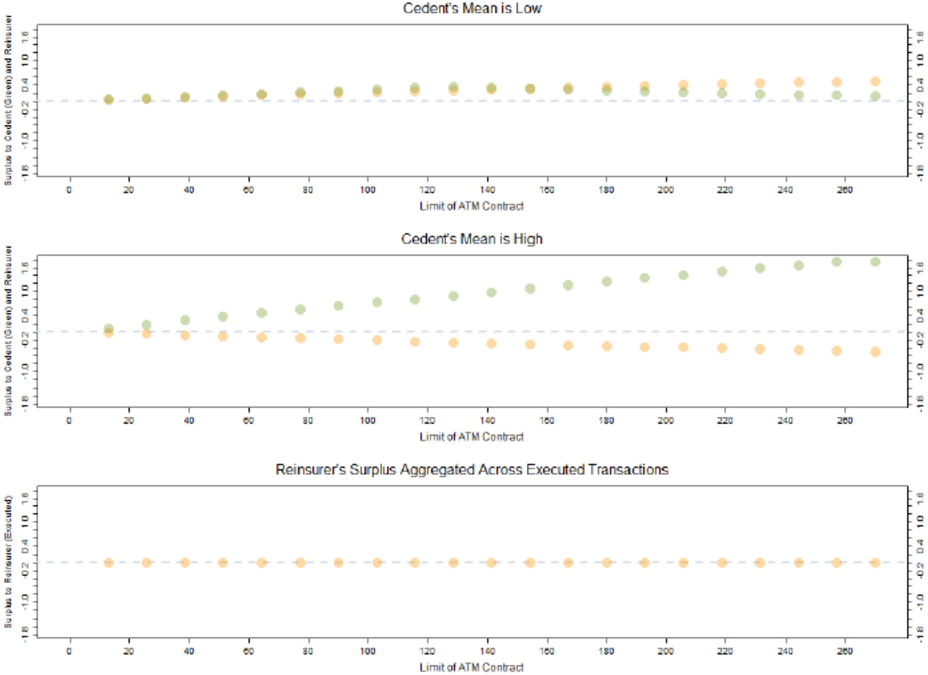


Shown is the reinsurer's surplus based on executed transactions. All cedents transact. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even.

High Frictional Cost (FC) Parameter

Reinsurer charges premium averaged across means

Orange: Reinsurer
Green: Cedent

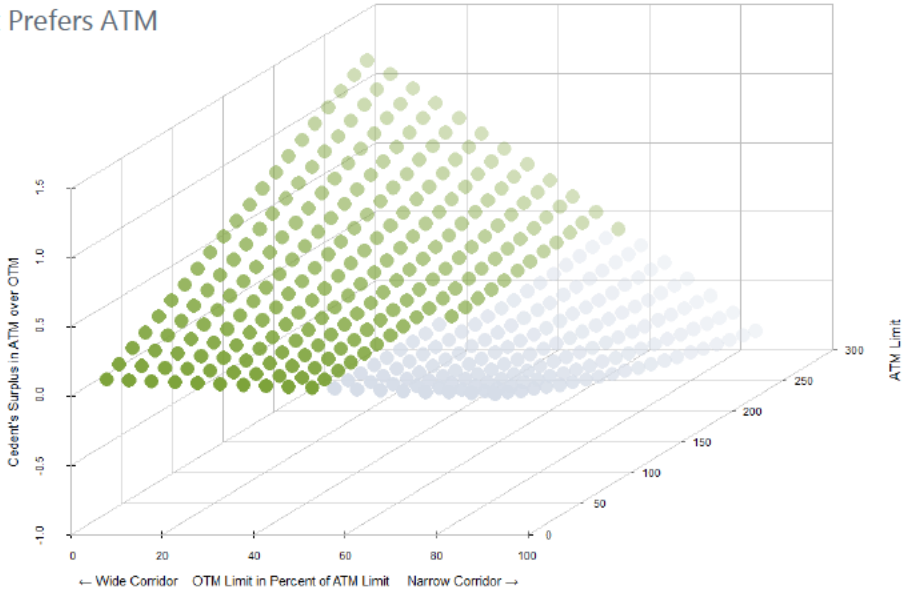


The low-mean cedent participates (top panel)—market forces permitting, as cedent pays more than actuarially fair premium. The high-mean cedent also participates (middle panel)—high-mean cedent pays less than actuarially fair premium. For the low-mean cedent, the reduction in frictional cost more than offsets the wealth transfer to the reinsurer.

High FC—High-Mean Cedent's Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Green: High-Mean Cedent Prefers ATM

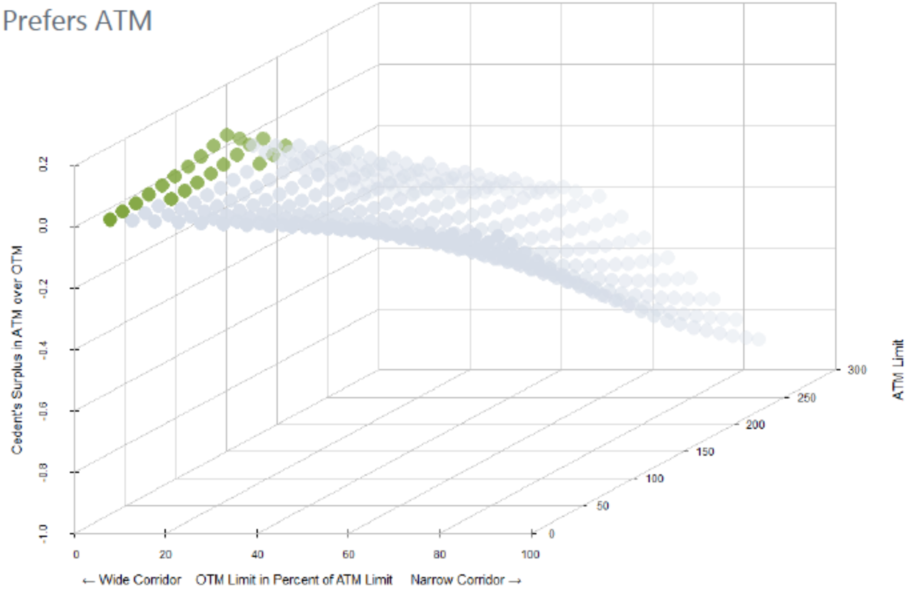


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For the high-mean cedent to select into the ATM, the limit must be sufficiently high, and the OTM corridor (distance of ATM attachment point to OTM attachment point) must be sufficiently wide.

High FC—Low-Mean Cedent's Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Green: Low-Mean Cedent Prefers ATM

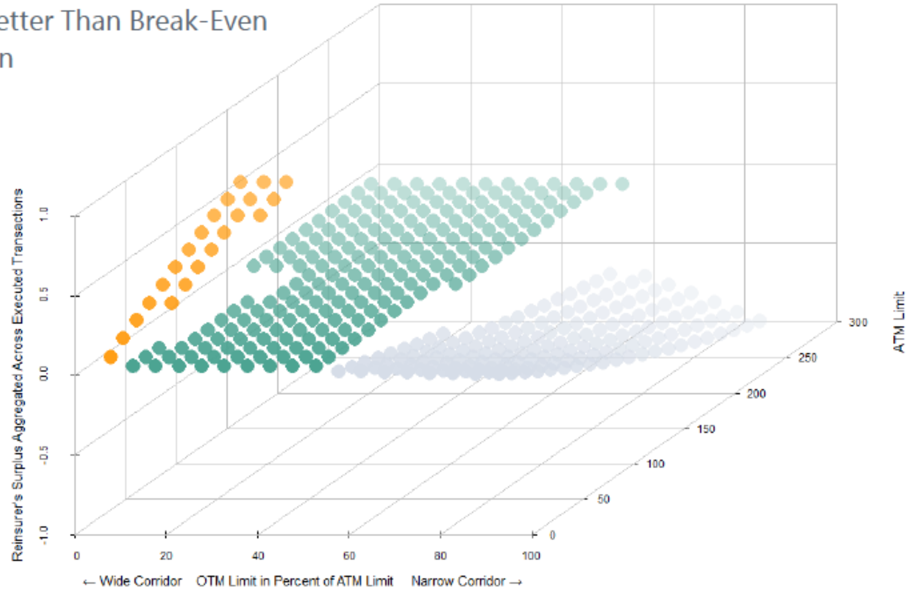


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the low-mean cedent selects into the ATM (OTM).**

High FC—Reinsurer's Surplus Based on Executed Transactions

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Orange: Reinsurer Does Better Than Break-Even
Teal: Reinsurer Breaks Even



Shown is reinsurer's surplus based on executed transactions. All cedents transact. Orange: Pairs of contracts for which reinsurer does better than break-even. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even.

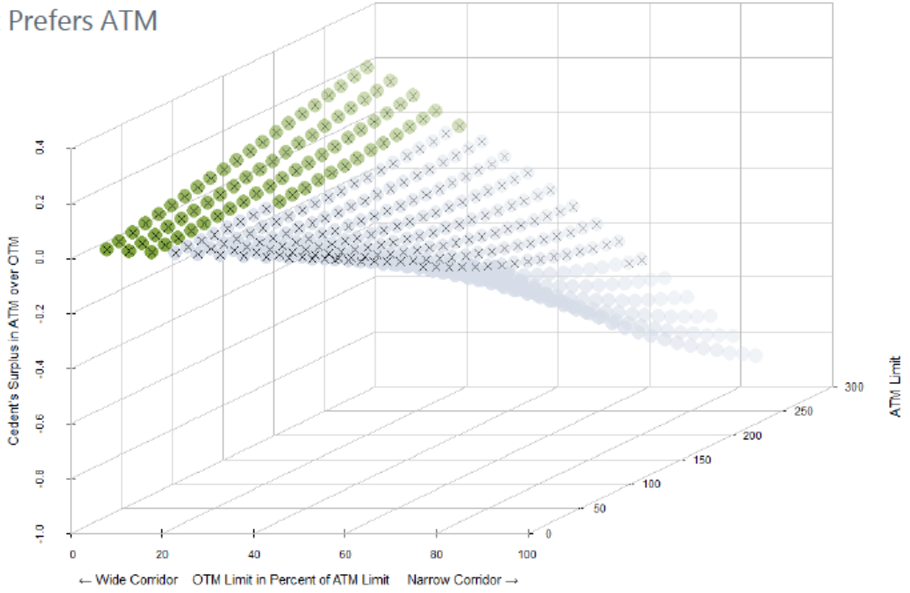
Reinsurer Faces Competition

- Baseline Frictional Cost
- High Frictional Cost

High-Mean Cedent's Contract Choice

Competitor charges premium averaged across means

Green: High-Mean Cedent Prefers ATM

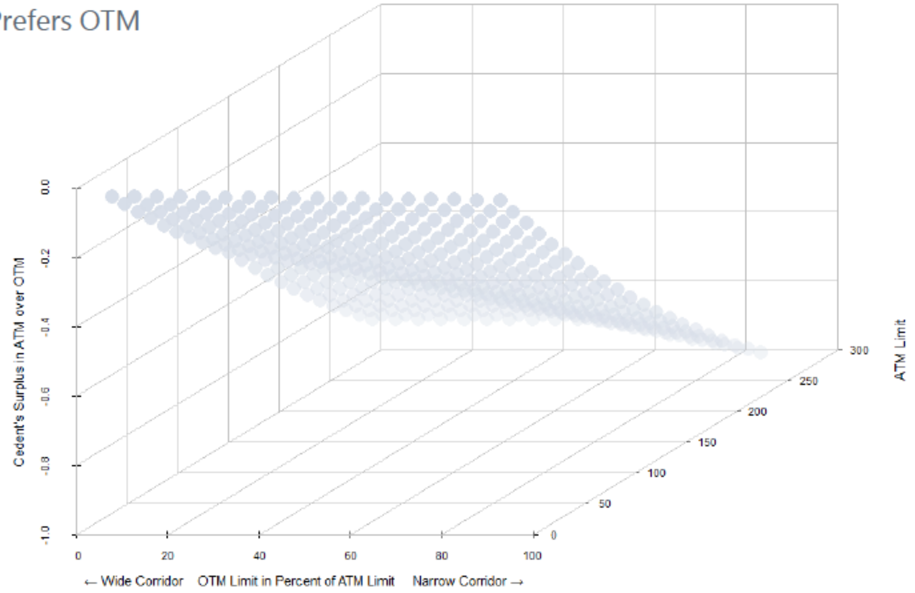


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For pairs of contracts marked with an x, the reinsurer fails to transact due to competition.

Low-Mean Cedent's Contract Choice

Competitor charges premium averaged across means

Gray: Low-Mean Cedent Prefers OTM



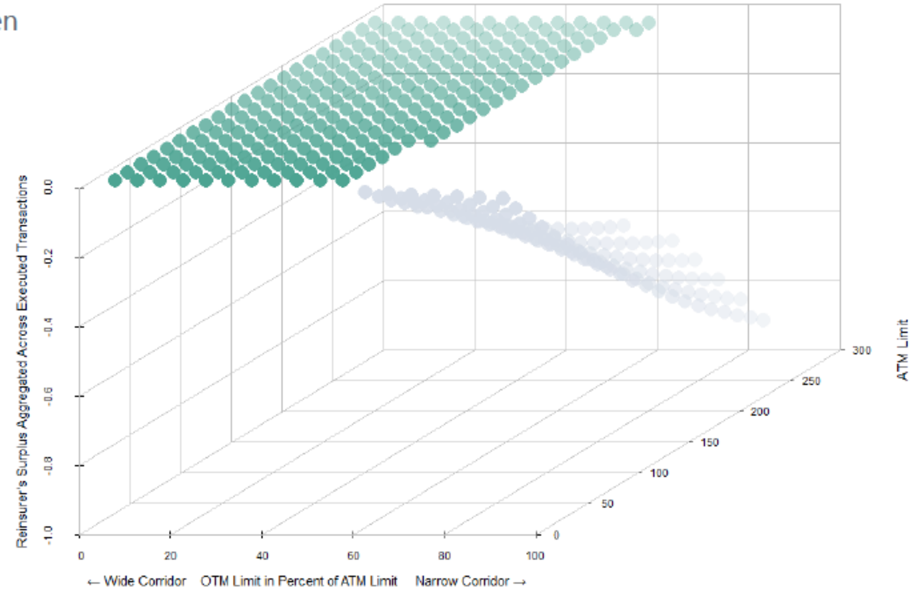
The ATM is priced to the high mean, and the OTM is priced to the low mean. **Here, the low-mean cedent always selects into the OTM.** Further, here there are no pairs of contracts for which the reinsurer fails to transact.

Reinsurer's Surplus (Executed Transactions)

Competitor charges premium averaged across means

Teal: Reinsurer Breaks Even

No dots for pairs of contracts for which the reinsurer does not transact with at least one type of cedent



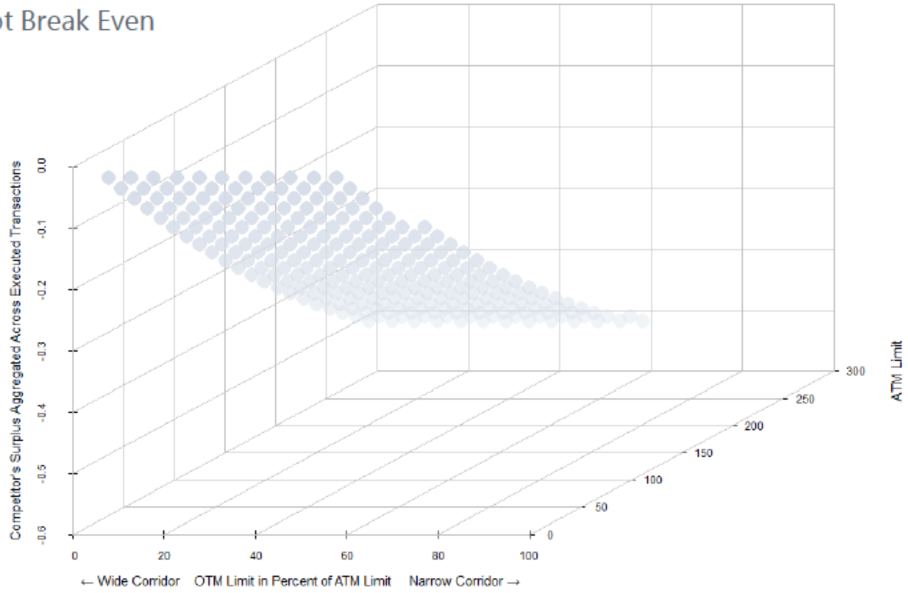
Shown is the **reinsurer's surplus** based on executed transactions. All cedents transact. Teal: Pairs of contracts for which the reinsurer breaks even. Gray: Reinsurer does not break even. For the reinsurer to break even, the OTM corridor (distance of ATM attachment point to OTM attachment point) must be sufficiently wide. For all depicted pairs of contracts, the reinsurer transacts with at least one type of cedent.

Competitor’s Surplus (Executed Transactions)

Competitor charges premium averaged across means

Gray: Competitor Does Not Break Even

No dots for pairs of contracts for which the competitor does not transact with at least one type of cedent

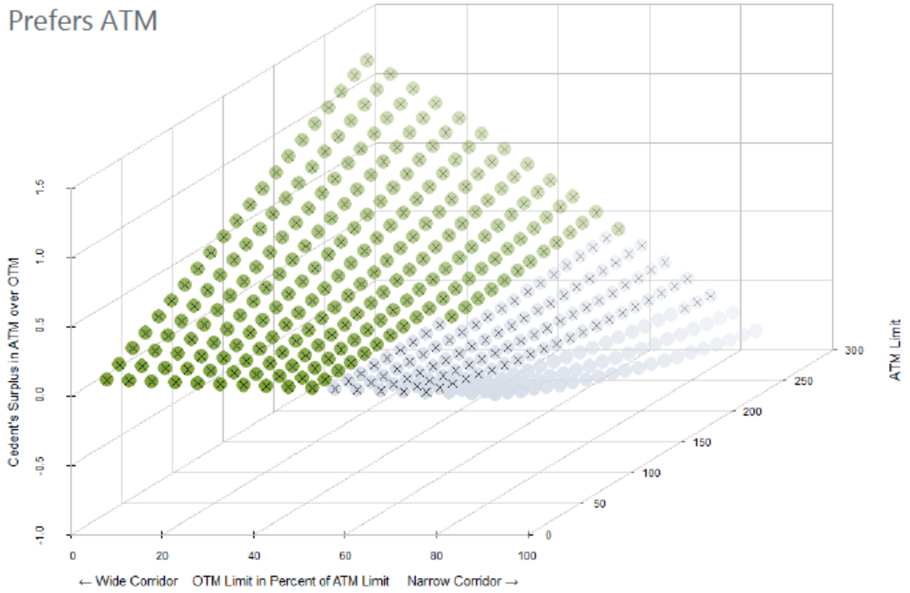


Shown is the **competitor’s surplus** based on executed transactions. The competitor, which charges a premium averaged across means, does not break even. For all depicted pairs of contracts, the competitor transacts with at least one type of cedent.

High FC—High-Mean Cedent's Contract Choice

Competitor charges premium averaged across means

Green: High-Mean Cedent Prefers ATM

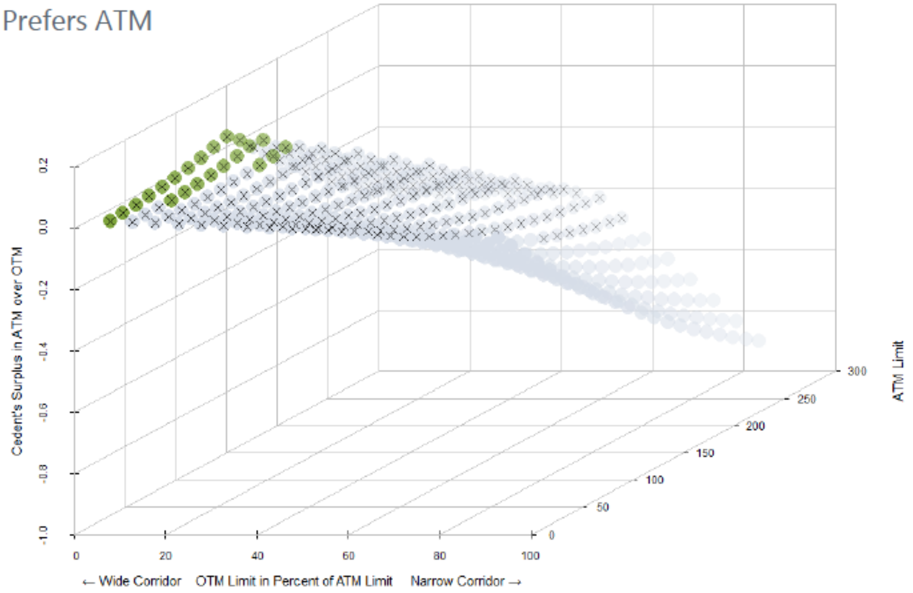


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For pairs of contracts marked with an x, the reinsurer fails to transact due to competition.

High FC—Low-Mean Cedent's Contract Choice

Competitor charges premium averaged across means

Green: Low-Mean Cedent Prefers ATM



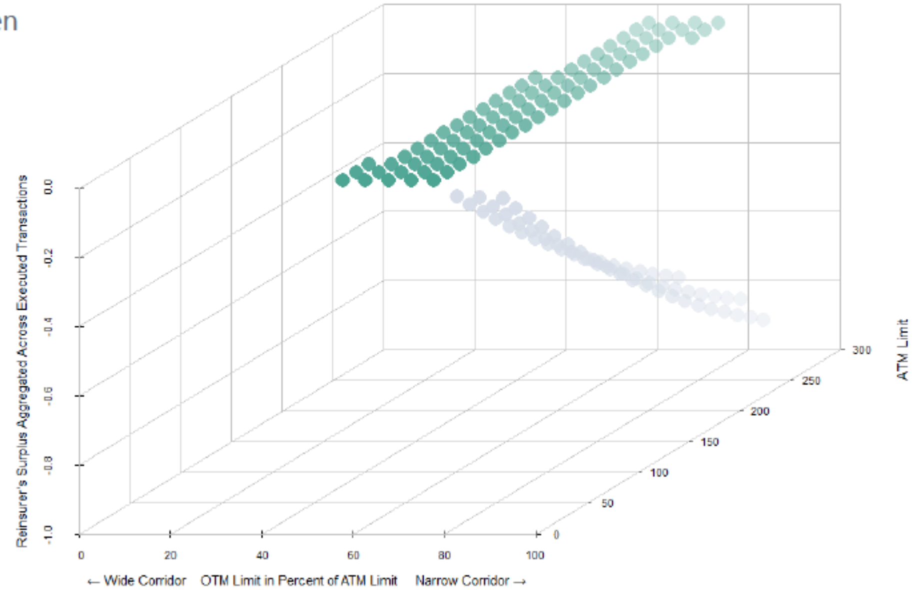
The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the low-mean cedent selects into the ATM (OTM).** For pairs of contracts marked with an x, the reinsurer fails to transact due to competition.

High FC—Reinsurer's Surplus (Executed Transactions)

Competitor charges premium averaged across means

Teal: Reinsurer Breaks Even

No dots for pairs of contracts for which the reinsurer does not transact with at least one type of cedent



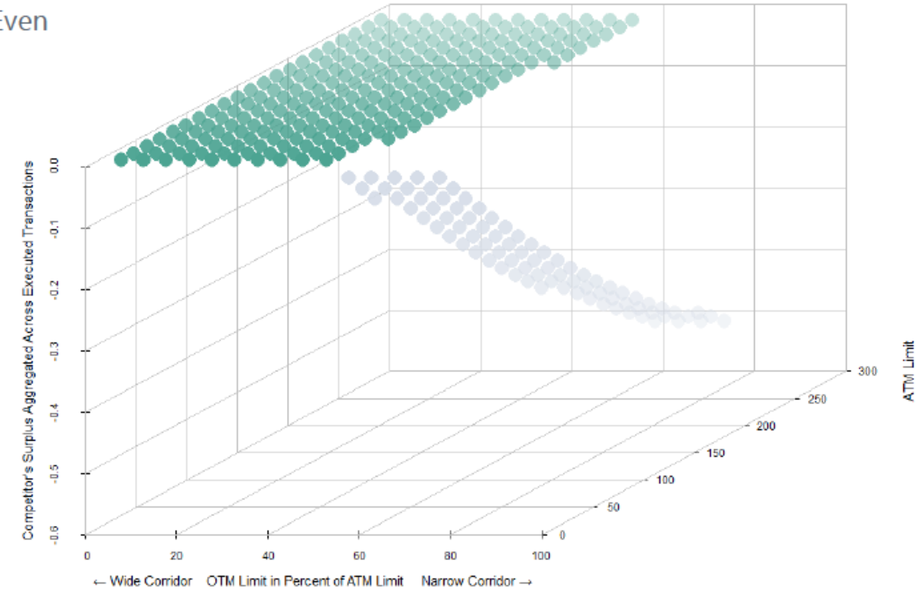
Shown is the **reinsurer's surplus** based on executed transactions. All cedents transact. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even. The reinsurer breaks even within a band of ATM limits and OTM corridors. For all depicted pairs of contracts, the reinsurer transacts with at least one type of cedent.

High FC—Competitor's Surplus (Executed Transactions)

Competitor charges premium averaged across means

Teal: Competitor Breaks Even

No dots for pairs of contracts for which the competitor does not transact with at least one type of cedent



Shown is the **competitor's surplus** based on executed transactions. Teal: Pairs of contracts for which competitor breaks even. Gray: Competitor does not break even. The competitor breaks even within a band of ATM limits and OTM corridors. For all depicted pairs of contracts, the competitor transacts with at least one type of cedent.

Conclusion

Menu of contracts as a means of preventing adverse selection

- A menu of contracts is a means of insulating the reinsurer from adverse selection
- Even in the presence of competition, a menu consisting of an ATM with a high limit and an OTM with a sufficiently wide corridor allows the reinsurer to break even
- All (potential) cedents transact when there is a menu-of-contracts reinsurer in the market
- The competitor, which charges the consideration averaged across the means, can break even only if the frictional cost parameter for the cedent is sufficiently high
  - The ability of the competitor to break even for a given frictional cost parameter depends on the properties (and particularly the skew) of the loss distribution generated by the collective risk model

Appendix

Retroactive Reinsurance

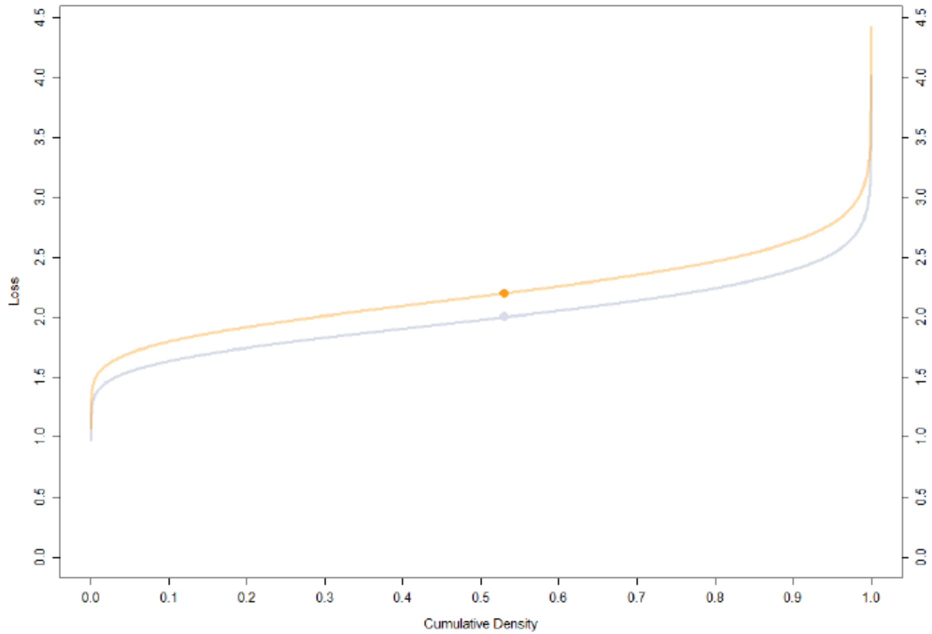
Model Parameters

Stylized volatility cover

Parameter	Value
Loss distribution	Lognormal
Mean	2 (low) 2.2 (high)
Coefficient of variation (CV)	0.15 (15%)
Probability of cedent being of low mean	0.5 (50%)
Frictional cost (applies to cedent only)	In proportion to difference between 99.5% value-at-risk (VaR) and mean
Frictional cost proportionality parameter	0.03 (3%) and 0.2 (20%) (case of financial distress)
Pairs of reinsurance contracts	ATM (at the money), attaching at the mean OTM (out-of-the-money), same exhaustion point as respective ATM, with corridor
Bargaining power	Social surplus (reduction of frictional cost) goes to cedent
Reinsurance pricing	Actuarially fair (expected layer loss)
Pricing to (weighted) average of means	Consideration equals the (weighted) average of expected layer losses across means

Loss Distribution

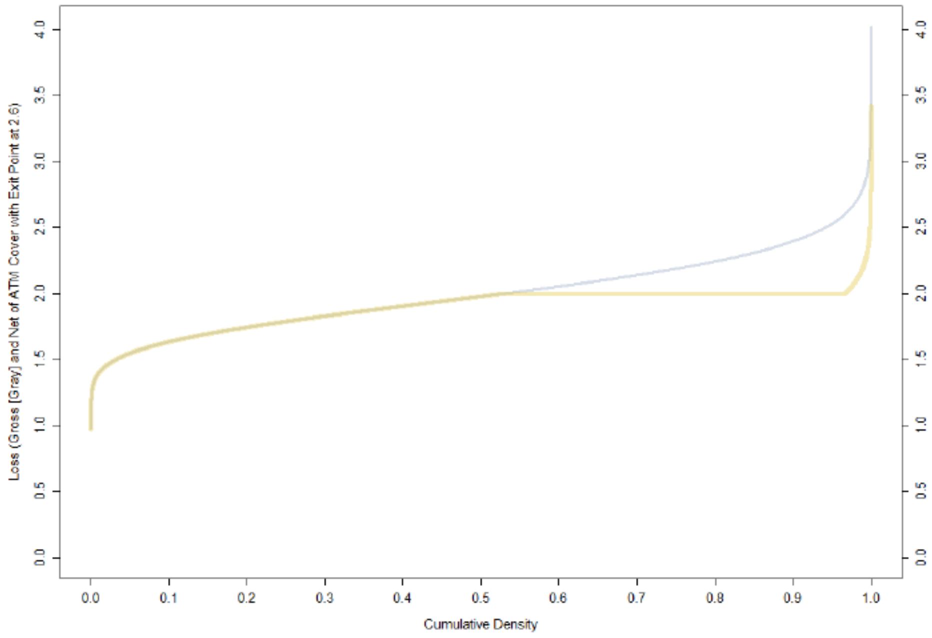
Lognormal. Mean of 2 (gray) and 2.2 (amber). CV = 0.15



The dots indicate the means.

Loss Distribution (Gross vs Net)

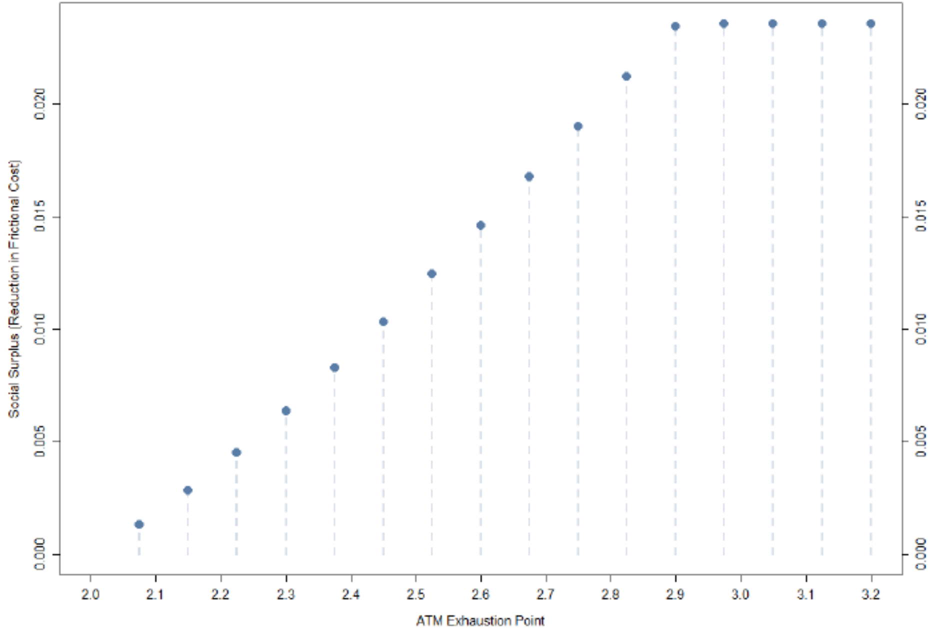
Illustration of ATM



Gray: gross (no reinsurance). Green: net of reinsurance.

Social Surplus

Surplus of reinsurance transaction originates in reduction of frictional cost to cedent

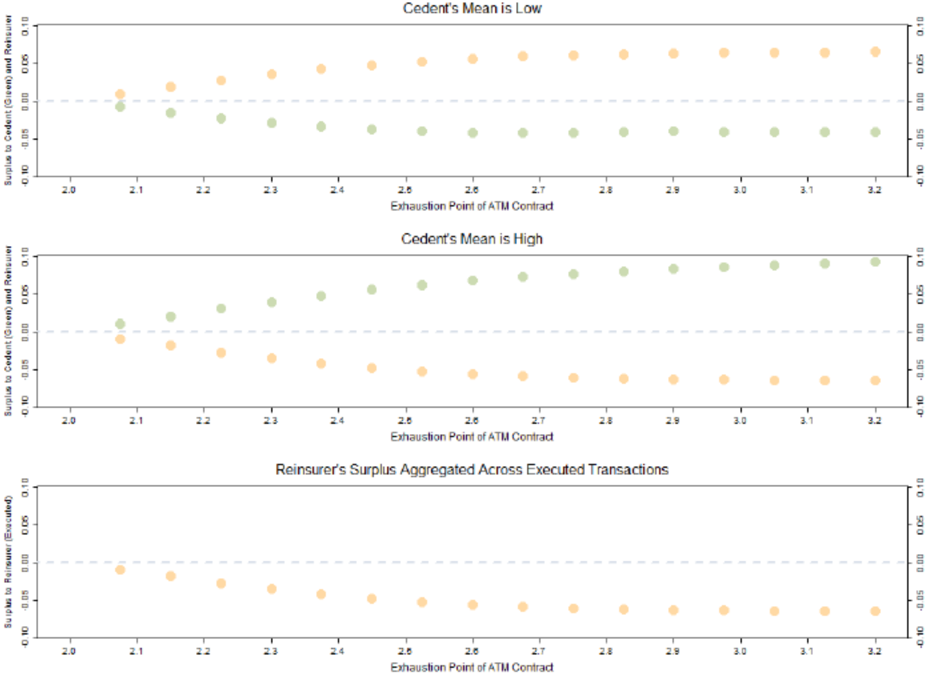


The social surplus is the feasible price range for the reinsurer, defined as the price interval between the cedent's non-participation and the reinsurer's break-even. For simplicity, it is assumed that the social surplus goes to the cedent. The increase in social surplus flattens materially once the 99.5% VaR of the loss net of reinsurance drops down to the attachment point.

Reinsurer Charges Premium Averaged Across Means

Adverse selection (Akerlof, 1970)

Orange: Reinsurer
Green: Cedent



The low-mean cedent does not participate (top panel), whereas the high-mean cedent transacts (middle panel). The reinsurer does not break even (bottom panel).

Menu of Contracts

Reinsurer offers an {ATM, OTM} pair of contracts

- The ATM (at-the-money) contract is priced to the high mean and has a high limit, generating a large reduction in frictional cost
- The OTM (out-of-the-money) contract is priced to the low mean, has the same exhaustion point as the ATM, and (by definition) has a corridor between the ATM attachment point and its own attachment point (which, here, is the low mean)
- If the ATM limit is sufficiently high and the corridor of the OTM is sufficiently wide, then the high-mean cedent selects the ATM contract and the reinsurer breaks even
- The low-mean cedent selects the OTM contract, in which case the reinsurer breaks even, or (if and only if the frictional cost parameter is sufficiently high) selects the ATM contract, in which case the reinsurer does better than break-even
- Both the high-mean cedent and the low-mean cedent will transact, and the reinsurer will break even (or do better in the case of the low-mean cedent selecting the ATM contract)

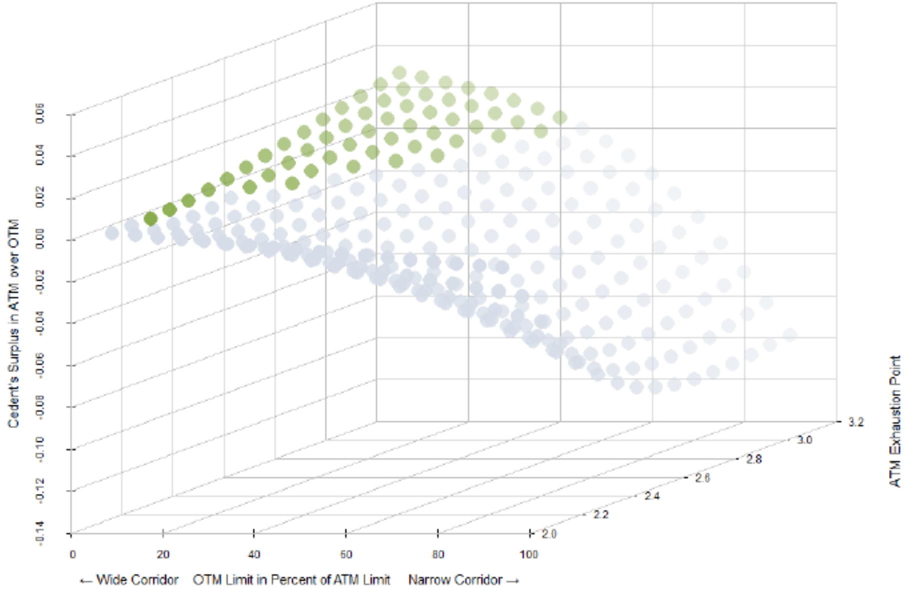
Reinsurer Faces No Competition

- Baseline Frictional Cost
- High Frictional Cost (Financial Distress)

Baseline: The High-Mean Cedent's Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Green: High-Mean Cedent Prefers ATM

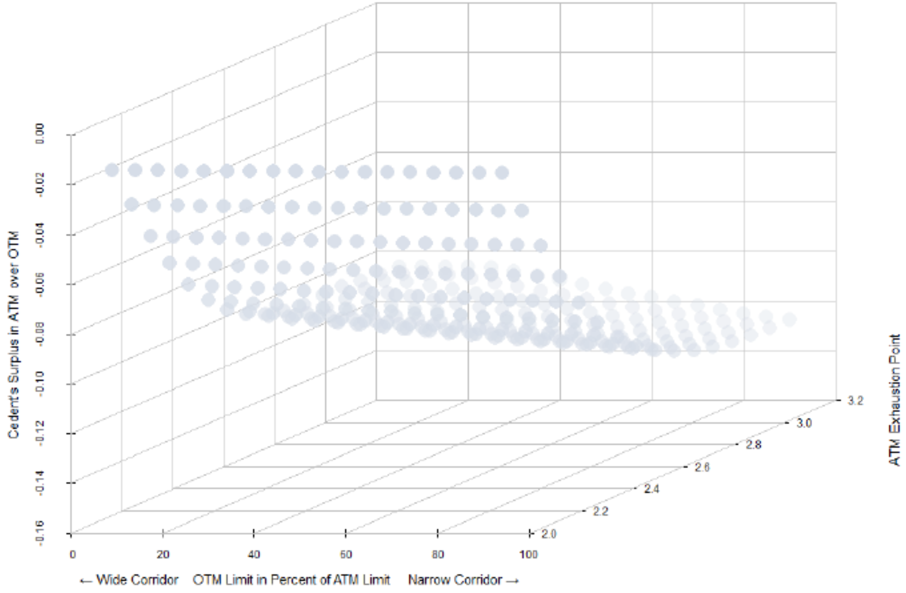


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For the high-mean cedent to prefer the ATM, the limit must be sufficiently high, and the OTM corridor (mean to attachment point) must be sufficiently wide.

Baseline: The Low-Mean Cedent' Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Gray: Low-Mean Cedent Prefers OTM

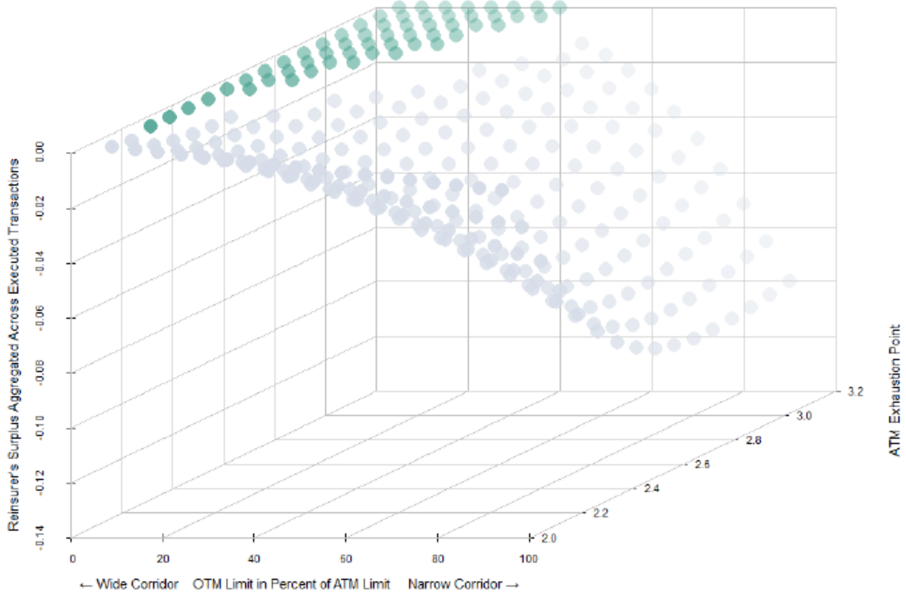


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Here, the low-mean cedent always selects into the OTM (gray dots).**

Baseline: Reinsurer's Surplus Based on Executed Transactions

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Teal: Reinsurer Breaks Even

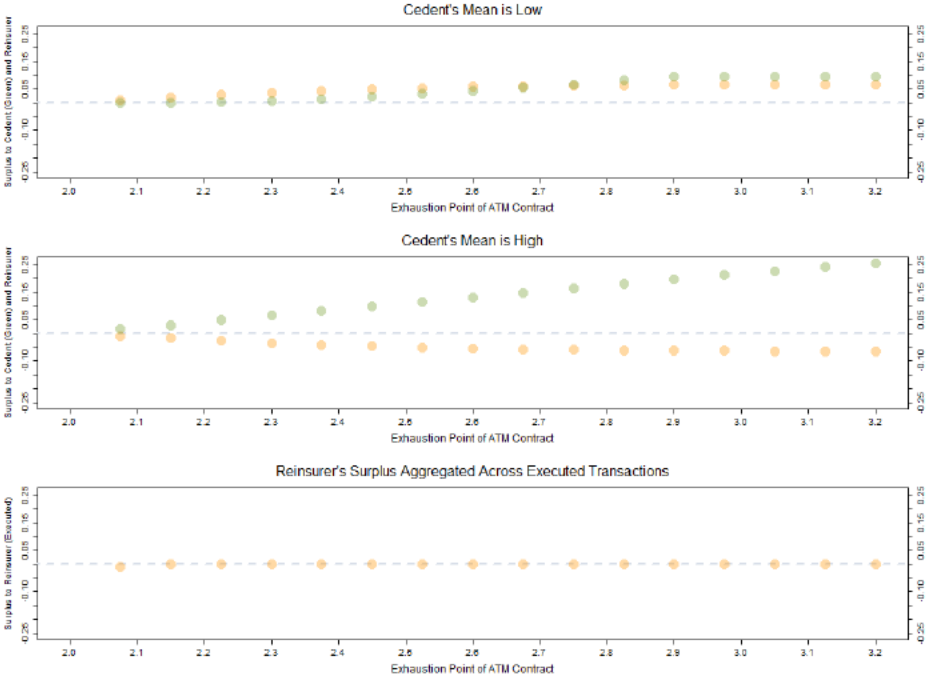


Shown is the reinsurer's surplus based on executed transactions. All cedents transact. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even.

Financial Distress: High Frictional Cost Parameter

Reinsurer charges premium averaged across means

Orange: Reinsurer
Green: Cedent

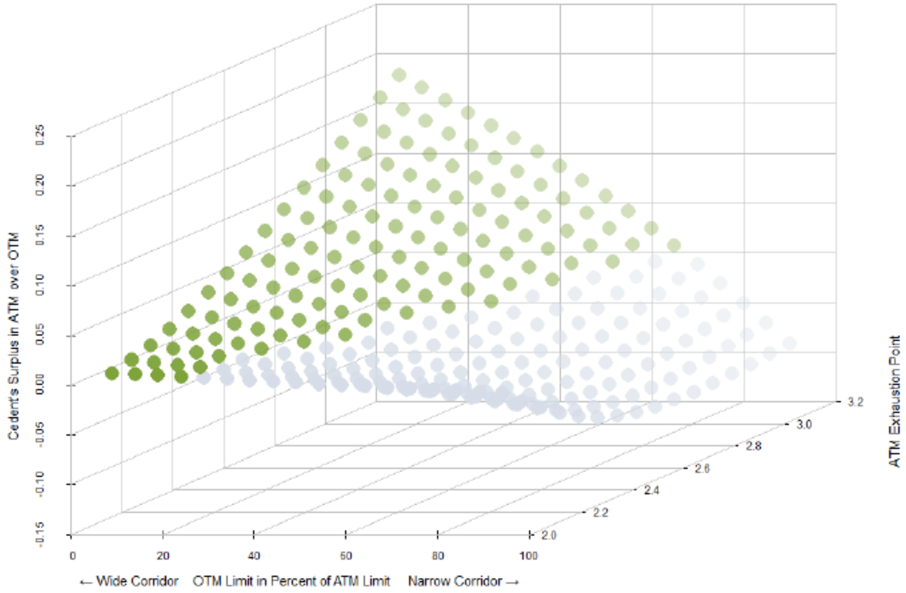


The low-mean cedent participates (top panel), unless the limit is low (first dot)—market forces permitting, as cedent pays more than actuarially fair premium. The high-mean cedent always participates (middle)—the high-mean cedent pays less than actuarially fair premium. For the low-mean cedent, the reduction in frictional cost more than offsets the wealth transfer (unless the limit is low).

Financial Distress—High-Mean Cedent's Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

Green: High-Mean Cedent Prefers ATM

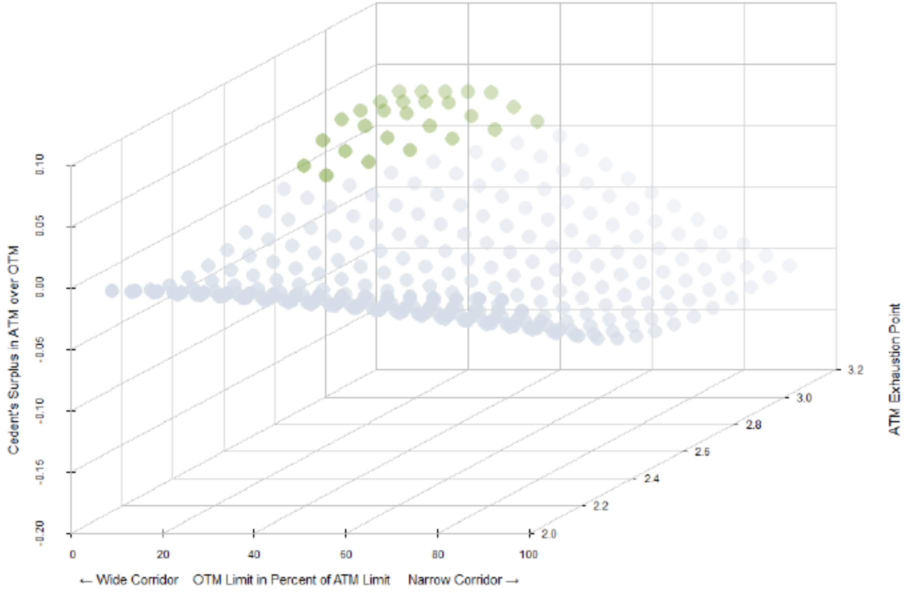


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For the high-mean cedent to prefer the ATM, the limit must be sufficiently high, and the OTM corridor (mean to attachment point) must be sufficiently wide.

Financial Distress—Low-Mean Cedent's Contract Choice

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type

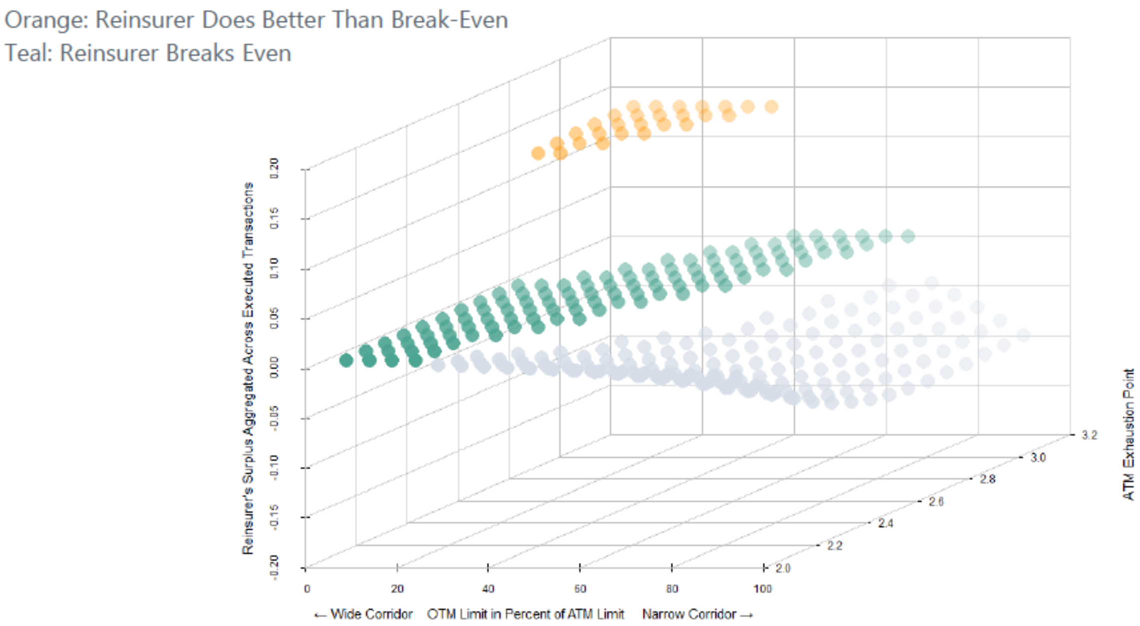
Green: Low-Mean Cedent Prefers ATM



The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the low-mean cedent selects into the ATM (OTM).**

Financial Distress—Reinsurer's Surplus Based on Executed Transactions

Reinsurer offers an {ATM, OTM} pair of contracts, not knowing the type



Shown is the reinsurer's surplus based on executed transactions. All cedents transact. Orange: Pairs of contracts for which reinsurer does better than break-even. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even.

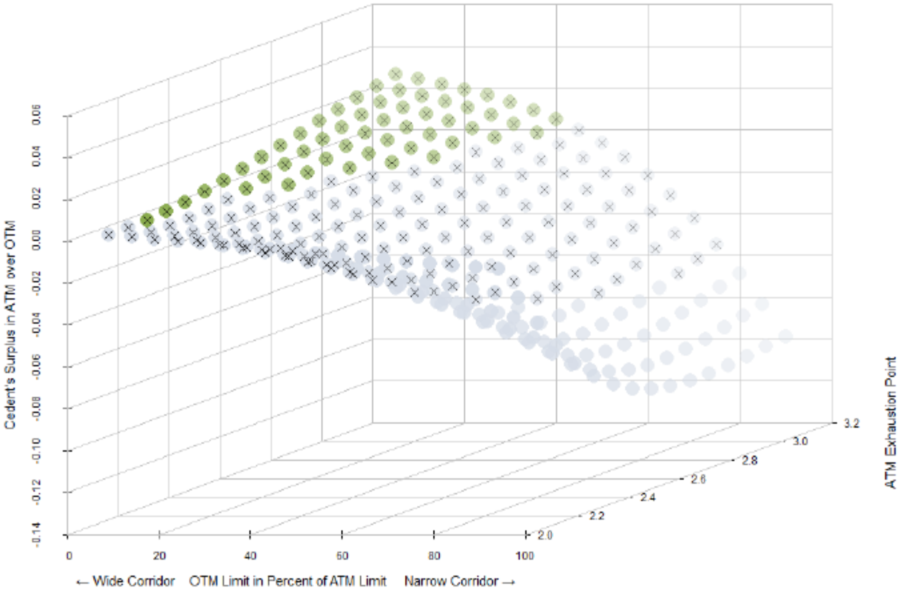
Reinsurer Faces Competition

- Baseline Frictional Cost
- High Frictional Cost (Financial Distress)

The Case of Competition—High-Mean Cedent's Contract Choice

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

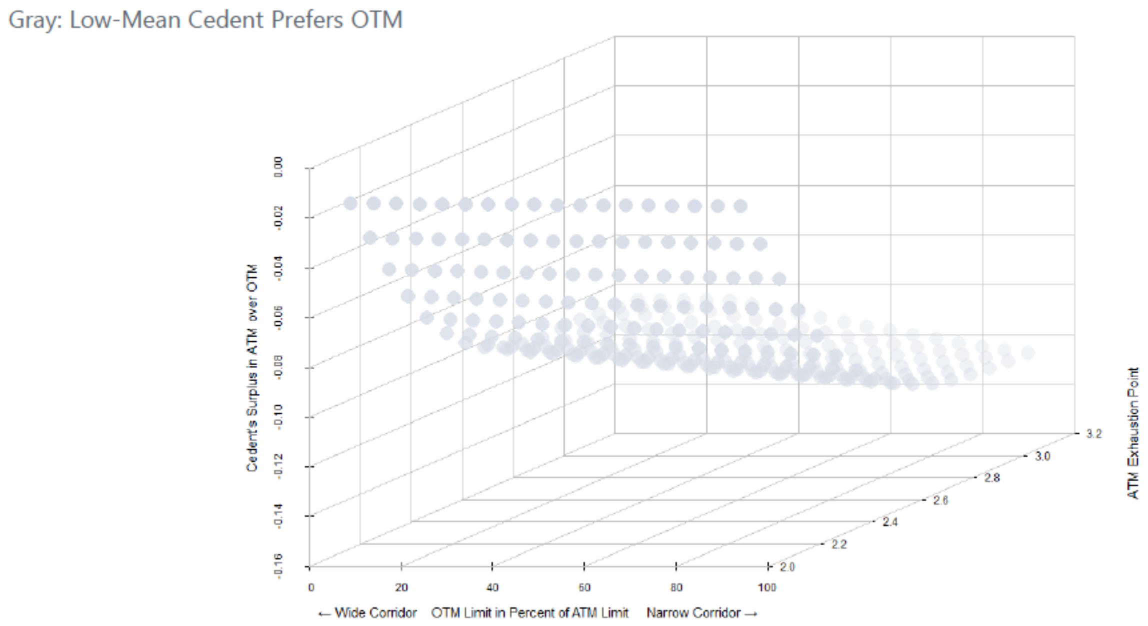
Green: High-Mean Cedent Prefers ATM



The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For pairs of contracts marked with an x, the reinsurer fails to transact due to competition.

The Case of Competition—Low-Mean Cedent's Contract Choice

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means



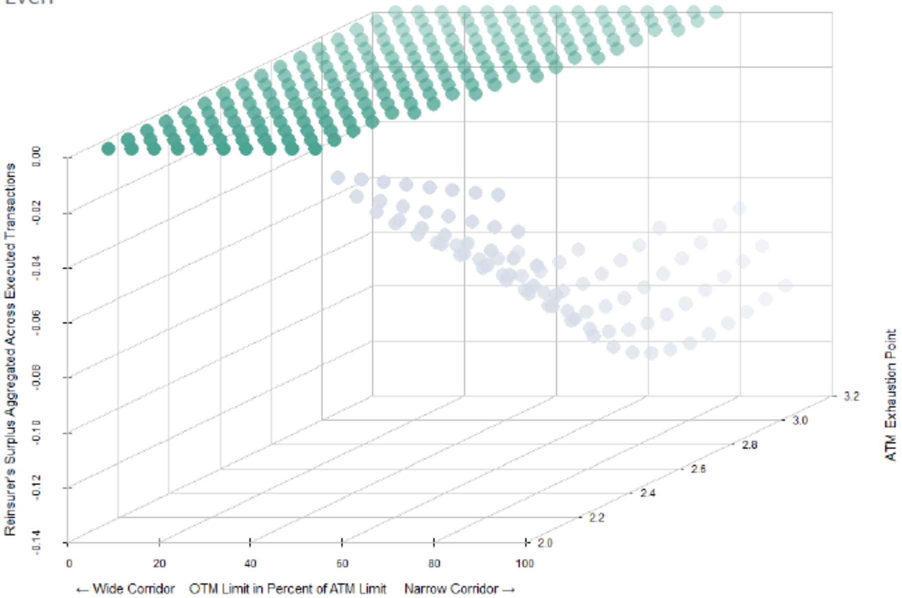
The ATM is priced to the high mean, and the OTM is priced to the low mean. **Here, the low-mean cedent always selects into the OTM.** Further, here there are no pairs of contracts for which the reinsurer fails to transact.

The Case of Competition—Reinsurer's Surplus (Executed Transactions)

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

Teal: Reinsurer Breaks Even

No dots for pairs of contracts for which the reinsurer does not transact with at least one type of cedent



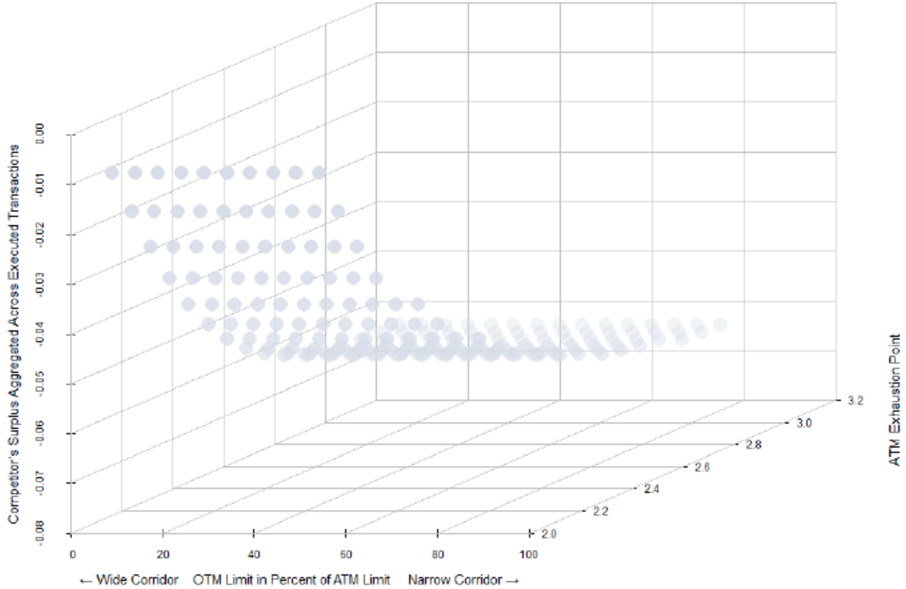
Shown is the **reinsurer's surplus** based on executed transactions. All cedents transact. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even. For the reinsurer to break even, the OTM corridor (mean to attachment point) must be sufficiently wide. For all depicted pairs of contracts, the reinsurer transacts with at least one type of cedent.

The Case of Competition—Competitor's Surplus (Executed Transactions)

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

Gray: Competitor Does Not Break Even

No dots for pairs of contracts for which the competitor does not transact with at least one type of cedent

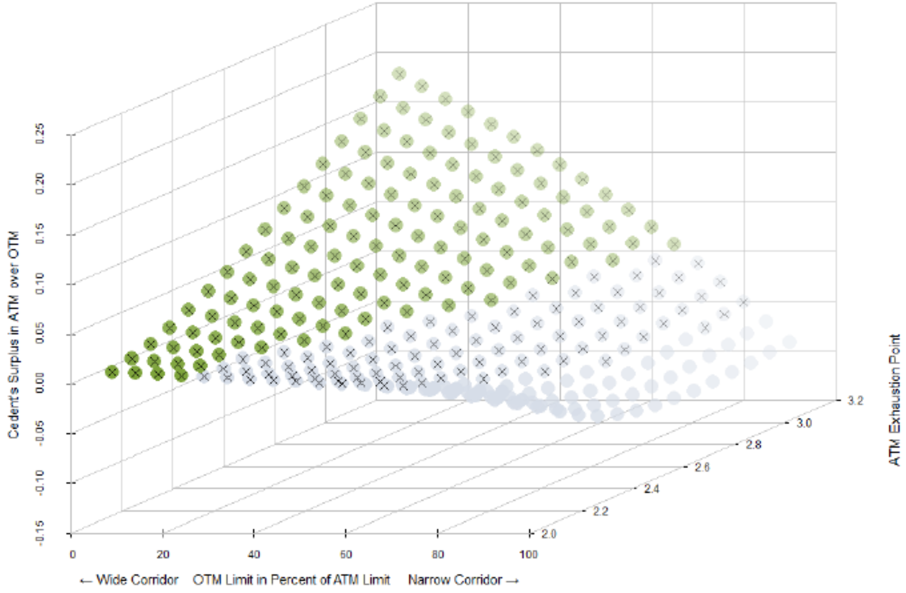


Shown is the **competitor's surplus** based on executed transactions. The competitor, which charges a premium averaged across means, does not break even. For all depicted pairs of contracts, the competitor transacts with at least one type of cedent.

Competition & Fin. Distress—High-Mean Cedent's Contract Choice

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

Green: High-Mean Cedent Prefers ATM

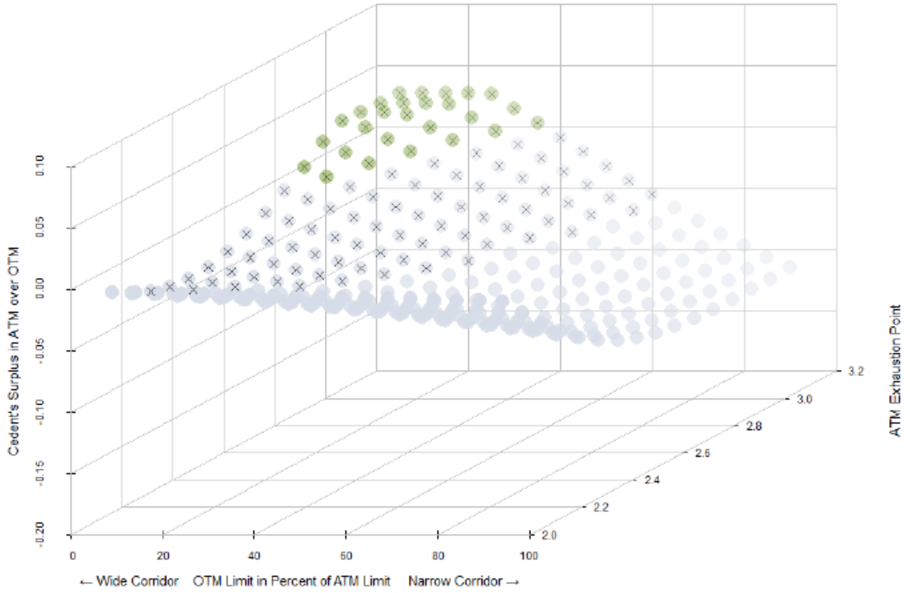


The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the high-mean cedent selects into the ATM (OTM).** For pairs of contracts marked with an x, the reinsurer fails to transact due to competition.

Competition & Fin. Distress—Low-Mean Cedent's Contract Choice

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

Green: Low-Mean Cedent Prefers ATM



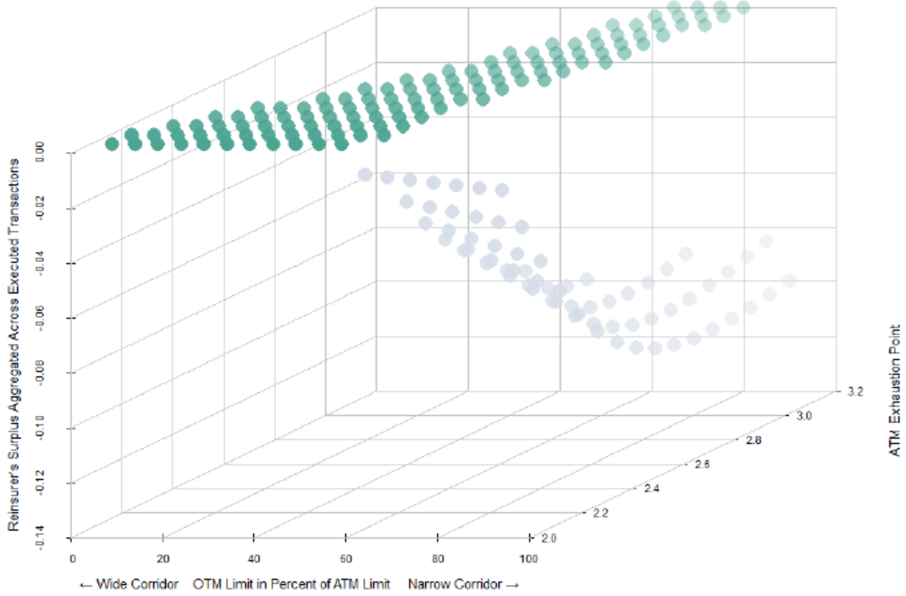
The ATM is priced to the high mean, and the OTM is priced to the low mean. **Green (gray) dots indicate pairs of contracts for which the low-mean cedent selects into the ATM (OTM).** For pairs of contracts marked with an x, the reinsurer fails to transact due to competition.

Competition & Financial Distress—Reinsurer's Surplus (Executed Transactions)

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

Teal: Reinsurer Breaks Even

No dots for pairs of contracts for which the reinsurer does not transact with at least one type of cedent



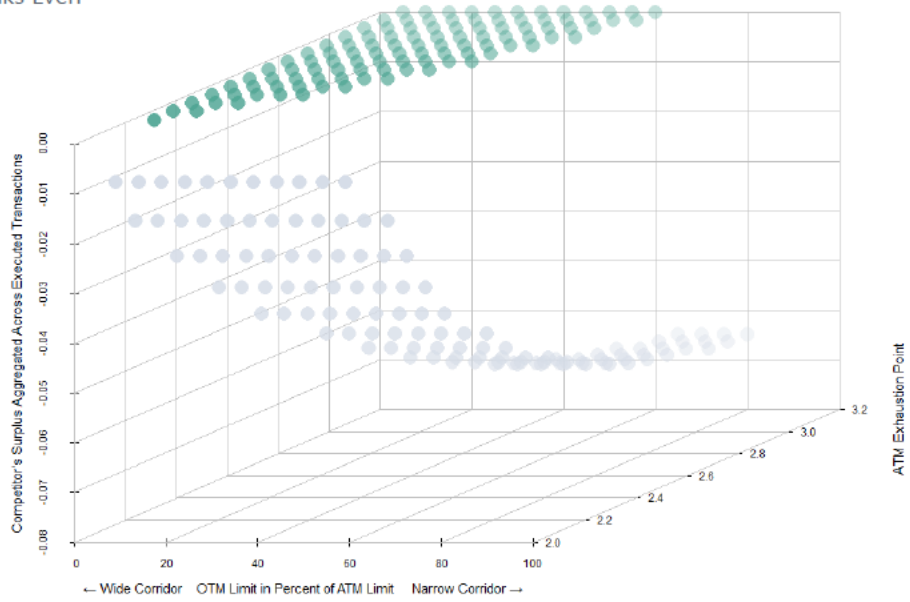
Shown is the **reinsurer's surplus** based on executed transactions. All cedents transact. Teal: Pairs of contracts for which reinsurer breaks even. Gray: Reinsurer does not break even. The reinsurer breaks even within a band of ATM limits and OTM corridors. For all depicted pairs of contracts, the reinsurer transacts with at least one type of cedent.

Competition & Financial Distress—Competitor's Surplus (Executed Transactions)

Menu-of-contracts reinsurer competes with reinsurer who charges premium averaged across means

Teal: Competitor Breaks Even

No dots for pairs of contracts for which the competitor does not transact with at least one type of cedent



Shown is the **competitor's surplus** based on executed transactions. Teal: Pairs of contracts for which competitor breaks even. Gray: Competitor does not break even. The competitor breaks even within a triangle of ATM limits and OTM corridors. For all depicted pairs of contracts, the competitor transacts with at least one type of cedent.

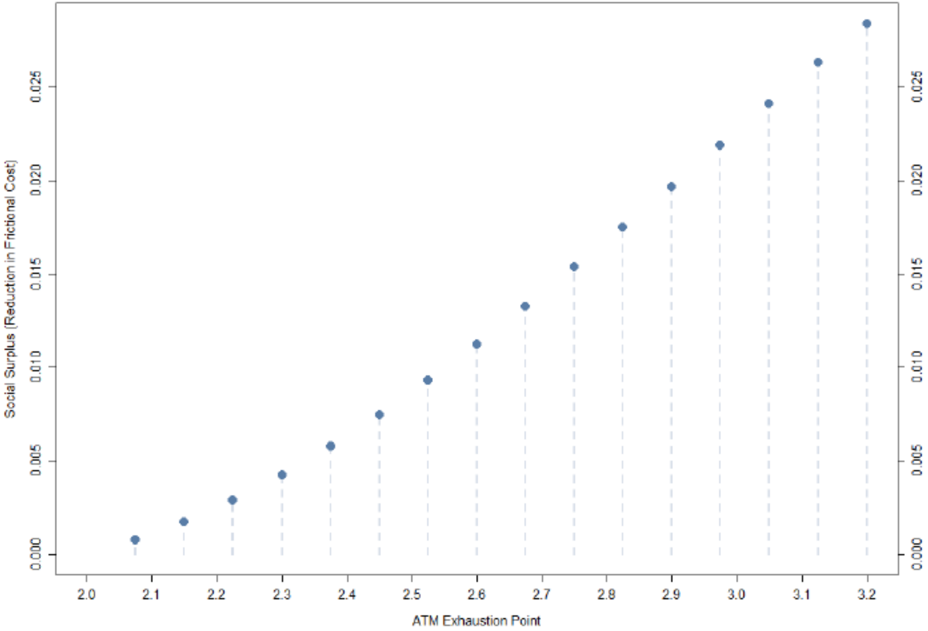
Conclusion

Menu of contracts as a means of avoiding adverse selection

- A menu of contracts is a means of insulating the reinsurer from adverse selection
- Even in the presence of competition, a menu consisting of an ATM with a high limit and an OTM with a sufficiently wide corridor allows the reinsurer to break even
- All (potential) cedents transact when there is a menu-of-contracts reinsurer in the market
- The competitor, which charges the consideration averaged across the means, breaks even only if the frictional cost parameter for the cedent is sufficiently high (and, in the presence of a lognormal distribution, is very high)

Addendum (Retroactive Reinsurance): Social Surplus of Reinsuring High-Mean Cedent

Surplus of reinsurance transaction originates in reduction of frictional cost to cedent



For a sufficiently high limit, the 99.5% VaR of the loss net of reinsurance drops down to the attachment point. Here, the right-most exhaustion point is the first on the grid for which the 95% VaR of the retained loss reaches the attachment point.