Market Discipline in Life Insurance Industry: Consumers’ Reaction to Enterprise Risks of Life Insurance Companies

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- market discipline
  - risk sensitivity of customer demand for insurance products

Abstract

- This paper investigates the relationship between insurance demand and the enterprise risks of insurers

- Insurance Demand
  - no. of new contracts
  - premium incomes of new contracts
  - persistency rates for 13 and 25 months.

- Four constructs of insurance operations
  - risk-taking strategies
  - financial soundness
  - underwriting service quality
  - corporate reputation.

- The empirical result, in general, supports the existence of market discipline for life insurance in Taiwan.

Outline of Paper

- Introduction
- Literature Review and Hypotheses Development
- Sample and Research Methodology
- Empirical Results
- Conclusion

I. Introduction

- According to the glossary of solvency II (CEA, 2007), the market discipline is explained as

- *"The creation of disciplining pressure through the publication of financial information and other information about the insurer's activities to the public,…, hence allowing market participants and policyholders to assess key organizational and product information. … Market discipline serves to ensure that insurers display a fair attitude towards policyholders…."*

I. Introduction

- This reaction mechanism through consumers may generate pressure on insurer’s operation so as to maintain solvency, which achieve the goal of insurance regulations.

II. Literature Review and Hypotheses Development

- Flannery (2001)
  - market discipline : the power of market forces, such as investors, consumers, and rating agencies, to influence the risk-taking behavior of financial institutions.

- Epermanis and Harrington (2006); Eling and Schmit 2012)
  - market discipline : risk sensitivity of customer demand for insurance products

II. Literature Review and Hypotheses Development

- Eling and Schmit (2012)
  - insurance demand is positively corresponding to insurer's credit rating which usually emphasizes on financial soundness.
- Sobol and Farrelly (1988)
  - financial performance indicators can influence corporate image for a firm.

- *H1: Demand for life insurance is positively related to financial soundness of insurers.*

II. Literature Review and Hypotheses Development

- Anton, Camarero, and Carrero (2007)
  - unfair price has a strong impact on consumers' switching and precipitates the consumers' decisions.

- *H2: Demand for life insurance is positively related to product fairness of insurers.*

II. Literature Review and Hypotheses Development

- Venetis and Ghauri (2004)
  - service quality can positively contribute to long-term relationship and customer retention.

- *H3: Demand for life insurance is positively related to with underwriting service quality of insurers.*

II. Literature Review and Hypotheses Development

- Ishihara (2006)
  - corporate reputation is a crucial factor in consumer's purchase decision for insurance because "trust" is the key
- Vegholm (2011)
  - corporate reputation is important for banks to maintain their marketing relationship with customers.

- *H4: Demand for life insurance is positively related to corporate reputation of insurers.*

II. Literature Review and Hypotheses Development

- Low (2009)
  - A better board will prefer more aggressive risk-taking in order to create profits which can enhance the financial strength
  -
- *H5: Demand for life insurance is positively related to risky investment strategy.*

II. Literature Review and Hypotheses Development

- Chung and Wynn (2008)
  - Risk-taking behavior may associate with risky operations and probability of bankruptcy.

- *H6: Demand for life insurance is negatively related to risky product strategy.*

III. Research Methodology and Sample

- **Insurance demand**
  = f (enterprise risks of an insurer)
  = f (risk-taking strategies,
  financial soundness,
  product satisfaction,
  corporate reputation)

III. Research Methodology and Sample

Table 1 The Expected Relation between Life Insurance Demand and Insurer's Risk

		Risk-taking Strategies		Financial soundness	Underwriting performance		Corporate reputation
		Invest	***Prod***	***Finsnd***	***Pdfair***	***Uwq***	***Rptn***
New business	**Policies**	+	—	+	+	+	+
	Premiums	+	—	+	+	+	+
Contract persistency	**13-month**	+	—	+	+	+	+
	25-month	+	—	+	+	+	+

III. Research Methodology and Sample

Table 2 Definitions of the Variables

Variable		Definition
Insurance demand	$lnNNC_{it}$	= ln (number of new contracts) of firm i in year t
	$lnPNC_{it}$	= ln (premium incomes of new contracts) of firm i in year t
	$P13_{it}$	= ratio of insurance policies remain effective for 13 months after issued by firm i in year t.
	$P25_{it}$	= ratio of insurance policies remain effective for 25 months after issued by firm i in year t.
Investment risk-taking strategy	$Cashr_{it}$	= cash and bank deposits / total investment assets of firm i in year t
	$Bondr_{it}$	= bonds / total investment assets of firm i in year t
	$Stockr_{it}$	= stocks / total investment assets of firm i in year t
	$Restater_{it}$	= real estates / total investment assets of firm i in year t
	$Finvestr_{it}$	= foreign investment / total investment assets of firm i in year t
Product risk-taking strategy	$Life_{it}$	= premiums of life ins. / total ins. premiums of firm i in year t
	$Accident_{it}$	= premiums of accident ins. / total ins. premiums of firm i in year t
	$Health_{it}$	= premiums of health ins. / total ins. premiums of firm i in year t
	$Annuity_{it}$	= premiums of annuity / total ins. premiums of firm i in year t

III. Research Methodology and Sample

Table 2 Definitions of the Variables

Variable		Definition
Financial soundness	$Arsk_{it}$	= risk-weighted of assets of firm i in year t
	$Prsk_{it}$	= risk-weighted of policy reserves of firm i in year t
	Cr_{it}	= equity/assets of firm i in year t
	$Cashr_{it}$	= cash and bank deposits / total investment assets of firm i in year t
	ROA_{it}	= net incomes/mean assets of of firm i in year t
	$lnAsst_{it}$	= ln(assets) of firm i in year t
Product fairness	Coa_{it}	= no of. complaints related to loss-adjusting / no. of contracts in force of firm i in year t
	$Dspt_{it}$	= dispute ratio related to lawsuits for loss-adjusting.
Service quality	$Cona_{it}$	= no. of complaints not related to loss-adjusting/no. of contracts in force of firm i in year t
	$lnExp_{it}$	= ln (business expenses) of firm i in year t
Corporate reputation	$Rptn_{it}$	= 30- RMIM rank of firm i in year t
Firm character	FHC_{it}	= 1 if firm *i* in year *t* is a subsidiary of financial holding co.
	FI_{it}	= 1 if firm *i* in year *t* with >50% of equities is hold by foreigners

III. Research Methodology and Sample

Table 3. The Measurements for Enterprise Risks of Insurance Company

Risk		Index
Investment risk-taking	$Invest_{it}$	$= -0.110001 Cashr_{it} - 0.551337 Bondr_{it} + 0.482148 Stockr_{it} + 0.487163 Restater_{it} + 0.462745 Finvestr_{it}$
Product risk-taking	$Prod_{it}$	$= -0.599007 Life_{it} + 0.579482 Accident_{it} + 0.543558 Health_{it} + 0.099679 Annuity_{it}$
Financial soundness	$Finsnd_{it}$	$= 0.25274 Arsk_{it} - 0.113 Prsk_{it} - 0.21416 Cr_{it} - 0.2644 Cashr_{it} + 0.249 ROA_{it} + 0.28548 lnAsst_{it}$
Product fairness	$Pdfair_{it}$	$= -0.67109\ Coa_{it} - 0.67109\ Dspt_{it}$
Service quality	Uwq_{it}	$= -0.66705 Cona_{it} + 0.66705 lnExp_{it}$

IV. Empirical Results

Table 4. Pearson Correlation between Insurance Demand and Enterprise Risks

	Invest	*Prod*	*Finsnd*	*Pdfair*	*Uwq*	*Rptn*
lnNNC	**0.51267** **(<.0001)**	**-0.01510** **(0.7994)**	**0.65443** **(<.0001)**	**0.12896** **(0.0289)**	**0.63506** **(<.0001)**	**0.72403** **(<.0001)**
lnPNC	**0.39443** **(<.0001)**	**-0.63438** **(<.0001)**	**0.83346** **(<.0001)**	**0.16667** **(0.0046)**	**0.44727** **(<.0001)**	**0.53357** **(<.0001)**
P13	**0.28193** **(<.0001)**	**-0.26238** **(<.0001)**	**0.43872** **(<.0001)**	**0.32402** **(<.0001)**	**0.24066** **(<.0001)**	**0.24819** **(<.0001)**
P25	**0.21390** **(0.0004)**	**-0.21216** **(0.0005)**	**0.34387** **(<.0001)**	**0.33643** **(<.0001)**	**0.20562** **(0.0007)**	**0.18383** **(0.0026)**

Correlation coefficients are listed with p-values in the parentheses.

IV. Empirical Results

Table 5 Stepwise Regression Analysis for Insurance Demand - *lnNNC*

Step	Variable Entered	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	*Rptn*	0.5918	0.5918	183.793	397.16	<.0001
2	*Invest*	0.0732	0.6650	104.048	59.66	<.0001
3	*Prod*	0.0235	0.6885	79.7728	20.55	<.0001
4	*Finsnd*	0.0596	0.7481	15.2852	64.06	<.0001
5	*Uwq*	0.0098	0.7579	6.3001	10.97	0.0011

IV. Empirical Results

Table 5 Stepwise Regression Analysis for Insurance Demand (*lnPNC*)

Step	Variable Entered	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	*Finsnd*	0.6822	0.6822	144.727	588.10	<.0001
2	*Prod*	0.0541	0.7362	75.8482	55.95	<.0001
3	*Rptn*	0.0356	0.7718	31.2052	42.40	<.0001
4	*Invest*	0.0152	0.7870	13.2349	19.38	<.0001
5	*Uwq*	0.0051	0.7922	8.5027	6.67	0.0103
6	*Pdfair*	0.0027	0.7948	7.0000	3.50	0.0624

IV. Empirical Results

Table 5 Stepwise Regression Analysis for Insurance Demand (*P13* and *P25*)

Step	Variable Entered	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
P13						
1	*Finsnd*	0.1923	0.1923	6.8538	63.09	<.0001
2	*Uwq*	0.0088	0.2011	5.9008	2.92	0.0886
3	*Prod*	0.0144	0.2155	3.1040	4.81	0.0291
P25						
1	*Finsnd*	0.1183	0.1183	4.5267	34.87	<.0001

IV. Empirical Results

Table 6 Regression Analysis for Insurance Demand

	lnNNC	*lnPNC*	*P13*	*P25*
Intercept	11.19832 (<.0001)	14.09091 (<.0001)	92.62421 (<.0001)	88.43894 (<.0001)
Invest	0.09361 (0.1009)	-0.29534 (0.0004)	-1.63433 (0.0038)	-2.56478 (0.0033)
Prod	0.43898 (<.0001)	-0.69333 (<.0001)	-0.78295 (0.1463)	-0.81392 (0.3235)
Finsnd	0.79322 (<.0001)	1.96791 (<.0001)	6.80657 (<.0001)	8.48387 (0.0016)
Pdfair	-0.06084 (0.3420)	-0.16713 (0.0718)	0.11315 (0.8606)	0.62814 (0.5366)
Uwq	0.27560 (0.0009)	0.25740 (0.0315)	1.54605 (0.0226)	2.17254 (0.0382)
Rptn	0.10677 (<.0001)	0.06032 (<.0001)	-0.12966 (0.1376)	-0.25586 (0.0574)
FHC	-0.07070 (0.6648)	0.64825 (0.0064)	-0.69066 (0.6052)	-1.16723 (0.5743)
FI	-0.53265 (0.0012)	0.09961 (0.6731)	-5.36475 (<.0001)	-8.95753 (<.0001)
adj-R2	0.7615	0.7946	0.2468	0.1801
N	276	276	267	262

IV. Empirical Results

Table 7 Cluster Analysis for Enterprise Risks

Cluster	N	*Invest*	*Prod*	*Finsnd*	*Pdfair*	*Uwq*	*Rptn*
A (5)	51	0.9458	-0.0521	0.6653	0.3789	1.2712	26.8627
B (4)	81	0.3174	-0.1422	0.2435	0.1559	0.3076	20.3797
C (3)	96	-0.3145	-0.2136	-0.0825	-0.0640	-0.3503	11.9579
D (2)	56	-0.5487	-0.1315	-0.4742	-0.1177	-0.8666	4.15384
E (1)	10	-2.1857	5.8895	-2.9781	-2.0966	-0.8485	2.6

Pseudo F Statistic = 497.13
Approximate Expected Over-All R-Squared = 0.87124
Cubic Clustering Criterion = 0.209

IV. Empirical Results

Table 8 Regression Analysis for Insurance Demand based on Risk Rating Score

	lnNNC	*lnPNC*	*P13*	*P25*
Intercept	9.11268 (<.0001)	10.46403 (<.0001)	83.76935 (<.0001)	80.58881 (<.0001)
RS	1.15598 (<.0001)	1.45513 (<.0001)	2.19035 (0.0010)	1.24950 (0.1188)
FHC	-0.05937 (0.8090)	0.82480 (0.0605)	0.28106 (0.8786)	0.66089 (0.7680)
FI	-1.17500 (<.0001)	-1.04519 (0.0023)	-6.29264 (<.0001)	-8.11063 (<.0001)
adj-R2	0.5362	0.3659	0.1425	0.1132
N	293	293	277	271

V. Conclusion

- All of the four measurements of insurance demand are significantly related to the six enterprise risks as predicted.
- Insurance demand also significantly responds to the risk rating score calculated by this paper.
- The empirical result of this study suggests the existence of market discipline in life insurance in Taiwan.

The Sensitivity of Reinsurance Demand to Counterparty Risks: Evidence from US Property-Liability Insurance Industry

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Functions of Reinsurance

- Risk management

- US SAP allows ceding insurers to take credit from (authorized) reinsurance transactions mainly through,
  - Reduction in loss reserves, unearned premium reserves and contingent commissions
  - Improve financial statements, provide **surplus relief**, increases the underwriting capacity of ceding insurers.

- And more good things

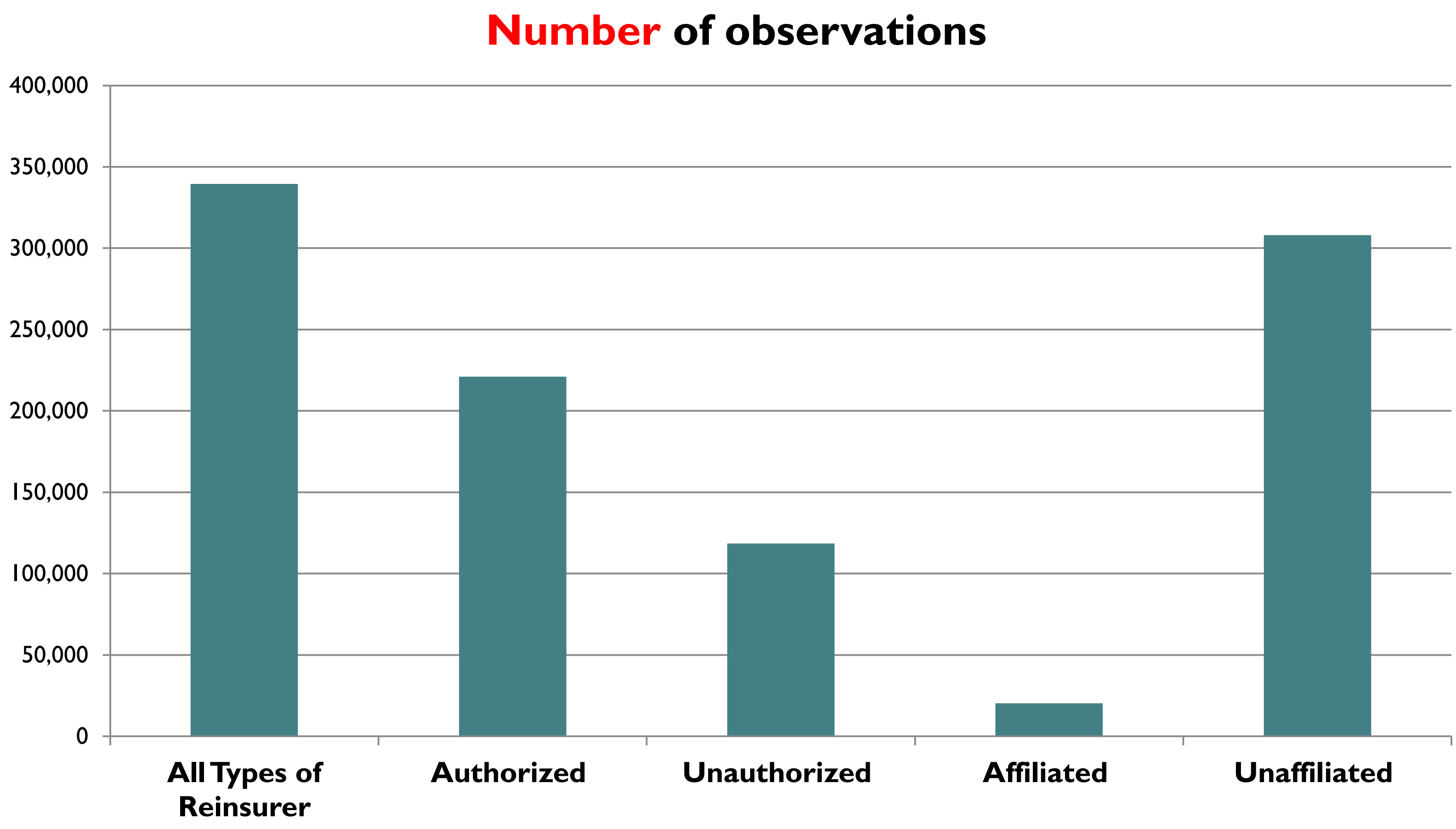
Insurance, Reinsurance and Credit Risk

- What happens if reinsurer becomes insolvent?

- Ways to deal with it
  - Market discipline: Market will do
    - Primary insurers consider creditworthiness (e.g. rating) of the reinsurer counterparties
      - Monitor accumulated risk exposures to any single contracted reinsurer
      - Contractual terms
        - Special termination clause (requires additional collateral)
    - If "surplus relief" is all that matters…

  - Regulation
    - Solvency regulation of insurers/reinsurers
      - For authorized reinsurance, regulation does not consider credit risk of insurers.
      - Require "100% collateral" from unauthorized (alien) reinsurers
        - Unauthorized reinsurance: reinsurers that are neither licensed nor accredited in the ceding insurer's state of domicile

Observations: Ceding Insurer-Reinsurers-Year



NAIC REINSURANCE COLLATERAL REFORM in Nov. 2011

- Rationale for the regulation: lack of market discipline

- Effort on the reduction of collateral
  - For "certified reinsurers" allow collateral requirement reduction

- Model law passed in 2011, a few states amended (e.g. Florida, New York, New Jersey, and Indiana) in 2012, now 23 states adopted. (as of 2015/2)

Research Questions

- Main question:
  - Does the market discipline reinsurers in the insurance-reinsurance market?
- Empirically,
  - How sensitive the reinsurance demand is to the credit risk change of reinsurers?
  - Does the demand sensitivity change with the types of reinsurance?
    - E.g. authorized vs. unauthorized

Hypotheses 1-1

- Reinsurance demand of ceding insurers is sensitive to the credit risk of reinsurers.
  - In particular, reinsurance demand from a counterparty reinsurer will decrease if the counterparty reinsurer suffers a rating downgrade.
  - The demand sensitivity stated in H1-1 may or may not apply to the cases of reinsurer rating upgrades.
    - Epermanis and Harrington(2006) finds very weak effect for upgrades
    - Halek and Eckles(2010): the title is "effect of analysts' ratings on insurer stock returns: evidence of asymmetric responses"
      - Other finance studies find similar results (e.g. Holthausen and Leftwich (1986))
    - The impact of reinsurer rating upgrades on reinsurance demand may depend on the ceding insurer's balance between a reduced credit risk and increased reinsurance price.

Hypotheses 2

- Reinsurance demand sensitivity is heterogeneous depending on the type of reinsurance transaction.
  - In particular, the reinsurance demand of **unauthorized reinsurance** is less sensitive to the change of the counterparty reinsurers than the demand of **authorized reinsurance**.

Hypotheses 3

Judgment proof hypothesis

- Ceding insurers with high leverage tend to contract with weak reinsurers, and are less sensitive to the downgrading of counterparty reinsurers because such insurers have fewer assets to protect, and tend to buy reinsurance mainly for surplus relief to meet the minimum regulatory requirements

Hypotheses 4

- Contract sustainability hypotheses
  - Reinsurance demand sensitivity is lower for downgraded/upgraded reinsurers that have maintained a long-term relationship with the ceding insurer.

Data and Sample

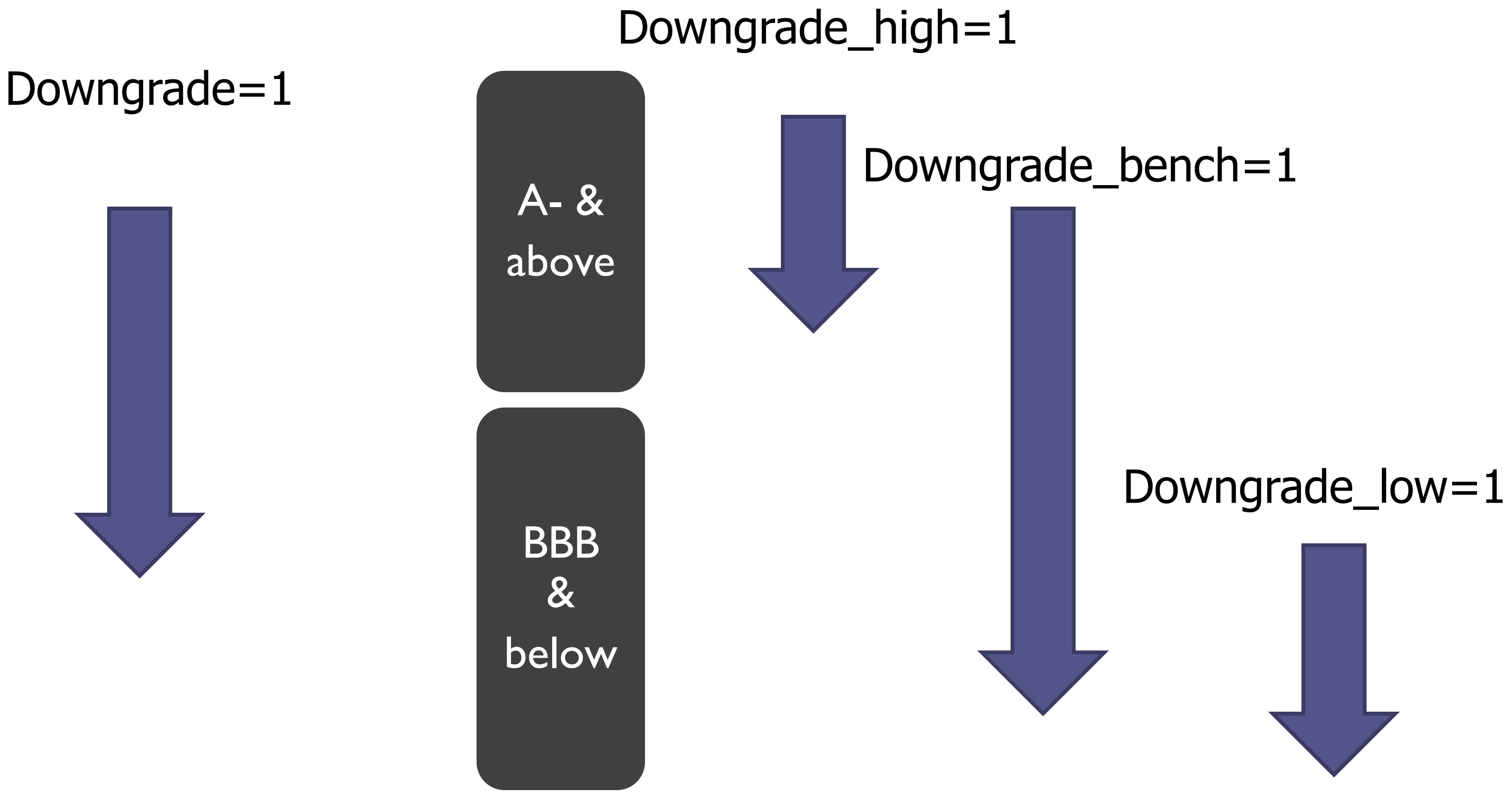
- US P/C insurance industry
- Sample period: 2002 – 2009
- Financial data of ceding insurers
  - NAIC,
- counterparty reinsurers' information
  - Schedule F-part 3
- Rating information
  - S&P, Moody's and A. M. Best
- Manually merge the rating data and NAIC data by matching reinsurer's name and domicile, and NAIC code if available
- Exclude reinsurer specialists

Methodology –

1. Calculation of reinsurance demand change
    - Reinsurance demand change from *t-1* to *t* in (ceded premiums to reinsurer *j* / total premiums ceded of insurer *i*)
2. Regression Analysis

$$\Delta R\_demand_{i,j,t} = \alpha_t + \gamma_1 Downgrade_{i,j,t} + \gamma_2 Upgrade_{i,j,t} + \theta X_{i,t} + \varepsilon_{i,t}$$

Key Independent Variables (same for upgrade)



Regression Results
- Hypothesis 1-1 and H1-2

Variable	Model 1	Model 2	Variable	Model 3	Model 4
Downgrade	-0.40***	-0.15***	Downgrade _bench	-0.54***	-0.43***
Upgrade	-0.12***	-0.03***	Downgrade _high	-0.25***	-0.06***
			Downgrade _low	-0.78***	-0.57***
			Upgrade _bench	0.66***	0.61***
			Upgrade_high	-0.18***	-0.10***
			Upgrade_low	0.16	0.31***
			Lag_high	0.04***	0.11***
			Lag_low	-0.54***	-0.47
			Ln_Numrein		-0.03**
			Rein_rec		-12.5***
controls	No	Yes		No	Yes

Regression Results
- Hypothesis 2 (Authorized vs. Unauthorized)

Variable	Author	Unauthor	P-Chow	Variable	Author	Unauthor	P-Chow
Downgrade	-0.17***	-0.10***	0.2646	Downgrade_bench	-0.50***	-0.18***	0.01
Upgrade	-0.06*	0.0171	0.1114	Downgrade_high	-0.05***	-0.07***	0.37
				Downgrade_low	-0.68***	-0.28***	0.01
				Upgrade_bench	0.74***	-0.01	0.00
				Upgrade_high	-0.18***	0.01	0.00
				Upgrade_low	0.27**	0.30**	0.75

Regression Results
- Hypothesis 3 (Judgment Proof)

Variable	High Lev	Low Lev	P-Chow	Variable	High Lev	Low Lev	P-Chow
Downgrade	-0.05**	-0.16***	0.33	Downgrade_bench	-0.03***	-0.45***	0.05
Upgrade	-0.13**	-0.02***	0.11	Downgrade_high	-0.01	-0.06***	0.89
				Downgrade_low	-0.28***	-0.61***	0.17
				Upgrade_bench	-0.03	0.67***	0.01
				Upgrade_high	-0.14**	-0.10***	0.43
				Upgrade_low	-0.20	0.36***	0.10

Regression Results
- Hypothesis 4 (Sustainability)

Variable	Long	Short	P-Chow	Variable	Long	Short	P-Chow
Downgrade	-0.24***	-0.38***	0.04	Downgrade_bench	-0.38***	-0.57	0.75
Upgrade	-0.16***	-0.16***	0.91	Downgrade_high	-0.18***	-0.33***	0.04
				Downgrade_low	-1.10***	-0.73***	0.35
				Upgrade_bench	0.29***	0.77***	0.03
				Upgrade_high	-0.20***	-0.22***	0.76
				Upgrade_low	0.62***	0.28	0.40

Conclusion

- Reinsurance demand **IS sensitive** to the counterparty risk.
  - Demand is reduced when a reinsurer is downgraded
    - the reduction was most severe when already weak reinsurer becomes weaker.
  - Demand change varies when a reinsurer is upgraded
    - When a weak reinsurer gets upgraded, the demand increases
    - However, an already strong reinsurer with A- or above financial strengt h upgraded, ceding firms did not appreciate this credit enhancement a nd reduced the reinsurance from this better credit quality reinsurer, pos sibly due to higher price

- Authorized reinsurance transactions are more sensitive to the rating change

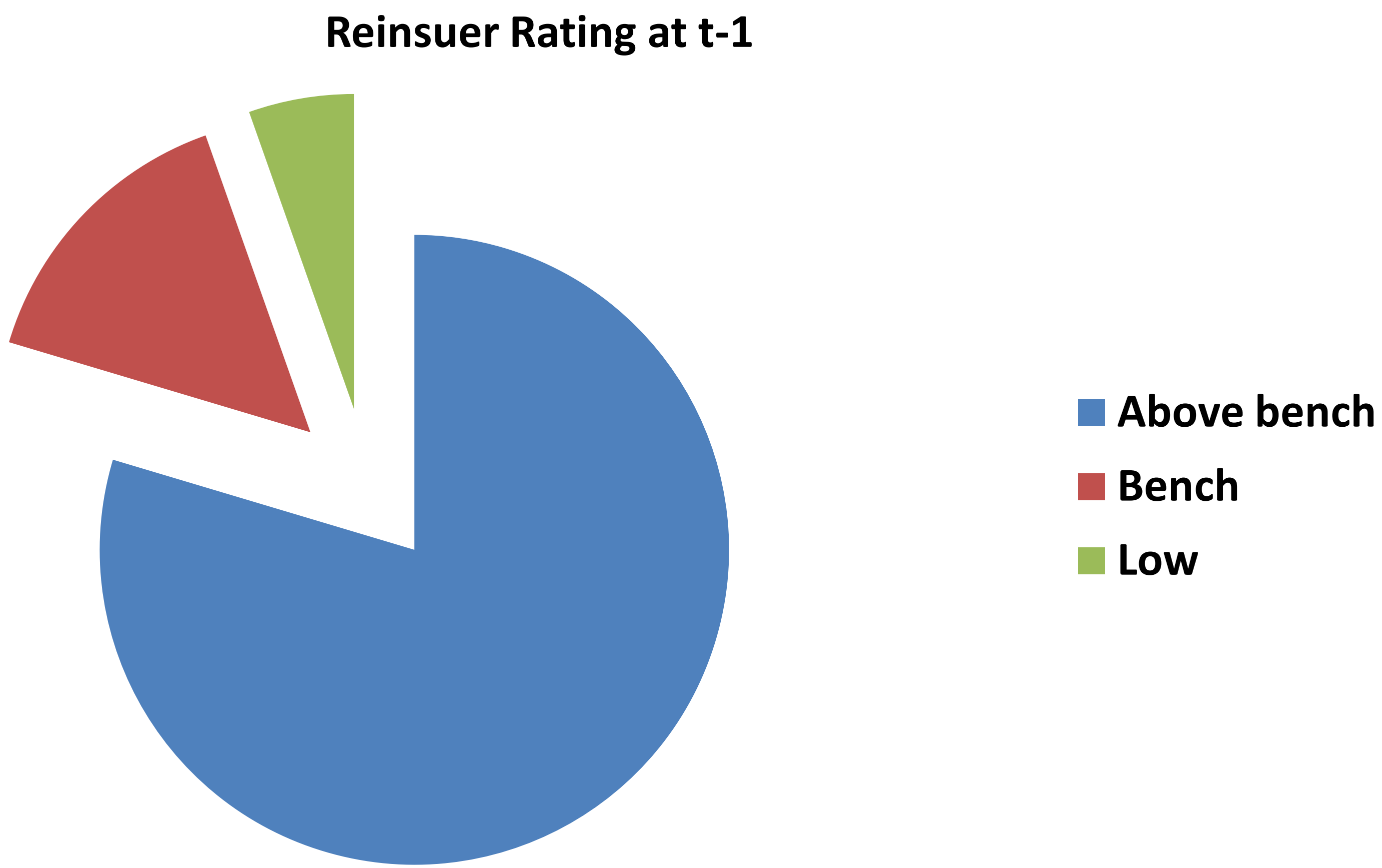
Conclusion (cont'd I)

- The sensitivity of ceding firms with high leverage is statistically lower, provide some support for judgment proof hypothesis

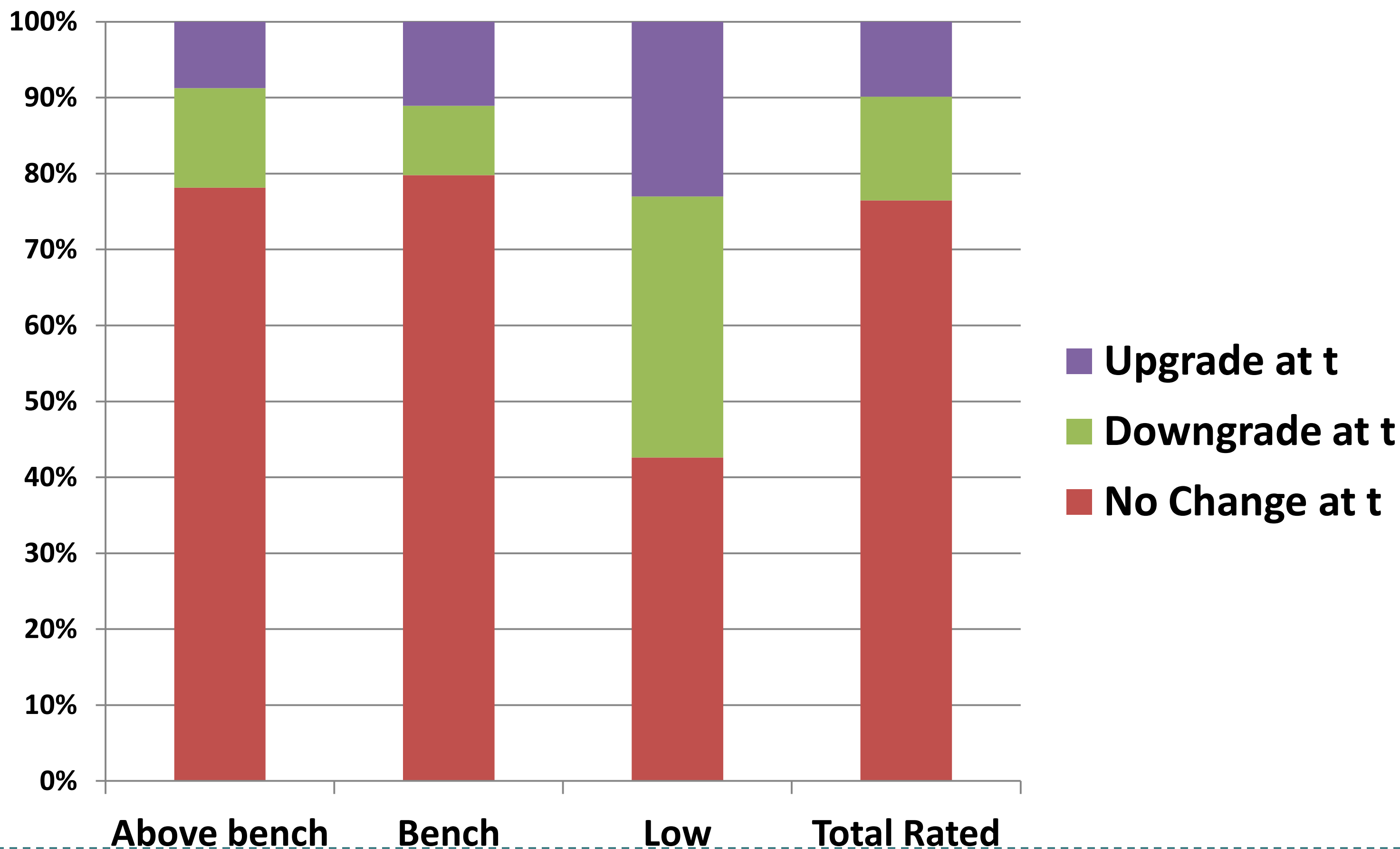
- Ceding firms which tend to maintain long-term relationship with reinsurers were less sensitive to the non-critical rating change

Thank you!

Sample Distribution by Reinsurer Rating at t-1



Reinsurer Rating Changes at *t*, by Rating at *t-1*



Methodology – Univariate Analyses

Calculation of Abnormal reinsurance demand change

- Reinsurance demand change from *t-1* to *t* in (ceded premiums to reinsurer *j* / total premiums ceded of insurer *i*)
- calculate the mean change in reinsurance demand for reinsurers experiencing no rating changes, separately for reinsurers with "above bench" rating, "bench" rating, and "low" rating
- For reinsurers with rating changes, deduct from their change in reinsurance demand the mean change of no-rating-change reinsurers in the same rating category

Methodology – Regression

- Model

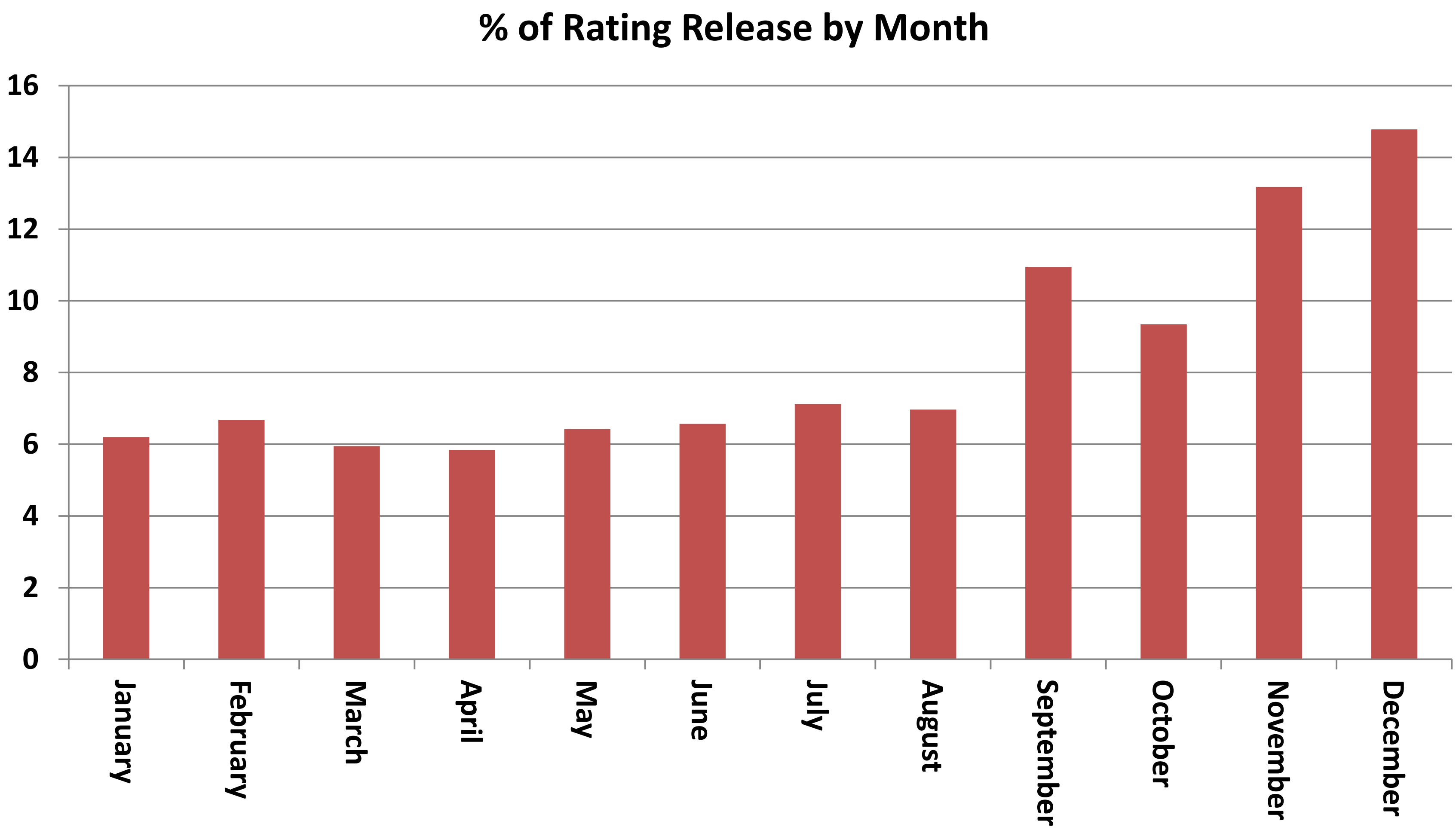
$$\Delta R\_demand_{i,j,t} = \alpha_t + \gamma_1 Downgrade_{i,j,t} + \gamma_2 Upgrade_{i,j,t} + \theta X_{i,t} + \varepsilon_{i,t}$$

- $\Delta R\_demand_{i,j,t}$ is a reinsurance demand change of insurer *i* from reinsurer *j* from year *t-1* to year *t*.
- $Downgrade_{i,j,t}$ and $Upgrade_{i,j,t}$ are indicator variables equal to one if a reinsurer *j* is downgraded or upgraded in year *t* or *t-1*, respectively.

Key Independent Variables

Variable	Description
Downgrade	=1 if a reinsurer is downgraded in year *t* or *t-1*
Downgrade_ bench	=1 if a reinsurer is downgraded from "above bench" or "bench" rating to below benchmark rating
Downgrade_ high	=1 if an "above bench" rating reinsurer is downgraded but still mai ntains an "above bench" or "bench" rating
Downgrade_ low	=1 if a "low" rating reinsurer is downgraded to lower rating
Upgrade	=1 if a reinsurer is upgraded in year *t* or t-*1*
Upgrade_ bench	=1 if a reinsurer is upgraded from "low" rating to "bench" or "abo ve bench" rating
Upgrade_high	=1 if a "high" rating ("above bench" or "bench") reinsurer is upgra ded
Upgrade_low	=1 if a "low" rating reinsurer is upgraded but still maintains a "lo w" rating

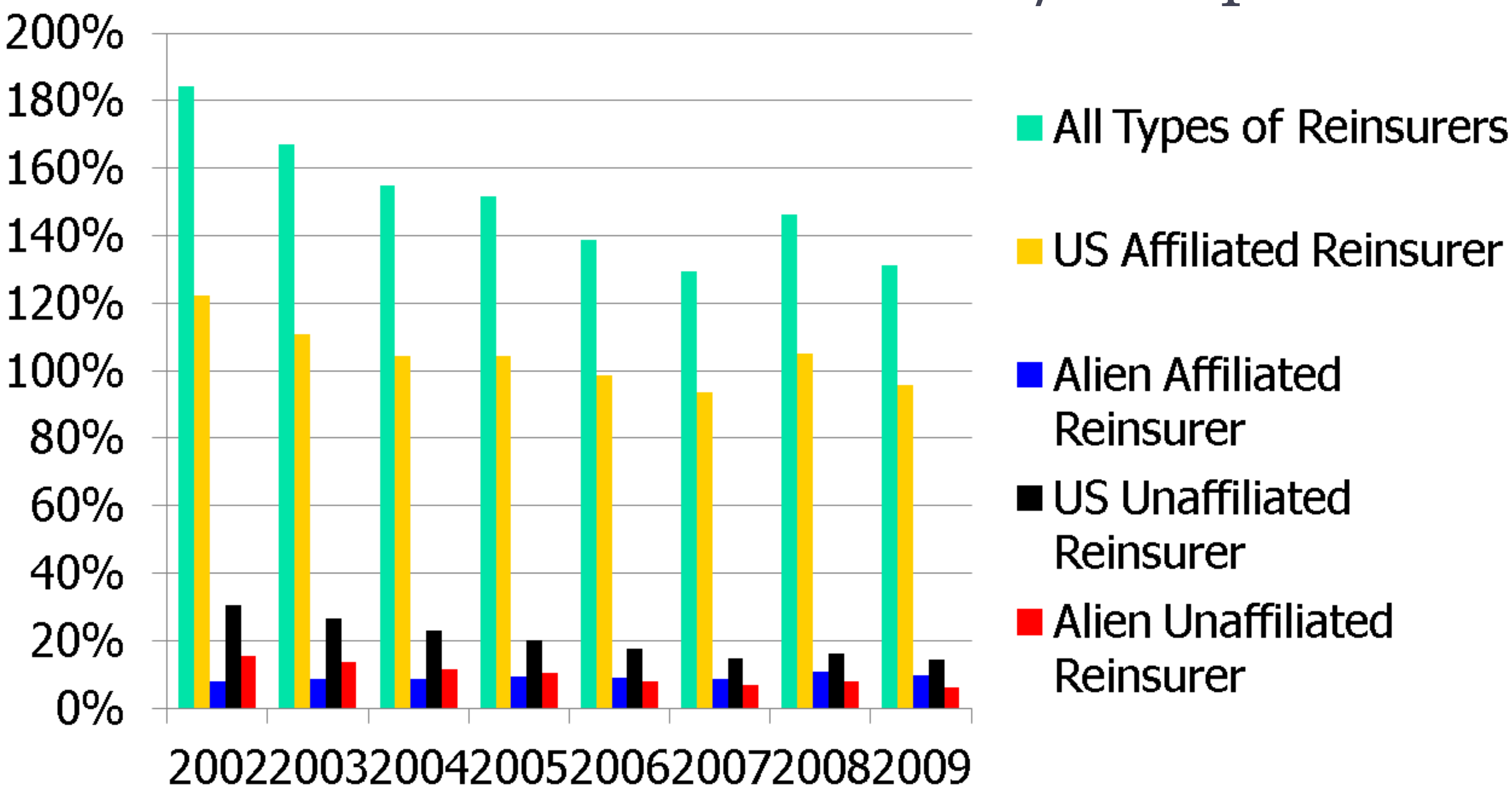
Reinsurer Rating Release by Months



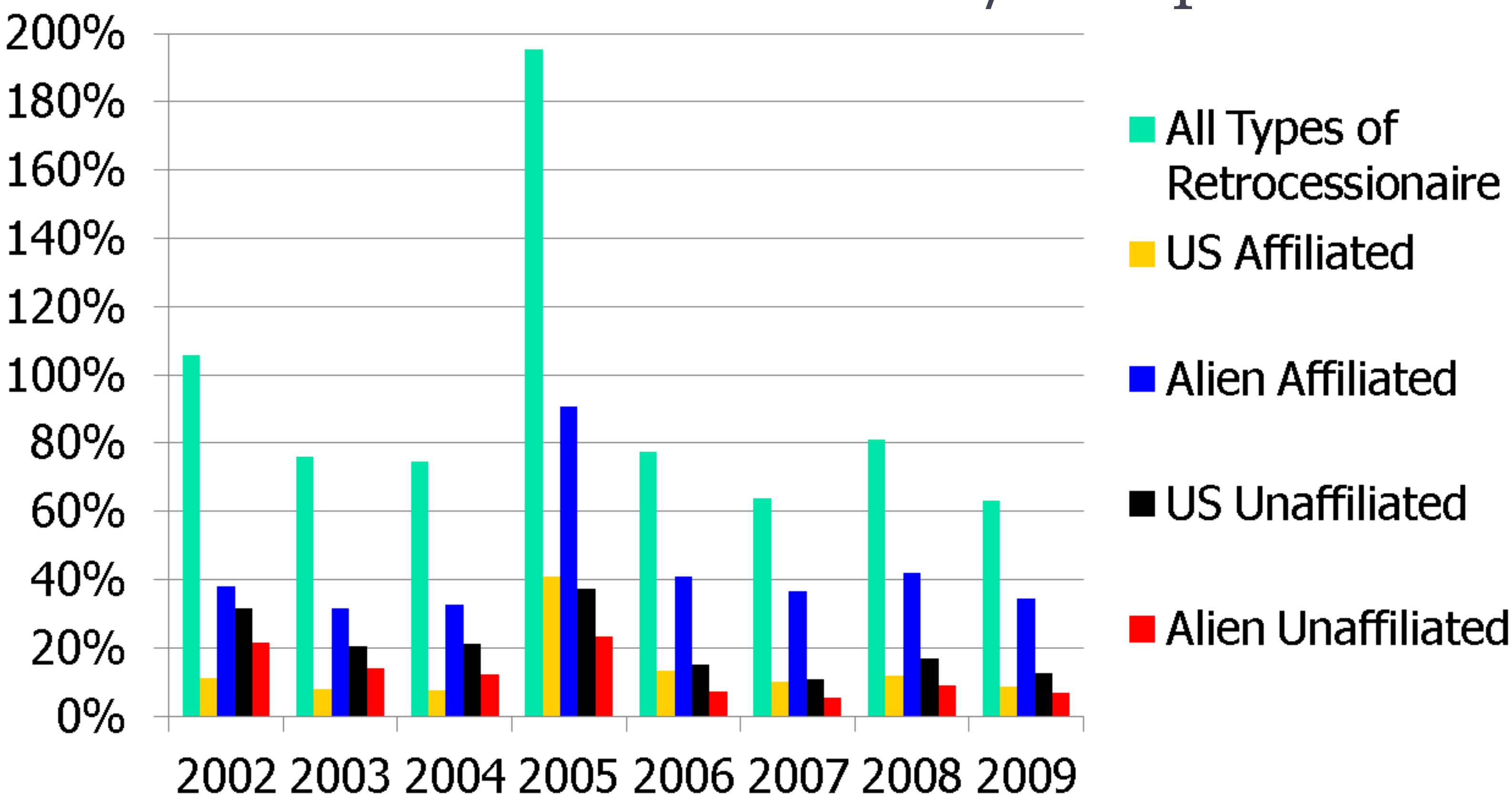
Global Reinsurer Rankings Based on Reinsurance (Total Unaffiliated Ceded Premiums) in US P/C Industry in 2009

Rank	Group Name	Domicile	Number of Transactions Recorded in Schedule F	Total Ceded Premiums (USD in 1000)	Total Net Recoverable (USD in 1000)
1	Lloyd's of London	U.K.	16960	4,105,209	4,303,533
2	Munich Re	Germany	1527	3,762,105	9,922,410
3	Swiss Re Group	Switzerland	1925	3,434,978	12,936,672
4	Berkshire Hathaway Group	US	1494	2,656,058	8,446,737
5	Transatlantic Hldgs Inc Group	US	696	1,689,502	4,571,281
6	Hannover Re	Germany	1697	1,590,996	3,950,339
7	Allianz	Germany	1085	1,468,878	670,635
8	Partner Re Group	Bermuda	893	1,343,674	2,451,282
9	ACE	Bermuda	1075	1,329,199	2,893,521
10	Everest Re Group	Bermuda	595	1,180,661	3,492,747

Dependency of Primary Insurers on Reinsurers – Total Rein Recoverable / Surplus

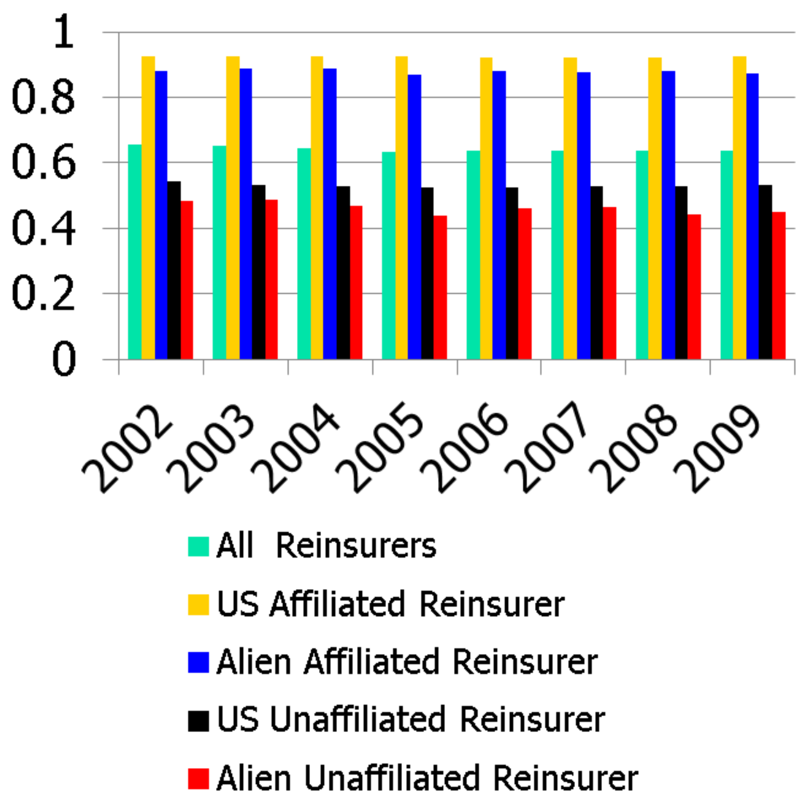


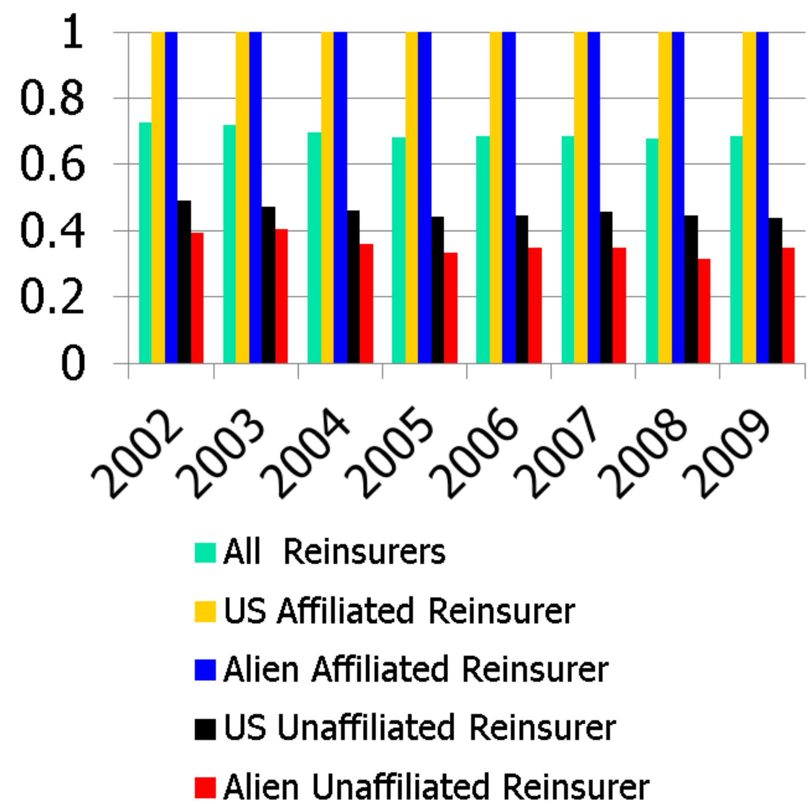
Dependence of US Professional Reinsurers on Retrocessionaires – Total Rein Recoverable / Surplus



Diversification of Reinsurance Portfolios

- Herfindahl Index (By Net Reinsurance Recoverable)



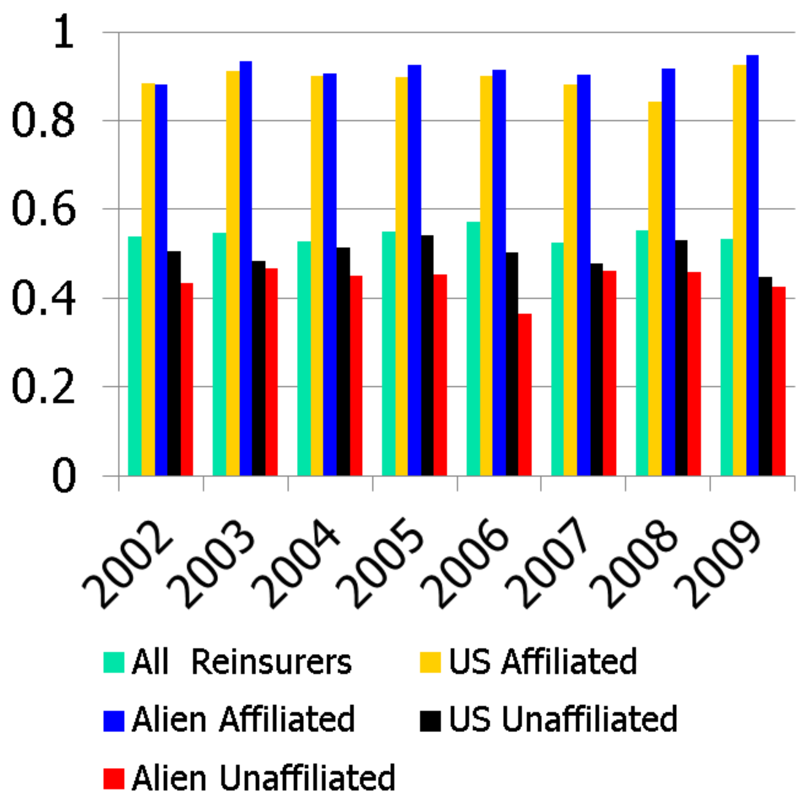


Mean

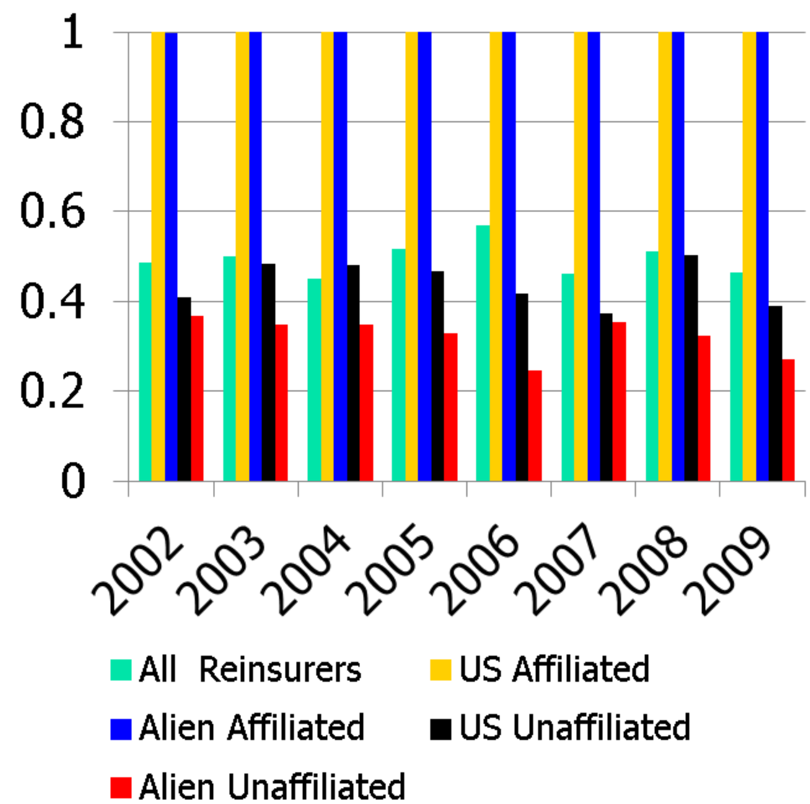
Median

Diversification of Retrocession Portfolios

- Herfindahl Index (By Net Reinsurance Recoverable)



Mean



Median

Summary Stat of Dependent and Independent Variables (1)

Variable Name	N	Mean
ΔR_demand $_{i,j,t}$	339516	0.010
Downgrade	339516	0.105
Downgrade_bench	339516	0.010
Downgrade_high	339516	0.081
Downgrade_low	339516	0.014
Upgrade	339516	0.081
Upgrade_bench	339516	0.006
Upgrade_high	339516	0.070
Upgrade_low	339516	0.004
Lag_high	339516	0.440
Lag_low	339516	0.025
Authorized	339516	0.651
Unauthorized	339516	0.349
Affiliated	339516	0.059
Unaffiliated	339516	0.907

Summary Stat of Dependent and Independent Variables (2)

Variable Name	N	Mean	STD	Min	Max
Size	339516	13.127	2.187	8.307	17.359
Leverage	338443	2.042	1.523	0.000	12.887
Capitalization	339516	0.904	0.593	0	2.486
CAT risk	339516	0.063	0.177	0	0.994
Long_tail	338639	0.710	0.264	0	1
Geo _Herf	332518	0.344	0.358	0.034	1
LOB_Herf	338793	0.405	0.273	0.111	1
STD_CF	338254	0.076	0.108	0.002	0.784
Pre_Best rating	312931	10.895	1.500	0	13
Pre_ROA	337817	2.533	4.432	-15	16
Ln_Numrein	339516	4.542	1.623	0	7.499
Rein_rec (t-1)	336989	0.038	0.155	0	1
Contract sustainability	146425	1.117	0.245	0.618	5

The Sensitivity of Reinsurance Demand to Counterparty Risks:

Evidence from US Property-Liability Insurance Industry

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The Sensitivity of Reinsurance Demand to Counterparty Risks:
Evidence from US Property-Liability Insurance Industry

Abstract

This article investigates market discipline in the reinsurance market by examining the sensitivity of reinsurance demand to reinsurer counterparty risks for a sample of US property-liability insurance companies. Using the financial strength rating of reinsurers as a proxy for reinsurance counterparty risk, we find evidence of market discipline that reinsurance demand is sensitive to counterparty risk. Specifically, reinsurance demand reacts negatively to reinsurer rating downgrade, with the reduction being the largest when a "weak" reinsurer gets "weaker," followed by a reinsurer being downgraded below a benchmark rating. The sensitivity is higher for authorized reinsurance than for unauthorized reinsurance. Reinsurance demand sensitivity to counterparty risk is found to be lower for ceding insurers with higher leverage. Ceding insurers with high reinsurer sustainability are less sensitive to the non-critical rating downgrade of reinsurers. In addition, reinsurance demand is found to be less sensitive to reinsurer upgrading than to reinsurer downgrading.

JEL classification: G22; G32

Keywords: counterparty risk, reinsurance demand, financial strength rating, market discipline, property-liability insurance

The Sensitivity of Reinsurance Demand to Counterparty Risks:
Evidence from US Property-Liability Insurance Industry

1. Introduction

Reinsurance plays an important economic role in risk management. With the capacity of diversifying risks nationwide and globally, reinsurance is an important tool for primary insurance companies to manage underwriting risks, alleviate insolvency risks, satisfy stringent regulatory requirements, and deal with uncertainties caused by regulation changes or catastrophic losses. In addition, primary insurance companies can improve their balance sheet items by using reinsurance. By transferring or ceding risks to reinsurers, a ceding insurer may take a credit (e.g., reducing loss reserves and unearned premium reserves) in its financial statements, which provides surplus relief and increases the underwriting capacity of ceding insurers. The use of reinsurance, however, creates a new type of risk for ceding insurers: reinsurer counterparty risk.

Until recently, a ceding reinsurer is allowed to take credit for reinsurance only when its counterparty reinsurer is authorized[1] or if unauthorized, posting full collateral for the reinsurance transaction. One important rationale for this collateral requirement is the reinsurer counterparty risk. The full collateral requirement, however, in some sense, disregards the ceding insurers' ability of managing reinsurance credit risk and offers little incentive for primary insurers to distinguish between reinsurers with stronger financial strength and those with weaker financial strength. This requirement is therefore considered to be excessive and may distort the reinsurance market.

In order to solve this problem, regulatory changes have recently occurred on reinsurance collateral requirements. NAIC (National Association of Insurance Commissioners) proposed a Reinsurance Regulatory Modernization Framework Proposal in

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[1] Reinsurers that register in a state, under state regulatory supervision, and satisfy certain conditions are classified as authorized reinsurers.

2008. The federal government also enacted a reform act. On July 21, 2010, the Nonadmitted and Reinsurance Reform Act was passed in Congress and became effective on July 21, 2011. Many states started to adopt the new reinsurance modernization framework and relax the collateral requirement for unauthorized reinsurance transactions.[2] With the changes in regulatory environment, it is important to understand the behavior of ceding insurers in reinsurance market. In this paper, we examine whether the ceding insurers are able to control counterparty reinsurance risk by testing the reinsurance demand sensitivity to the reinsurer credit risk change, and also investigate whether the collateral requirement indeed distorted the demand sensitivity for unauthorized reinsurance transactions.

Traditionally, research on reinsurance has focused on dealing with asymmetric information in the insurer-reinsurer relationship (e.g., Doherty and Smetters, 2005 and Garven, Hilliard, and Grace, 2014) and on exploring the optimal design for reinsurance contracts (e.g., Cai et al., 2013 and Tan and Weng, 2012). More recently, there has been more empirical research on the factors determining the demand for reinsurance by ceding insurers (e.g., Cole and McCullough, 2006 and Lin, Yu, and Peterson, 2014). Additionally, the most recent financial crisis of 2007-2010 has put the reinsurance industry into the public eye for its close interconnectedness with the primary insurance industry and for the possibility of creating systemic risks for the economy. Therefore, reinsurer risk and financial solvency has become an important concern for regulators, ceding insurers, and researchers. Ceding insurers may take "credit" from their reinsurance transactions, but for regulators, that credit for reinsurance only makes sense when reinsurers are able to fulfill their obligations. Also, it is argued that even in the absence of regulations, ceding insurers should still have concerns

[2] For example, in New York, from January 1, 2011, Regulation 20 (11 NYCRR 12) provided a way for ceding insurers to receive credit for unauthorized reinsurance transactions with less than 100% of collateral. Depending on the financial strength of reinsurers and various factors such as business practices and other relevant information, the Superintendent can decide the collateral amount required, which can even be zero. In New York, Hannover Re became the first reinsurer to qualify to post 20% loss reserves instead of 100%.

regarding reinsurance credit quality. Poor reinsurance contracting may adversely affect the solvency ability of ceding insurers and lower their financial strength ratings (Park and Xie, 2014), which may ultimately lower the revenue of ceding insurers, as insurance buyers may opt to "pay for quality" (Cummins and Danzon, 1997).

Despite the credit risk imposed by reinsurance, little empirical research has been done to examine how credit risk from reinsurers may actually affect ceding insurers' behaviors. Park and Xie (2014) analyze the impact of credit risk from reinsurers on ceding insurers' financial strength and stock performance and find both that ceding insurers are more likely to be downgraded when their contracting reinsurers are downgraded and that ceding insurers' stocks also react negatively to their reinsurers' downgrades. The paper suggests that counterparty risk from reinsurers is important to ceding insurers and should be carefully managed.

The objective of this paper is to examine the relationship between reinsurance demand and the credit risk change of reinsurers by using the US property-liability insurance industry as an experiment. In particular, we investigate the sensitivity of reinsurance demand to the downgrading of reinsurers and likelihood that ceding insurers will revise a contract relationship with a reinsurance partner whose financial strength changes. We hypothesize that, if market discipline exists, a ceding insurer will recognize the impact of reinsurers' credit risk change and adjust its contracts accordingly when a reinsurer's rating changes. In particular, ceding insurers would adjust trading terms with the downgraded counterparty reinsurers through changes in both price and quantity of reinsurance purchased, or, in extreme cases, terminate the relationship with the downgraded reinsurers. If this is the case, direct regulation on reinsurance may not be needed. On the other hand, if ceding insurers fail to adjust their reinsurance position in accordance with reinsurers' credit risks, it may suggest that such insurers simply use reinsurance for surplus relief and have neglected credit quality. Solvency risk to ceding insurers may therefore increase when the reinsurer downgrades, and such risk has to be taken seriously by the insurers, market, and regulators.

This paper contributes to the literature in several ways. First, it enriches the existing literature on counterparty risk in the financial services industries (Jarrow and Yu, 2001 and Jorion and Zhang, 2009) by extending the research into the insurance-reinsurance market. With the collapse of the subprime mortgage market in 2007, counterparty risk has received increasing attention from the financial services industry and regulators and has become a crucial issue in risk management. Managing counterparty risk is an important theme of the Dodd-Frank Act of 2010 and is also an important concern of rating agencies (Moody's Investors Services, 2015).

Second, the paper intends to provide implication of counterparty risk regulation in the insurance/reinsurance market. With the turmoil brought by the meltdown of insurance giant AIG and the financial difficulties experienced by some life insurers and global reinsurers during the crisis, counterparty risk in the insurance/reinsurance market has become an important issue in insurance regulation as well. Discussion continues as to how much regulation is needed in order to supervise reinsurance contracts/transactions and whether market discipline can serve as a substitute for regulation (Gatumel and Lemoyne De Forges, 2013). Our paper will provide further evidence for the effectiveness of market discipline.

Third, the reinsurance market in the United States provides a great opportunity to test the question of customer-driven market discipline. Epermanis and Harrington (2006) examine market discipline in the primary insurance market by looking at policyholders' insurance demand changes following insurance companies' financial strength rating changes. One difficulty experienced by that research is that state guaranty funds will compensate part (or all) of policyholders' losses in case of insurers' insolvency, which may distort the incentive of policyholders to look for healthy insurers. Such contamination does not exist in the reinsurance market, as guaranty funds do not protect insurance companies. Therefore, the paper can provide a "cleaner" testing result of market discipline without the contamination of the guaranty fund.

The remainder of the article is structured as follows. The next section presents the literature review and hypotheses tested, followed by the discussion of the data and methodology. We then report empirical results and conclude the paper.

2. Literature Review and Hypotheses

Insurance, Reinsurance Credit Risk, and Market Discipline

Ceding insurers transfer part of their underwriting risks to reinsurers to obtain surplus relief, hedge the risk of catastrophic losses, and stabilize underwriting performance. This act of risk management, however, gives rise to another type of risk: reinsurance credit risk; that is, ceding insurers may not be able to recover losses from their counterparty reinsurers. As a general practice, ceding insurers manage credit risk by taking into consideration the creditworthiness of the reinsurer counterparties and by monitoring their own accumulated risk exposures to any single contracted reinsurer (Bodoff, 2013). To assess the credit risk of reinsurers, most ceding insurance companies rely on rating agency models. In addition, in the US, it is a common practice for ceding insurers to require "collateral" from unauthorized (alien) reinsurers. Also, reinsurance contracts often contain a "special termination clause," which states that if the counterparty reinsurer's financial strength rating deteriorates below some crucial threshold, then the ceding company has the right to require the reinsurer to post collateral for unpaid reinsured claims.

The US statutory accounting principle (SAP) allows ceding insurers to take credit from reinsurance tractions by deducting from their loss reserves the losses ceded to authorized reinsurers.[3] However, current regulation provides little incentive for ceding insurers to manage reinsurance credit risk. As argued by Bodoff (2013), the balance sheet of ceding insurers has an item titled "provision for reinsurance," which is connected to Schedule F and reduces the surplus of ceding insurers, but this penalty does not reflect the varying credit risk of reinsurers and therefore offers no incentive for the ceding insurers to distinguish between reinsurers of stronger or weaker financial strength. With such loose regulation on reinsurance credit risk, it is important to determine whether or not the private market offers adequate discipline for ceding insurers to manage counterparty risk.

Literature on market discipline in insurance is somewhat limited. Harrington (2004) provides some general discussion of market discipline in the insurance and reinsurance market. Eling (2012) provides a literature review on market discipline in the banking and insurance industries. Empirical work on market discipline in insurance falls into two categories: customer-driven market discipline and investor-driven market discipline.

Studies on customer-driven market discipline examine the impact of an insurer's financial strength rating change on policyholders' demand for insurance, usually measured by premium growth or lapse of policies. Epermanis and Harrington (2006) analyze the relationship between insurance premium growth and changes in financial strength ratings for US property/casualty insurers and find significant premium declines in the year of and the year following rating downgrades, with insurers losing an A- rating suffering the most. Premium declines were generally greater for firms with relatively low pre-downgrade ratings (A.M. Best's rating of either A- or B++ and below) and were also concentrated among commercial insurance, where little state fund guarantee is provided. They conclude that premiums surrounding rating changes are consistent with risk-sensitive demand. Similarly,

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[3] The Nonadmitted and Reinsurance Reform Act of 2010 released the collateral requirement for unauthorized reinsurers. Financially stronger (unauthorized) reinsurers are no longer required to post 100 percent collateral.

Baranoff and Sager (2007) and Grace et al. (2015) also examine the issue in the US life insurance market, while Eling and Schmit (2012) look at the issue in the German insurance market.

Studies on investor-driven market discipline mainly focus on the impact of rating changes on insurance companies' stock prices, such as Singh and Power (1992) and Halek and Eckles (2010).

Research examining market discipline in the reinsurance market specifically and the impact of the creditworthiness of reinsurers is scarce. Park and Xie (2014) is the only paper providing empirical evidence on how a reinsurer's financial rating downgrade affects a ceding insurer's rating and stock prices. That paper finds that both financial ratings and stock prices of ceding insurers react negatively to the downgrading of counterparty reinsurers. However, the paper does not look into how ceding insurers change their reinsurance demand in regard to the downgraded counterparty reinsurers.

Determinants of Reinsurance Demand

Existing literature in general examines reinsurance demand at the firm aggregate level. Garven and Lamm-Tennant (2003) summarize the literature on theoretical motivations for and analytic approaches of studying the demand for reinsurance. The paper documents that some traditional literature focuses on the risk management aspect of the reinsurance decision (e.g., Borch, 1962 and Blazenko, 1986), and others analyze the issue from a capital structure perspective (Doherty and Tiniç, 1981; Mayers and Smith, 1981; and Garven, 1987). Mayers and Smith (1990) and Garven and Lamm-Tennant (2003) provide empirical analyses on the factors that may affect an insurer's total reinsurance demand, using a sample of US property-liability insurers. Mayers and Smith (1990) find that ownership structure (in a more refined way) matters for reinsurance demand, and firm size, line-of-business concentration, and geographic concentration all have a significant (negative) impact on the demand for reinsurance. Garven and Lamm-Tennant (2003) additionally find that leverage, asset volatilities, equity risk (cash flow volatilities), and length of tail have a significantly positive impact on the demand for reinsurance.

Recent literature on reinsurance demand considers more subtle relationships between ceding insurers and reinsurers. For example, Cole and McCullough (2006) examine whether the state of the reinsurance industry affects the demand for reinsurance by exploring the overall demand for reinsurance and the utilization of foreign reinsurance by US insurers. Bernard and Ludkovski (2012) design a static model to examine the counterparty default risk on optimal reinsurance contracts. They argue that reinsurance becomes unreliable in the presence of counterparty risk and find that this risk both increases the reinsurance demand in the tail and decreases the overall optimal reinsurance premium level. Garven, Hilliard, and Grace (2014) specifically examine the tenure of the insurer-reinsurer relationship and its impact on reducing information asymmetry in reinsurance transactions. The paper provides empirical evidence that the amount of reinsurance, the ceding insurer’s profitability, and the credit quality all increase with the tenure of the insurer-reinsurer relationship. Lin, Yu, and Peterson (2014) further enrich the literature on reinsurance demand by testing the impact of contracted numbers of reinsurers (network centrality) and the business linkage among the set of reinsurers used (network cohesion) on the reinsurance level.

Despite the fact that the insurer-reinsurer relationship and the counterparty risk imposed by reinsurers have both received more attention following the recent financial crisis, there is no direct empirical work testing how ceding insurers’ reinsurance strategy changes with the credit quality change of reinsurers, and this paper intends to fill that gap.

Hypotheses:

Reinsurance transactions are less regulated in the US insurance industry. The existing regulations focus on rules affecting the financial statements of the ceding insurers, i.e., whether the ceding insurers can take any credit to reduce their liabilities from reinsurance transactions. However, these regulations give little consideration to the credit risk imposed by reinsurers and basically rely on the market mechanism to control counterparty risk in the reinsurance market.

Theoretically, in a competitive market, ceding insurers will have incentive to reduce counterparty risk, because by successfully managing counterparty risk, ceding insurers can reduce the probability of insolvency and increase the possibility of securing a good financial rating, which in turn may have a positive impact on their contractual relationships with policyholders and other stakeholders, and protect firms' franchise value. This market-discipline mechanism can only work if ceding insurers have good information on the creditworthiness of reinsurers and can adjust their contractual relationship with the reinsurers accordingly. Epermanis and Harrington (2006) demonstrate the effect of market discipline in the primary insurance market, documenting that insurance premium revenue declines when an insurance company suffers a rating downgrade in the primary insurance market, with the insurers downgraded below certain benchmarks (A.M. Best's rating of A-, for example) suffering the greatest losses in premium income. In addition, the paper finds that premium revenue drops more when weaker insurers (A.M. Best's rating of either A- or B++ and below) get weaker. We therefore hypothesize that:

H1-1: The reinsurance demand of ceding insurers is sensitive to the credit risk of reinsurers. In particular, reinsurance ceded to a counterparty reinsurer will decrease if the counterparty reinsurer suffers a rating downgrade.

The demand sensitivity is heterogeneous depending on the pre-downgrading financial strength of the reinsurers and the level of rating changes. Specifically, if a reinsurer is downgraded below certain benchmark rating, the reinsurance ceded to it will be reduced more than the amount ceded to those reinsurers suffering a downgrading but still maintaining *a rating above the benchmark.*

Harrington (2004) mentions that potentially high search costs and the opacity of insurance firms may make it difficult for policyholders to identify high-quality insurers and advisors, which in turn reduce the risk sensitivity of demand in the primary insurance market. The reduced risk sensitivity in primary insurance demand may have some impact on the reinsurance market, as it may reduce ceding insurers' risk sensitivity in reinsurance demand and may actually encourage ceding insurers to contract with low-quality reinsurers for cost-effectiveness. In addition, as pointed out by Bodoff (2013), there is a divergence in time and personnel in managing counterparty risk by ceding insurers in the current mechanism, which may make it hard for ceding insurers to respond to a reinsurer's creditworthiness change. If the current counterparty risk management system of ceding insurers is not effective or even provides an excuse for mismanagement of counterparty risk, the above hypothesis will not hold and no sensitivity will be observed.

The conjecture of H1-1 can also easily be applied to reinsurer rating upgrades. That is, reinsurance ceded to a counterparty reinsurer will increase if the counterparty reinsurer enjoys a rating upgrade that suggests the credit risk of the counterparty reinsurer is now reduced. A reinsurer rating upgrade may represent good news to the ceding insurer because the ceding insurer has already built certain relationships with the reinsurer. A ceding insurer can now enjoy a lower reinsurer credit risk, without incurring the extra costs of creating a new reinsurance contract. However, stronger financial strength may also encourage the reinsurer to increase its price for reinsurance to reflect its better quality. The ceding insurer, in contrast, may have a target counterparty risk and price, and it may not be willing to pay extra for a lower reinsurer credit risk. In considering the tradeoff between price and risk, it is possible that the ceding insurer may reduce its demand for reinsurance from a counterparty reinsurer after the reinsurer's rating upgrade. Depending on the strengths of these two effects, the reinsurance demand change due to reinsurer rating upgrade can be either positive or negative.

H1-2: The impact of reinsurer rating upgrades on reinsurance demand is ambiguous; it may depend on the ceding insurer striking a balance between a reduced credit risk and an increased reinsurance price.

In the United States, the Credit for Reinsurance Model law places collateral requirements for unauthorized reinsurance in place (Cole, McCullough, and Powell, 2010) to reduce reinsurer counterparty credit risk. Before 2010, unauthorized reinsurers were required to deposit 100% collateral for the risk they assumed from US ceding insurers; otherwise, ceding insurers could not take a credit against their loss reserve or unearned premium reserve if uncollateralized. These collaterals may help mitigate the impact of the credit risk of the reinsurers and make reinsurance demand less sensitive to reinsurers' financial rating. Hence, we hypothesize that:

H2: Reinsurance demand sensitivity is heterogeneous depending on the type of reinsurance transaction. In particular, the demand for ***unauthorized reinsurance*** *is less sensitive to the rating changes of counterparty reinsurers than the demand for* ***authorized reinsurance****.*

Epermanis and Harrington (2006) argue that the possible effect of rating changes on reinsurance demand is ambiguous if reinsurance is used simply to satisfy regulatory scrutiny or action. If this is the primary purpose of a reinsurance transaction, the default risk of a reinsurer may not matter, as long as the regulations allow the ceding insurer to take credit from the reinsurance transaction. For ceding insurers with abundant capital and low leverage, the regulatory scrutiny may not be a strong binding condition, but the regulatory scrutiny may matter more for ceding insurers with high leverage. In addition, the judgment proof hypothesis may also apply to high-leveraged ceding insurers. Such insurers have fewer assets to protect, and therefore have less concern for insolvency risk, which may make them less sensitive to reinsurance credit risk. We therefore predict that

H3: Ceding insurers with high leverage are less sensitive to the downgrading of counterparty reinsurers because such insurers have fewer assets to protect, and they tend to buy reinsurance mainly for surplus relief to meet minimum regulatory requirements.

As suggested by Garven, Hilliard, and Grace (2014), some ceding insurers tend to maintain a network with a group of reinsurers and may develop an implicit long-term contract relationship with specific reinsurers (contract sustainability). This long-term relationship may in turn provide ceding insurers less incentive to quickly adjust their placement of business with those reinsurers when they suffer credit quality problems. We then predict that

H4: Reinsurance demand sensitivity is lower for downgraded/upgraded reinsurers that have maintained a long-term relationship with the ceding insurer.

3. Data and Methodology

Data source and sample description

We study the sensitivity of reinsurance demand to credit risk of counterparty reinsurers in the US property-liability insurance industry. The data period used is 2002-2009.[4] Financial data for individual ceding insurers is obtained from NAIC annual statements. The counterparty reinsurers' information about each ceding reinsurer is collected from the NAIC Schedule F−part 3, from which we are able to collect information such as reinsurers' names, domiciles, ceded reinsurance premiums, and recoverable amounts. The financial strength rating information for reinsurers is collected from A.M. Best, S&P, and Moody's. We manually

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[4] We end our sample period in 2009 in order to minimize the regulatory effect on our results. Congress passed the federal legislation on the Nonadmitted and Reinsurance Reform Act in 2010, and early adopters like New York revised and implemented the new regulation from January 2011. As state regulation governs in insurance industry, the process is still ongoing, with more and more states revising their provisions on collateral requirements ever since.

merge the rating data with the NAIC data by matching the reinsurer's name, domicile, and NAIC code if available.

Our analysis is at the firm level. We keep in our sample unaffiliated single firms and affiliated firms of each group if a group contains multiple affiliates.[5] To be included in the sample, a ceding insurer must have positive direct and net premiums written in year *t-1*, year *t*, and year *t+1*, and have at least two annual observations for other variables used.

Table 1 tabulates the number of insurer-reinsurer observations, reinsurance rating changes by rating category, and rating changes by rating category and reinsurance type during the sample period. The table shows that there are more authorized reinsurance transactions than unauthorized reinsurance transactions, and more unaffiliated transactions than affiliated transactions. The majority of rated reinsurance transactions have benchmark (A- or equivalent) or above benchmark ratings. During the sample period, there were more reinsurer rating downgrades than upgrades overall, but for reinsurers that already had benchmark ratings, more upgrades were observed than downgrades. In addition, reinsurers with low ratings tend to experience more rating changes than other groups.

[Insert Table 1 Here]

Methodology

A. Univariate analyses

We begin with univariate analysis to document the abnormal reinsurance demand change upon a reinsurer's rating change. We measure reinsurance demand change, $\Delta\text{R\_demand}_{i,j,t}$, as a growth in the proportion of reinsurance premium ceded to a particular reinsurer *j* by ceding insurer *i*. $\Delta\text{R\_demand}_{i,j,t}$ is defined as (reinsurance premiums ceded to reinsurer *j* in year *t* / total reinsurance premiums ceded of ceding insurer *i* in year *t*) –

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[5] Ceding insurers that are reinsurance specialists are excluded from the sample.

(reinsurance premiums ceded to reinsurer *j* in year *t-1* / total reinsurance premiums ceded of ceding insurer *i* in year *t-1*).[6] Instead of measuring reinsurance demand at the aggregate level for a ceding insurer, we calculate this reinsurance demand amount from each counterparty reinsurer of any one ceding insurer, which allows us to observe changes in reinsurance demand associated with an individual reinsurer over time.

Following a similar procedure used in Epermanis and Harrington (2006), we use a control-group practice in the univariate analysis to estimate abnormal growth in reinsurance demand. We first calculate the mean change in reinsurance demand ($\Delta \text{R\_demand}_{i,j,t}$) for reinsurers experiencing no rating changes during the investigation periods, calculating separately for reinsurers with "above bench" ratings (A or higher), "bench" ratings (A- and equivalent), and "low" ratings (rating of B++ or lower) (at the beginning of year *t*). Next, for sample reinsurers with rating changes, we deduct from their change in reinsurance demand the mean change of no-rating-change reinsurers in the same rating category ("above bench," "bench," or "low"). We then test whether the demeaned changes in reinsurance demand of the upgraded and downgraded reinsurers are significantly different from zero. We run analyses on the whole sample and various sub-samples in order to test the hypotheses presented in the previous section.

B. Regression analyses

We adopted regression analyses to test our hypotheses. The general regression model used is as follows:

$$\Delta \text{R\_demand}_{i,j,t} = \alpha_t + \gamma_1 \text{Downgrade}_{i,j,t} + \gamma_2 \text{Upgrade}_{i,j,t} + \theta \text{X}_{i,t} + \varepsilon_{i,t} \qquad (1),$$

where $\Delta \text{R\_demand}_{i,j,t}$ is the reinsurance demand change of insurer *i* from reinsurer *j* from

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[6] As a robustness check, we also measure reinsurance demand change using the difference in the logarithm of reinsurance premium ceded to a particular reinsurer *j* from year *t-1* to year *t*. Our main results still hold. We argue that the changes in the proportion of reinsurance premium ceded is a better measure because it is scaled by total reinsurance ceded of a ceding insurer, which helps control the impact brought by the strategic changes of a ceding insurer's total reinsurance need.

year *t-1* to year *t*. $\text{Downgrade}_{i,j,t}$ and $\text{Upgrade}_{i,j,t}$ are indicator variables equal to one if a reinsurer *j* is downgraded or upgraded in year *t* or *t-1*, respectively. $\text{X}_{\text{i,t}}$ is a vector of control variables. Time effects and firm fixed effects are also controlled in the regression.

The downgrade and upgrade dummy variables count the changes in both year *t* and *t-1* because insurance companies report financial data, including reinsurance premium ceded, on a calendar-year basis without the reinsurance transaction date, but rating agencies update financial strength ratings throughout the year.[7] As a result, some reinsurance transactions reported in year *t* are made after a reinsurance credit rating change in year *t*, while other reinsurance transactions are made before the reinsurer credit rating assignment in year *t* and after the rating in year *t-1*. For the latter case, the rating change in year *t-1* may affect the reinsurance demand in year *t*. Therefore, we define the downgrade/upgrade variables to include rating changes in both *t* and *t-1*. This may capture some cases where ceding insurers adjust their reinsurance portfolio in a somewhat delayed way.

Our control variables in the model follow the existing literature on reinsurance demand (Mayers and Smith, 1990; Garven and Lamm-Tennant, 2003; Cole and McCullough, 2006; Garven, Hilliard, and Grace, 2014; and Lin, Yu, and Peterson, 2014) and key rating agency topic factors that may affect reinsurance demand (Aon Benfield, 2013). Variables measuring the characteristics of ceding insurers that may affect their reinsurance demand include the ceding insurers' size, financial leverage, lagged combined ratio, underwriting leverage that serves as a proxy for the capital adequacy of the ceding insurers, the ceding insurer's exposure to catastrophic risks, exposure to workers' compensation risks and other long-tail risks, the ceding insurer's diversification across business lines and geographical areas, cash flow volatility, and the number of contracted reinsurers. In addition, a ceding

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[7] It is known that the ratings of ceding insurers are mostly assigned in June, three months after the NAIC filing (Epermanis and Harrington, 2006). However, the months of reinsurance rating assignments do not follow this pattern but instead spread throughout the calendar year.

insurer's A.M. Best rating and return on asset at *t-1* is also controlled. We also control for the ceding insurer's existing exposure to the contracted reinsurer (percentage of reinsurance recoverable from the reinsurer at *t-1*). The definitions of variables are provided in Table 2.

After we examine whether reinsurance demand is sensitive to the reinsurer's credit quality change, we modify this basic regression in order to test other hypotheses. We first create a new set of rating change dummy variables by a reinsurer's pre-change financial strength. We define a reinsurer's rating as "high" if its average rating from the three rating agencies – Moody's, S&P, and A.M. Best – is above or equal to A- (A3 for Moody's) ("above bench" or "bench"). Similarly, a reinsurer's rating is classified as "low" when its average rating is below A- or equivalent (below "bench"). Then we classify downgrades and upgrades into three groups each: changes within the "high" rating (Downgrade_high, Upgrade_high), benchmark rating changes (Downgrade_bench, Upgrade_bench), and changes within the "low" rating (Downgrade_low, Upgrade_low) (see Table 2 for detailed description). The lagged rating dummies of reinsurers (lag_high and lag_low) are also controlled in the regressions.

[Insert Table 2 Here]

To test if the demand sensitivity varies among different types of reinsurers, we split the sample into subsamples based on the type of reinsurers or other criteria to be tested, and perform Chow-tests for the sub-sample regressions to examine if the coefficients of the rating change variables are significantly different between the sub-samples.[8] Three types of sub-sample regressions are conducted to test related hypotheses: authorized vs. unauthorized (H2), high leverage vs. low leverage (H3), and high sustainability vs. low sustainability (H4).

[8] In addition to this approach, we also conducted regressions with interaction variables of rating change dummies and types of reinsurers. The main results stay the same and are available from authors upon request.

4. Empirical results

4.1. Sample statistics

Table 3 presents the summary statistics of our dependent variable, key independent variables, and other control variables. Variables are winsorized at the 1% level in order to remove outliers.

[Insert Table 3 Here]

4.2. Univariate analyses: control group test – risk sensitivity demand of reinsurance

Table 4 presents the univariate analyses of abnormal changes in reinsurance ceded to counterparty reinsurers that are downgraded or upgraded. Overall, the results demonstrate that reinsurance demand is sensitive to reinsurer rating downgrades and upgrades, and the sensitivity varies with the types of downgrading or upgrading.

Panel A shows the results for downgraded reinsurers. The "All" sample result is consistent with our prediction that downgraded reinsurers experience a decrease in reinsurance ceded, and the amount of that decrease is the largest when "weak" reinsurers get "weaker" (Downgrade_low), followed by a reinsurer being downgraded below the benchmark rating (Downgrade_bench). The decrease is the smallest if a reinsurer is downgraded but still maintains a "high" rating (Downgrade_high). The results suggest that ceding insurers view that the increase in counterparty risk is limited when a reinsurer is downgraded within the "high" rating category, but they are less tolerable when the already weak reinsurers become weaker. Similar conclusions can be drawn for unaffiliated reinsurers only. Both unauthorized and authorized reinsurance transactions are sensitive to the rating downgrades, but authorized reinsurance transactions are economically more sensitive in all downgrading categories. Affiliated reinsurance transactions are statistically insensitive to rating downgrades overall.[9]

Panel B shows the results for upgraded reinsurers. In the case of rating upgrading, the overall reaction is negative but to a lesser degree than the reaction to downgrading. The overall negative reaction is driven by the negative reaction to further upgrade of already-strong reinsurers and "within low" upgrade of weak reinsurers. The reaction to a reinsurer's upgrading from low to benchmark rating is significantly positive, suggesting that ceding insurers do value reduced credit risk for this set of reinsurers more than their possible price increase. The negative reaction to upgrading of strong reinsurers may be caused by increased pricing by stronger reinsurers, leading to reduced demand. The negative reaction to the upgrading of weaker reinsurers is somewhat puzzling. This might support the "judgment proof" argument that ceding insurers contracting with weak reinsurers care more about the cost of reinsurance than about the credit risk, or it simply could be because the reduced credit risk from these weak reinsurers cannot offset their increase in reinsurance price after upgrading. Similar conclusions hold for unaffiliated reinsurers and authorized reinsurers. Again, affiliated reinsurance transactions are statistically insensitive to rating upgrades overall.

[Insert Table 4 Here]

4.3. Regression analyses

Fixed effects estimates of the regression model in section 3 are shown in Table 5 to test H1-1 and H1-2. We present the regression results both with and without firm characteristic control variables. The estimation results for our key independent variables are similar in these regressions, results of which are also mostly consistent with our univariate findings. Model (1)

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[9] The issue of affiliated insurance demand is not the focus of this paper, as the relationship of ceding insurers and their affiliated reinsurers may be governed by many other factors in addition to credit risk management concerns. As a matter of interest, we do conduct regression analyses of demand sensitivity for affiliated reinsurance. We obtain negative coefficients for types of downgrade and upgrade dummies, but they are not statistically significant. The results are available from the authors upon request.

and Model (2) show the overall effect of downgrading and upgrading. Reinsurance demand is significantly reduced when a reinsurer is downgraded; it is also reduced when upgrading occurs, but to a lesser extent.

Model (3) and Model (4) examine if the reinsurance demand sensitivity varies by a reinsurer's rating and rating changes. We find that ceding insurers reduce the reinsurance ceded to the downgraded reinsurers the most when weak reinsurers become even weaker (Downgrade_low), followed by benchmark downgrading (Downgrade_bench), and the reduction is the smallest when strong reinsurers are downgraded but still maintain a strong rating (Downgrade_high). In the case of upgrading, we find that ceding insurers increased reinsurance premium ceded when weak reinsurers become stronger – receiving a benchmark upgrade (Upgrade_bench) or a within-weak upgrade (Upgrade_low) – but when an already strong reinsurer becomes stronger (within-strong upgrade, Upgrade_high), reinsurance ceded to this reinsurer is actually reduced. This supports the arguments that the cost of contracting with a super-strong reinsurer carries more weight than the benefit from the reduced credit risk.

[Insert Table 5 Here]

Table 6 tests the demand sensitivity between authorized and unauthorized reinsurance transactions (H2). Authorized reinsurance reacts significantly negatively in both downgrade and upgrade cases, but unauthorized reinsurance only reacts significantly negatively in the downgrade scenario. When examining demand sensitivity by types of rating changes, the p-values of the Chow-test show that authorized reinsurance transactions react more negatively to benchmark downgrading and within-low downgrading. Authorized reinsurance demand increases in the benchmark-upgrade cases and within-low upgrade cases, but it decreases when strong reinsurers get stronger (Upgrade_high). Unauthorized reinsurance demand only increases in the within-low upgrade case, and no significant changes are found in the other two types of upgrade. Overall, these results support our hypothesis 2, that authorized reinsurance demand is more sensitive to counterparty risk change.

[Insert Table 6 Here]

Table 7 compares the demand sensitivity of reinsurance for high-leverage ceding insurers and low-leverage ceding insurers. We divide ceding insurers into two groups based on their leverage in order to test H3, with the high-leverage group defined as being at the top 10^{th} percentile by leverage value. The downgrade dummy is insignificant for high-leverage ceding insurers and significantly negative for low-leverage ceding insurers. High-leverage ceding insurers reduce their reinsurance demand when counterparty reinsurers are upgraded, but the demand change is insignificant for low-leverage ceding reinsurers. Analyses by types of rating changes show that, compared with low-leverage ceding insurers, high-leverage ceding insurers' reinsurance demand is less sensitive to benchmark downgrading of counterpart reinsurers (a lesser reduction in demand for reinsurance). These insurers do not increase their reinsurance demand when their counterparty reinsurers experience benchmark upgrading or "within-low" upgrading (as low-leverage insurers do), but they do reduce their demand when their contracted reinsurers become super-strong (Upgrade_high). Overall, the results provide support for our hypothesis 3.

[Insert Table 7 Here]

In order to test H4, we define the insurer-reinsurer relationship sustainability following Garven, Hilliard, and Grace (2014). The 5-year Sustainability is defined as

Sustainability = mean of the reinsurer count distribution / (standard deviation of the reinsurer count distribution+1).

The highest possible value for this variable is 5, and it happens when a ceding insurer cedes to the same group of reinsurers during the 5-year period. Therefore, a higher value for sustainability means persistent ceding insurers. Because we need five years of data to calculate this variable, we use 2002-2006 data to get the sustainability for 2007. As a result, we have the years 2007-2009 in the regression analysis sample. We split ceding insurers into "long-sustain" and "short sustain" samples using median sustainability as a cut.[10] The results are provided in Table 8. Our results suggest that sustainability does not affect the demand sensitivity in upgrading cases; the differences between the two groups are insignificant (Upgrade dummy), but reinsurance demand by persistent ceding insurers is slightly less sensitive to counterparty reinsurer downgrades (Chow-test of downgrade dummy is significant at the 5% level).

A further look at the sensitivity by types of rating changes show that the above finding is primarily driven by the fact that persistent ceding insurers are less sensitive to the "within strong" downgrading of counterparty reinsurers, which may suggest that persistent ceding insurers have a higher tolerance for non-critical rating changes. In contrast, the analyses also show that ceding insurers with long sustainability also increase reinsurance less when their counterpart reinsurers experience a benchmark upgrading. Overall, the results provide some support for hypothesis 4.

[Insert Table 8 Here]

5. Conclusions

This article examines the sensitivity of reinsurance demand to counterparty risks in a sample of US property-liability insurance companies to test market discipline in the reinsurance market. We examine whether reinsurance premium growth is sensitive to a counterparty reinsurer's rating change. We use the financial strength rating of reinsurers as a proxy for reinsurer counterparty risk, and use the change in the proportion of reinsurance premium ceded to a reinsurer over the total reinsurance premium ceded as a proxy for reinsurance

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[10] We also test the hypotheses by comparing the top 25th percentile and bottom 25th percentile of the ceding insurers by sustainability and obtain similar results.

demand change. The paper finds that the reinsurance demand of US ceding insurers is sensitive to reinsurer counterparty risk. In general, reinsurance demand changes negatively with reinsurer rating changes, and demand sensitivity is heterogeneous depending on the types of reinsurance contracts and the rating of reinsurers.

In particular, we find that when a reinsurer is downgraded, the reinsurance ceded to this downgraded reinsurer decreases overall, and the reduction was the most severe when an already weak reinsurer becomes weaker, followed by situations in which a reinsurer is downgraded below the benchmark rating. The reduction is the smallest when a strong reinsurer is downgraded but still maintains a strong rating. In the case of reinsurer upgrading, the reinsurance ceded to the upgraded reinsurer either increased or decreased depending on the rating of the reinsurer. When a weak reinsurer gets upgraded, the reinsurance demand associated with this upgraded reinsurer increases. However, when an already strong reinsurer (with A- or above financial strength rating) is upgraded, ceding insurers do not appreciate this credit improvement and reduce the reinsurance ceded to this reinsurer, possibly due to higher prices.

We also find that authorized reinsurance transactions are more sensitive to reinsurer rating changes. With collateral protections in place, it is reasonable to observe lower demand sensitivity in unauthorized reinsurance because credit risk has been partially mitigated by those collateral requirements.

The demand sensitivity of ceding insurers with high leverage is statistically different from the sensitivity of ceding insurers with low leverage. Low-leverage firms are found to reduce their reinsurance demand significantly in all downgrading cases, but the reduction is significant for high-leverage ceding insurers only when their weak counterparty reinsurers get weaker. In addition, high-leverage insurers do not increase their reinsurance demand when their weak counterpart reinsurers experience rating upgrades, but they do reduce their demand when their contracted reinsurers become super-strong.

Ceding insurers that tend to maintain long-term relationships with reinsurers are found to be less sensitive to counterparty reinsurer downgrades, mainly driven by the phenomenon that they are less sensitive to noncritical rating downgrades. However, they do not possess more tolerance when the credit risk of their counterparty reinsurer increases dangerously to below benchmark or even lower ratings. Symmetrically, these insurers also increase their reinsurance demand less when their counterpart reinsurers experience a benchmark upgrading.

Our results show that overall reinsurance demand is sensitive to the counterparty risk, supporting the traditional arguments of market discipline in the reinsurance market. Without any protections of a guaranty fund, the results are expected. If ceding insurers mostly utilize reinsurance to deal with regulatory scrutiny, the reinsurance demand is not necessarily sensitive to the counterparty risk. This is partly supported by our results that highly-leveraged firms are less sensitive to reinsurer rating downgrades, which could call for some regulatory attention. However, the overall demand sensitivity shows that this type of moral hazard is not very severe, and ceding insurers do manage reinsurance counterparty risk as market discipline predicts.

Future studies can look at the recent regulatory changes in the collateral requirements for unauthorized reinsurers. Individual states have been adopting the new regulation over the years and this provides a natural experiment for testing the behavior change in demand sensitivity to reinsurance counterparty risk.

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Table 1. Reinsurance Transactions by Reinsurer Rating Changes, 2002-2009

Reinsurer Rating at t-1	Number of observations at t-1	No Change at t	Downgrade at t	Upgrade at t
All Types of Reinsurer				
Above Bench	125,824	98,322	16,479	11,023
Bench	23,664	18,878	2,163	2,623
Low	8,546	3,642	2,939	1,965
Total Rated	158,034	120,842	21,581	15,611
Non-rated	181,482			
Total	339,516			
Authorized Reinsurer				
Above Bench	89,904	71,881	11,352	6,671
Bench	13,880	10,983	1,371	1,526
Low	6,579	2,829	2,190	1,560
Total Rated	110,363	85,693	14,913	9,757
Non-rated	110,755			
Total	221,118			
Unauthorized Reinsurer				
Above Bench	35,920	26,441	5,127	4,352
Bench	9,784	7,895	792	1,097
Low	1,967	813	749	405
Total Rated	47,671	35,149	6,668	5,854
Non-rated	70,727			
Total	118,398			
Affiliated Reinsurer				
Above Bench	10,709	9,255	1,093	361
Bench	1,871	1,724	60	87
Low	988	626	177	185
Total Rated	13,568	11,605	1,330	633
Non-rated	6,598			
Total	20,166			
Unaffiliated Reinsurer				
Above Bench	114,954	88,939	15,363	10,652
Bench	21,739	17,109	2,098	2,532
Low	7,546	3,012	2,761	1,773
Total Rated	144,239	109,060	20,222	14,957
Non-rated	163,810			
Total	308,049			

Note: The table shows the number of insurer-reinsurers-year transactions by reinsurer rating changes at *t*. "Above Bench" rating category includes A (A2 for Moody's) or Above; "Low" rating category includes B++ or lower (BBB+ for S&P, Baa1 for Moody's); "Bench" rating category includes A- (A3 for Moody's).

Table 2. Variable Description and Definition

Variable Name	Definition
Dependent Variable	
ΔR_demand $_{i,j,t}$ – Change in reinsurance demand of ceding insurer *i* from reinsurer *j*	(reinsurance premiums ceded to reinsurer *j* in year *t* / total reinsurance premiums ceded of ceding insurer *i* in year *t*) – (reinsurance premiums ceded to reinsurer *j* in year *t-1* / total reinsurance premiums ceded of ceding insurer *i* in year *t-1*)
Key independent variables: reinsurer rating changes and reinsurer characteristics	
Downgrade	Dummy variable equal to 1 if a reinsurer is downgraded in year *t* or *t-1*; 0 otherwise
Downgrade_bench	Dummy variable equal to 1 if a reinsurer is downgraded from "high" rating ("above bench" or "bench") to a below benchmark rating ; 0 otherwise
Downgrade_high	Dummy variable equal to 1 if an "above bench" rating reinsurer is downgraded but still maintains an "above bench" or "bench" rating; 0 otherwise
Downgrade_low	Dummy variable equal to 1 if a "low" rating reinsurer is downgraded to a lower rating; 0 otherwise
Upgrade	Dummy variable equal to 1 if a reinsurer is upgraded in year *t* or t-*1;* 0 otherwise
Upgrade_bench	Dummy variable equal to 1 if a reinsurer is upgraded from "low" rating to "bench" or "above bench" rating; 0 otherwise
Upgrade_high	Dummy variable equal to 1 if a "high" rating ("above bench" or "bench") reinsurer is upgraded; 0 otherwise
Upgrade_low	Dummy variable equal to 1 if a "low" rating reinsurer is upgraded but still maintains a "low" rating; 0 otherwise
Lag_high	Dummy variable equal to 1 if a reinsurer possesses a "high" rating ("bench" or "above bench") prior to rating change; 0 otherwise
Lag_low	Dummy variable equal to 1 if a reinsurer possesses a "low" rating prior to rating change; 0 otherwise
Authorized	Dummy variable equal to 1 if a reinsurer is an authorized reinsurer; 0 otherwise
Unauthorized	Dummy variable equal to 1 if a reinsurer is an unauthorized reinsurer; 0 otherwise
Affiliated	Dummy variable equal to 1 if the reinsurer and the ceding insurer are affiliated; 0 otherwise
Unaffiliated	Dummy variable equal to 1 if the reinsurer and the ceding insurer are unaffiliated; 0 otherwise
Control variables: Characteristics of ceding insurers that affect their reinsurance demand	
Size	Log value of ceding insurer's admitted assets
Leverage	Liability / policyholders' surplus
Lag_combined	Combined ratio at *t-1*
Capitalization	Net premiums written / policyholders' surplus
CAT risk	The proportion of catastrophic risk exposure: defined as direct premiums written in homeowners, farmowners, auto physical damage, commercial multiperil, or inland marine in AL, FL, MS, SC, or TX to total premiums written
Long_tail	Percentage of premiums in workers' compensation and other long-tail lines
Geo_Herf	Herfindahl index by geographical areas
LOB_Herf	Herfindahl index by business lines
STD_CF	Standard deviation of ceding insurer's net cash flow over the previous four years
Pre_rating	Ceding insurer's financial strength rating by A.M. Best at *t-1*
Pre_ROA	Net income after dividend & before tax/total assets at *t-1*
Ln_Numrein	Log value of ceding insurer's numbers of contracted reinsurers at *t-1*
Variables measuring relationship between ceding insurers and reinsurers	
Rein_rec	Reinsurance recoverable from reinsurer *j* / total reinsurance recoverable of ceding insurer *i* at *t-1*
Contract sustainability	Sustainability of primary insurer, calculated following Grace et al. (2014)

Table 3. Summary Statistics of variables

Variable Name	N	Mean	STD	Min	Max
Dependent Variable					
ΔR_demand $_{i,j,t}$	338251	-0.011	4.039	-22.629	21.150
Key independent variables: reinsurer rating changes and reinsurer characteristics					
Downgrade	339516	0.105	0.306	0	1
Downgrade_bench	339516	0.010	0.099	0	1
Downgrade_high	339516	0.081	0.273	0	1
Downgrade_low	339516	0.014	0.117	0	1
Upgrade	339516	0.081	0.272	0	1
Upgrade_bench	339516	0.006	0.079	0	1
Upgrade_high	339516	0.070	0.255	0	1
Upgrade_low	339516	0.004	0.065	0	1
Lag_high	339516	0.440	0.496	0	1
Lag_low	339516	0.025	0.157	0	1
Authorized	339516	0.651	0.477	0	1
Unauthorized	339516	0.349	0.477	0	1
Affiliated	339516	0.059	0.236	0	1
Unaffiliated	339516	0.907	0.290	0	1
Control variables: Characteristics of ceding insurers that affect their reinsurance demand					
Size	339516	13.127	2.187	8.307	17.359
Leverage	338443	2.042	1.523	0.000	12.887
Lag_combined	314804	101.01	27.91	38	271
Capitalization	339516	0.904	0.593	0	2.486
CAT risk	339516	0.063	0.177	0	0.994
Long_tail	338639	0.710	0.264	0	1
Geo_Herf	332518	0.344	0.358	0.034	1
LOB_Herf	338793	0.405	0.273	0.111	1
STD_CF	338254	0.076	0.108	0.002	0.784
Pre_rating	312931	10.895	1.500	0	13
Pre_ROA	337817	2.533	4.432	-15	16
Ln_Numrein	339516	4.542	1.623	0	7.499
Variables measuring relationship between ceding insurers and reinsurers					
Rein_rec	336989	0.038	0.155	0	1
Contract sustainability	146425	1.117	0.245	0.618	5

Table 4. Univariate Analyses: Reinsurance Demand Change by Reinsurer Rating Change

Panel A: Impact of Reinsurer Downgrading on Reinsurance Demand Change

Types of Reinsurers		All Downgrades	Downgrade_ bench	Downgrade_ high	Downgrade_ low
All	**Mean**	-0.34	-0.65	-0.17	-1.19
	T-value	(-12.00)***	(-7.37)***	(-5.30)***	(-13.54)***
Affiliated	**Mean**	-0.23	-1.51	-0.05	-0.75
	T-value	(-1.13)	(-1.65)	(-0.26)	(-0.88)
Unaffiliated	**Mean**	-0.35	-0.61	-0.17	-1.22
	T-value	(-12.92)***	(-7.48)***	(-5.76)***	(-15.36)***
Authorized & Unaffiliated	**Mean**	-0.47	-0.87	-0.24	-1.47
	T-value	(-12.55)***	(-7.30)***	(-5.66)***	(-14.41)***
Unauthorized & Unaffiliated	**Mean**	-0.09	-0.15	-0.04	-0.45
	T-value	(-3.32)***	(-1.91)**	(-1.33)	(-6.01)***

Panel B: Impact of Reinsurer Upgrading on Reinsurance Demand Change

Types of Reinsurers		All Upgrades	Upgrade_ bench	Upgrade_ high	Upgrade_ low
All	**Mean**	-0.14	0.29	-0.16	-0.44
	T-value	(-4.54)***	(2.17)**	(-5.20)***	(-2.70)***
Affiliated	**Mean**	-0.22	-0.58	-0.39	1.80
	T-value	(-0.68)	(-0.71)	(-1.10)	(1.35)
Unaffiliated	**Mean**	-0.14	0.39	-0.15	-0.65
	T-value	(-4.95)***	(3.43)***	(-5.33)***	(-5.02)***
Authorized & Unaffiliated	**Mean**	-0.25	0.49	-0.31	-0.78
	T-value	(-6.29)***	(3.74)***	(-7.00)***	(-4.80)***
Unauthorized & Unaffiliated	**Mean**	0.07	-0.15	0.08	-0.14
	T-value	(2.43)	(-0.92)	(2.80)***	(-4.25)***

Note: Significant at the ***1%, **5%, and *10% levels. Reinsurance demand change is defined as the change in proportion of a ceding insurer *i*'s reinsurance premium ceded to a reinsurer *j* over total reinsurance premiums ceded of the ceding insurer *i*. The variable is demeaned using the mean change in demand of control firms (reinsurers in the same rating category but experiencing no rating changes). A rating is defined as "high" ("low") when a reinsurer's average rating from the three rating agencies – Moody's, S&P, and A.M. Best – is above or equal to (below) A- or equivalent. When a rating change is within high (low) rating, we classify it as downgrade_high or upgrade_high (downgrade_low or upgrade_low). When a rating downgrades (upgrades) from high to low (low to high), it is classified as downgrade_bench (upgrade_bench).

Table 5. Regression–Reinsurance Demand Change by Reinsurer Rating Change (Hypothesis 1)

Variable	Model 1	Model 2	Variable	Model 3	Model 4
Downgrade	-0.3953***	-0.1512***	Downgrade_bench	-0.5354***	-0.4123***
	[0.0206]	[0.0209]		[0.0644]	[0.0599]
Upgrade	-0.1213***	-0.0281	Downgrade_high	-0.2482***	-0.0611***
	[0.0227]	[0.0225]		[0.0243]	[0.0226]
Lag_high		0.1145***	Downgrade_low	-0.7757***	-0.5736***
		[0.0135]		[0.0637]	[0.0588]
Lag_low		-0.5741***	Upgrade_bench	0.6596***	0.6095***
		[0.0406]		[0.0827]	[0.0778]
Size		0.2478***	Upgrade_high	-0.1829***	-0.1023***
		[0.0372]		[0.0252]	[0.0237]
Leverage		-0.0867***	Upgrade_low	0.1581	0.3131***
		[0.0148]		[0.1027]	[0.0964]
Lag_combined		0.0005	Lag_high	0.0410***	0.1091***
		[0.0004]		[0.0145]	[0.0135]
Capitalization		0.3680***	Lag_low	-0.5354***	-0.4707***
		[0.0290]		[0.0549]	[0.0511]
CAT risk		-0.3795*	Size		0.2449***
		[0.2225]			[0.0372]
Long_tail		-0.1086	Leverage		-0.0858***
		[0.0949]			[0.0148]
Geo_Herf		0.2899***	Lag_combined		0.0005
		[0.1013]			[0.0004]
LOB_Herf		0.1256	Capitalization		0.3675***
		[0.0934]			[0.0290]
STD_CF		-0.4593***	CAT risk		-0.3783*
		[0.1540]			[0.2224]
Pre_rating		-0.0530***	Long_tail		-0.1102
		[0.0121]			[0.0949]
Pre_ROA		0.0009	Geo_Herf		0.2952***
		[0.0023]			[0.1013]
Ln_Numrein		-0.029	LOB_Herf		0.1262
		[0.0178]			[0.0934]
Rein_rec		-12.4799***	STD_CF		-0.4547***
		[0.0868]			[0.1539]
			Pre_rating		-0.0517***
					[0.0121]
			Pre_ROA		0.0011
					[0.0023]
			Ln_Numrein		-0.0293
					[0.0178]
			Rein_rec		-12.4894***
					[0.0867]
Year dummies	Yes	Yes		Yes	Yes
Firm fixed effects	Yes	Yes		Yes	Yes
Observations	318,739	264,794		318,739	264,794
r2-w	0.0013	0.0758		0.0028	0.0765

Note: Standard errors are in brackets. Significant at the ***1%, **5%, and *10% levels. Both firm and time fixed effects are included but not reported due to space limit. Dependent variable is the change in proportion of a ceding insurer *i*'s reinsurance premium ceded to a reinsurer *j* over total reinsurance premiums ceded of the ceding insurer *i*. Definitions of control variables are in Table 2.

Table 6. Regression–Reinsurance Demand Sensitivity: Authorized vs. Unauthorized Reinsurers (Hypothesis 2)

Variable	Authorized	Unauthorize	P-Chow	Variable	Authorized	Unauthorized	P-Chow
Downgrade	-0.1702***	-0.0967***	0.2646	Downgrade _bench	-0.5009***	-0.1826***	0.0148
	[0.0295]	[0.0240]			[0.0866]	[0.0666]	
Upgrade	-0.0579*	0.0171	0.1114	Downgrade _high	-0.0537*	-0.0704***	0.3723
	[0.0331]	[0.0240]			[0.0321]	[0.0258]	
Lag_high	0.1515***	0.0139	<0.000	Downgrade _low	-0.6822***	-0.2896***	0.0057
	[0.0190]	[0.0160]			[0.0810]	[0.0733]	
Lag_low	-0.6917***	-0.2190***	<0.000	Upgrade _bench	0.7430***	-0.0053	0.0002
	[0.0551]	[0.0515]			[0.0991]	[0.1184]	
Size	0.3612***	0.0281	0.1273	Upgrade _high	-0.1793***	0.0085	0.0001
	[0.0522]	[0.0447]			[0.0356]	[0.0248]	
Leverage	-0.1219***	-0.0104	0.5143	Upgrade _low	0.2681**	0.2966**	0.7589
	[0.0206]	[0.0180]			[0.1274]	[0.1318]	
Lag_combined	0.0001	0.0015***	0.4468	Lag_high	0.1444***	0.0124	<0.000
	[0.0006]	[0.0005]			[0.0191]	[0.0160]	
Capitalization	0.4759***	0.1276***	0.0201	Lag_low	-0.5427***	-0.1723***	0.0009
	[0.0401]	[0.0352]			[0.0712]	[0.0614]	
CAT risk	-0.4856	-0.0277	0.1163	Size	0.3595***	0.0256	0.1398
	[0.3125]	[0.2625]			[0.0522]	[0.0447]	
Long_tail	-0.1204	-0.0791	0.5508	Leverage	-0.1205***	-0.0105	0.563
	[0.1410]	[0.1016]			[0.0206]	[0.0180]	
Geo_Herf	0.3509**	0.1675	0.1544	Lag_combined	0.0001	0.0015***	0.4559
	[0.1424]	[0.1194]			[0.0006]	[0.0005]	
LOB_Herf	0.2276	-0.0113	0.0671	Capitalization	0.4743***	0.1288***	0.0201
	[0.1447]	[0.0943]			[0.0401]	[0.0352]	
STD_CF	-0.7578***	0.2326	0.1311	CAT risk	-0.4831	-0.0237	0.1044
	[0.2073]	[0.2025]			[0.3123]	[0.2625]	
Pre_rating	-0.0656***	-0.0391***	0.1057	Long_tail	-0.1251	-0.0802	0.5704
	[0.0180]	[0.0136]			[0.1409]	[0.1016]	
Pre_ROA	0.0007	0	0.5789	Geo_Herf	0.3530**	0.1695	0.1505
	[0.0033]	[0.0027]			[0.1423]	[0.1194]	
Ln_Numrein	-0.0614**	0.0168	0.7127	LOB_Herf	0.2336	-0.013	0.0645
	[0.0250]	[0.0210]			[0.1446]	[0.0943]	
Rein_rec	-	-19.4543***	<0.000	STD_CF	-0.7516***	0.2341	0.1333
	[0.1047]	[0.2300]			[0.2072]	[0.2025]	
				Pre_rating	-0.0643***	-0.0385***	0.1183
					[0.0180]	[0.0136]	
				Pre_ROA	0.001	0.0001	0.5622
					[0.0033]	[0.0027]	
				Ln_Numrein	-0.0617**	0.017	0.6679
					[0.0250]	[0.0210]	
				Rein_rec	-	-19.4557***	<0.000
					[0.1047]	[0.2300]	
Year dummies	Yes	Yes			Yes	Yes	
Firm fixed	Yes	Yes			Yes	Yes	
Observations	168,529	96,265			168,529	96,265	
r2-w	0.0795	0.0715			0.0804	0.0717	

Note: Standard errors are in brackets. Significant at the ***1%, **5%, and *10% levels. Both firm and time fixed effects are included but not reported due to space limit. Dependent variable is the change in proportion of a ceding insurer *i*'s reinsurance premium ceded to a reinsurer *j* over total reinsurance premiums ceded of the ceding insurer *i*. Definitions of control variables are in Table 2.

Table 7. Regression–Reinsurance Demand Sensitivity: High Leverage Ceding Insurers vs. Low Leverage Ceding Insurers (Hypothesis 3)

Variable	High Lev	Low Lev	P-Chow	Variable	High Lev	Low Lev	P-Chow
Downgrade	-0.0471	-0.1566***	0.3369	Downgrade	-0.0293	-0.4489***	0.0483
	[0.0555]	[0.0222]		_bench	[0.1520]	[0.0642]	
Upgrade	-0.1341**	-0.0211	0.1103	Downgrade	-0.0121	-0.0602**	0.8982
	[0.0655]	[0.0237]		_high	[0.0610]	[0.0241]	
Lag_high	0.0816**	0.1163***	0.8055	Downgrade	-0.2838**	-0.6074***	0.1689
	[0.0371]	[0.0143]		_low	[0.1440]	[0.0633]	
Lag_low	-0.2626***	-0.6083***	0.0075	Upgrade	-0.0251	0.6718***	0.0133
	[0.1014]	[0.0436]		_bench	[0.2036]	[0.0830]	
Size	0.2463	0.1913***	0.2118	Upgrade	-0.1416**	-0.1008***	0.427
	[0.1725]	[0.0397]		_high	[0.0705]	[0.0250]	
Lag_combined	0.0004	0.0002	0.17	Upgrade	-0.2001	0.3605***	0.0995
	[0.0016]	[0.0004]		_low	[0.2522]	[0.1028]	
Capitalization	0.1089	0.3470***	0.0605	Lag_high	0.0741**	0.1111***	0.8442
	[0.0854]	[0.0287]			[0.0374]	[0.0143]	
CAT risk	1.0943	-0.3991*	0.0147	Lag_low	-0.1634	-0.5017***	0.0354
	[1.7057]	[0.2385]			[0.1250]	[0.0549]	
Long_tail	-0.0088	-0.0031	0.3676	Size	0.2488	0.1884***	0.1963
	[0.6311]	[0.1014]			[0.1725]	[0.0396]	
Geo_Herf	0.7062	0.2636**	0.8781	Lag_combined	0.0004	0.0002	0.168
	[0.6775]	[0.1069]			[0.0016]	[0.0004]	
LOB_Herf	-0.4819	0.1509	0.3431	Capitalization	0.1088	0.3476***	0.0634
	[0.7033]	[0.0988]			[0.0854]	[0.0287]	
STD_CF	-0.4672	-0.3975**	0.9759	CAT risk	1.0586	-0.3986*	0.0143
	[0.6484]	[0.1667]			[1.7058]	[0.2384]	
Pre_rating	0.0364	-0.0534***	0.5923	Long_tail	-0.0183	-0.0037	0.3544
	[0.0412]	[0.0135]			[0.6312]	[0.1014]	
Pre_ROA	-0.0134	0.0027	0.8582	Geo_Herf	0.7037	0.2698**	0.8567
	[0.0092]	[0.0025]			[0.6776]	[0.1069]	
Ln_Numrein	-0.3479***	-0.0539***	0.1123	LOB_Herf	-0.4754	0.1526	0.3545
	[0.1059]	[0.0190]			[0.7033]	[0.0987]	
Rein_rec	-	-	<0.000	STD_CF	-0.4673	-0.3930**	0.9784
	[0.3651]	[0.0899]			[0.6484]	[0.1667]	
				Pre_rating	0.0359	-0.0518***	0.5538
					[0.0412]	[0.0135]	
				Pre_ROA	-0.0134	0.0028	0.8618
					[0.0092]	[0.0025]	
				Ln_Numrein	-0.3470***	-0.0541***	0.108
					[0.1059]	[0.0190]	
				Rein_rec	-18.0391***	-12.3180***	<0.000
					[0.3652]	[0.0899]	
Year dummies	Yes	Yes			Yes	Yes	
Firm fixed	Yes	Yes			Yes	Yes	
Observations	23,455	241,339			23,455	241,339	
r2-w	0.0965	0.0755			0.0966	0.0763	

Note: Standard errors are in brackets. Significant at the ***1%, **5%, and *10% levels. Both firm and time fixed effects are included but not reported due to space limit. Dependent variable is the change in proportion of a ceding insurer *i*'s reinsurance premium ceded to a reinsurer *j* over total reinsurance premiums ceded of the ceding insurer *i*. Ceding insurers with leverage value in the top 10th percentile are classified as high leverage firms (High Lev); others are classified as low leverage firms (Low Lev). Definitions of control variables are in Table 2.

Table 8. Regression–Reinsurance Demand Sensitivity: Ceding Insurers with Long Sustainability vs. Short Sustainability (Hypothesis 4)

Variable	Long	Short	P-Chow	Variable	Long	Short	P-Chow
Downgrade	-0.2405***	-0.3781***	0.0472	Downgrade	-0.3813	-0.5709	0.7515
	[0.0461]	[0.0603]		_bench	[0.4745]	[0.4828]	
Upgrade	-0.1565***	-0.1561***	0.9147	Downgrade	-0.1836***	-0.3350***	0.0383
	[0.0371]	[0.0459]		_high	[0.0479]	[0.0629]	
Lag_high	0.0658***	0.0651**	0.9212	Downgrade	-1.0092***	-0.7296***	0.3556
	[0.0230]	[0.0285]		_low	[0.1765]	[0.2261]	
Lag_low	-0.1527	-0.048	0.5486	Upgrade	0.2892**	0.7673***	0.0298
	[0.1038]	[0.1411]		_bench	[0.1404]	[0.1708]	
Size	0.3206*	0.2781*	0.6339	Upgrade	-0.2039***	-0.2272***	0.7668
	[0.1709]	[0.1509]		_high	[0.0385]	[0.0477]	
Leverage	-0.1059*	-0.0711	0.7092	Upgrade	0.6221***	0.2811	0.4045
	[0.0587]	[0.0483]		_low	[0.2247]	[0.2743]	
Lag_combined	0.0013	0.0014	0.0785	Lag_high	0.0632***	0.0630**	0.9396
	[0.0014]	[0.0012]			[0.0232]	[0.0287]	
Capitalization	0.4841***	0.8560***	0.2213	Lag_low	-0.069	-0.193	0.5698
	[0.0931]	[0.0947]			[0.1383]	[0.1831]	
CAT risk	1.5455**	-1.7803**	0.2811	Size	0.3175*	0.2819*	0.5899
	[0.7598]	[0.7749]			[0.1709]	[0.1509]	
Long_tail	0.1134	0.5452*	0.7465	Leverage	-0.1043*	-0.0691	0.7242
	[0.4085]	[0.3274]			[0.0587]	[0.0482]	
Geo_Herf	0.8041*	0.7249*	0.3804	Lag_combined	0.0013	0.0015	0.0797
	[0.4255]	[0.4067]			[0.0014]	[0.0012]	
LOB_Herf	-0.036	-0.0358	0.0015	Capitalization	0.4809***	0.8521***	0.233
	[0.3557]	[0.4020]			[0.0931]	[0.0946]	
STD_CF	-1.2942**	-0.4167	0.0805	CAT risk	1.5370**	-1.7640**	0.2844
	[0.5913]	[0.5134]			[0.7595]	[0.7747]	
Pre_rating	-0.1103*	0.0623	0.0304	Long_tail	0.1318	0.5534*	0.7461
	[0.0599]	[0.0462]			[0.4084]	[0.3273]	
Pre_ROA	0.0095	0.0179***	0.0688	Geo_Herf	0.7991*	0.7374*	0.3921
	[0.0062]	[0.0064]			[0.4253]	[0.4066]	
Ln_Numrein	0.0735	0.2250***	0.9065	LOB_Herf	-0.0252	-0.0436	0.0018
	[0.0544]	[0.0439]			[0.3556]	[0.4019]	
Rein_rec	-9.5224***	-	<0.000	STD_CF	-1.2846**	-0.4173	0.0795
	[0.1744]	[0.1917]			[0.5911]	[0.5133]	
				Pre_rating	-0.1073*	0.0629	0.0295
					[0.0599]	[0.0461]	
				Pre_ROA	0.0096	0.0178***	0.0786
					[0.0062]	[0.0064]	
				Ln_Numrein	0.0758	0.2228***	0.9573
					[0.0543]	[0.0439]	
Year dummies	Yes	Yes		Rein_rec	-9.5010***	-12.8348***	<0.000
Firm fixed	Yes	Yes			[0.1744]	[0.1917]	
Observations	58,686	54,637			58,686	54,637	
r2-w	0.0515	0.0815			0.0522	0.0822	

Note: Standard errors are in brackets. Significant at the ***1%, **5%, and *10% levels. Both firm and time fixed effects are included but not reported due to space limit. Dependent variable is the change in proportion of a ceding insurer *i*'s reinsurance premium ceded to a reinsurer *j* over total reinsurance premiums ceded of the ceding insurer *i*. A ceding insurer has a high sustainability score when the reinsurance portfolio did not change much during the past five years. Median sustainability score is used as a cutoff for division of long sustainability (Long) vs. short sustainability (Short). Definitions of control variables are in Table 2.

The Impact of Outsourced Health Information Technology on Hospital Productivity

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Nov. 5, 2016

Health Information Technology

- “Innovations in electronic health records will help transform healthcare in America”, President Bush
- “We will update and computerize our health care system to cut red tape, prevent medical mistakes, and help reduce health care costs by billions of dollars each year”, President Obama

Background

- Health IT is widely regarded as a solution to health quality and cost problems
  - Bush Administration: establish the Office of the National Coordinator for health IT in 2004
  - Obama Administration: sign Health Information Technology for Economic and Clinical Health in 2009

Research Questions

- Does Information Technology outsourcing affect hospital productivity?
- Other ancillary Questions;
  1. Is outsourced health IT comparatively more effective than in-house health IT?
  2. What are the optimal amounts of IT outsourcing to improve productivity?
  3. How do the effects of IT outsourcing on productivity differ across hospital characteristics?
  4. Are there learning spillover effects in IT outsourcing?

IT Outsourcing Expansion

- A rapid expansion of outsourcing in manufacturing and services over the two decades.
    - A notable area is the information technology (IT) services.
    - The global IT outsourcing market grew over $250 billion for last two decades
- Healthcare IT outsourcing has grown significantly among healthcare organizations
    - global healthcare IT outsourcing market forecast to grow at a significant annual growth rate of 7.6 percent
    - north America accounts for the largest share, 72 percent, of the global healthcare IT outsourcing market

IT Outsourcing Expansion Cont.

- Drivers for IT outsourcing in health industry differs from those for general industry
  - U.S. healthcare spending accounted for 17.5% of gross domestic product (GDP) in 2014
  - BBA imposed reduced access to funding
  - HIPAA makes security a priority for healthcare providers
  - HITECH act requires providers to demonstrate meaningful use (MU) of EMR

Theoretical Background of Outsourcing

- Transaction Cost Eeconomics (TCE)
  1. Reduction of direct operating costs
     - focuse on reduction of wage and managerial administrative overhead
  2. Specialization in core competences
     - asset specificity is involved if specific investments are required to support transactions and realize least cost performance
  3. Substitution of non-core competences with inputs from a specialist provider
     - substitution effect arises when an organization replace its non-core operations with inputs from a specialist provider with greater knowledge depth.

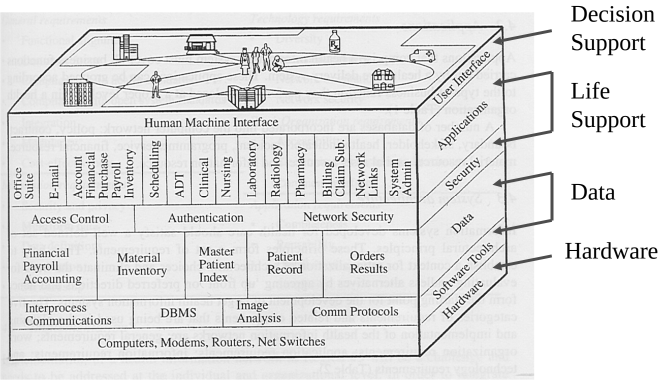
IT Outsourcing Literatures

- The relationship between IT outsourcing and performance is mixed
  - Cost savings (Lacity et al, 1996; Saunders et al., 1997)
  - Higher financial performance (Loh and Venkatraman, 1995; Han et al., 2011;Knittel and Stango, 2007; Chang and Gurbaxani, 2013)
  - No effects on performance (Bhalla et al., 2008; Florin et al., 2005)
  - Worsened Financial performance (Wang et al, 2008; Oh et al, 2006)

What does Health IT do?

- Different types of IT
  - Clinical ITs: EHRs, CPOE, etc
  - Administrative ITs: Cost Accounting, Patient Billing, etc
- These and other systems serve a wide range of purposes, including:
  - Discharge planning and Capacity utilization
  - Decrease transaction costs
  - Improve billing and charge capture
  - Avert decision errors and Prevent communication errors

Integrated Delivery System IT Network



Hospital Production Function

- $Y = f(L, K, L_c, K_c^I, K_c^O, \epsilon) = \epsilon^{\beta_\epsilon} L^{\beta_l} K^{\beta_k} {L_c}^{\beta_{l_c}} {K_c^I}^{\beta_{k_c^I}} {K_c^O}^{\beta_{k_c^O}}$
  - Use the Cobb-Douglas specification, widely used to represent the relationship of an output to inputs.
  - $\beta_l, \beta_k, \beta_{l_c}, \beta_{k_c^I}$ and $\beta_{k_c^O}$: output elasticities
  - Value added production function:
    Operating revenues less intermediate inputs

Hospital Production Function - Cobb Douglas

- $y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_{l^c} l^c_{it} + \beta_{k^I_c} k^I_{cit} + \beta_{k^O_c} k^O_{c\ it} + \epsilon_{it}$
- $\epsilon_{it} = \alpha_i + \gamma_t + \omega_{it} + \eta_{it}$

y_{it} : log of value added
l_{it} : log conventional labor
k_{it} : log conventioanl capital
l^c_{it} : log IT labor
k^I_{cit} : log owned IT capital
$k^O_{c\ it}$: log outsourced IT capital
α_i : hospital fixed effect
γ_t : time varying productivity shock
ω_{it} : unobserved productivity shock
η_{it} : observed productivity shock.

Estimating Production Functions

- Marshak & Andrews (1944)
  - $y_{it} = \beta x_{it} + \eta_i + v_{it}$
  - Endogeneity Problem in Production Function
- Anderson & Hsiao (1981, 1982)
  - Basic First Differenced Two Stage Least Squares (2SLS)
  - $\Delta y_{it} = \beta \Delta x_{it} + \Delta v_{it}$
  - Use x_{it-2} as instrument variables because $E(x_{it-2}\Delta v_{it}) = 0$
  - Not asymptotically efficient

Estimating Production Functions Cont.

- Allerano & Bond (1991) and Holtz-Eakin *et al.*(1998)
  - First Differenced Generalized Method of Moments (GMM)
  - Asymptotically efficient
  - Weak instrument problem when data are highly persistent
- Blundell & Bond (1998, 2000)
  - Dynamic Panel Data (PDP)
  - Use lagged difference and lagged levels as instruments
    - $E[x_{it-s}\Delta v_{it}] = 0$ & $E[y_{it-s}\Delta v_{it}] = 0$, for $s \geq 2$ and $t \geq 3$
    - $E[\Delta x_{it-s} v_{it}] = 0$ & $E[\Delta y_{it-s} v_{it}] = 0$, for $s \geq 1$ and $t \geq 3$
  - Show a lower finite sample bias and a substantial increase in precision

Data

- California Hospital Data (Office of Statewide Health Planning and Development): 1997-2007
  - Hospital level
  - Provide the hospital income statement, balance sheet, and statement of cash flows.
  - **Dollar measure of IT capital and IT labor**

Sample

Average number of Acute Care Hospitals by Ownership

Total	*For Profit*	*Not For Profit*	*Gov.*
333.7	78.6	194.4	61.5
100%	23.6%	58.3%	18.4%

Average Bed Size by Ownership

Total	*For Profit*	*Not For Profit*	*Gov.*
226.2	159.6	257.7	210.4

Descriptive Statistics

Average share for entire sample (Unit: thousand)

Variable	*Total*	*Share*	*FP Share*	*NFP Share*	*Gov. Share*
Value added	133,895	100.0%	100.0%	100.0%	100.0%
	(181,806)				
Labor, L	117,851	88.0%	89.7%	88.0%	86.4%
	(151,530)				
Capital, K	173,090	129.3%	108.4%	133.6%	121.3%
	(267,923)				
IT Labor, L^c	1,576	1.2%	0.7%	1.2%	1.4%
	(3,146)				
IT Capital, K_c^I	3,636	2.7%	0.8%	3.1%	2.6%
	(8,579)				
IT Capital, K_c^O	1,901	1.4%	1.0%	1.6%	1.1%
	(4,040)				

*Share: input relative to value added

Estimation results

Variable	OLS Level	Fixed Effect	DPD
Labor, l_t	0.779**	0.602**	0.776**
	(0.099)	(0.070)	(0.046)
Capital, k_t	0.099**	0.089**	0.147**
	(0.014)	(0.015)	(0.026)
IT Labor, l_t^c	0.012**	0.011**	0.019**
	(0.003)	(0.003)	(0.007)
IT Capital, Owned, $k_{t_c}^I$	0.014**	0.012**	0.018**
	(0.002)	(0.003)	(0.005)
IT Capital, Outsourced, $k_{t_c}^O$	0.006**	0.006**	0.014**
	(0.002)	(0.003)	(0.007)

$** : p < 0.01$

Identification of DPD

- Estimates in OLS & FE model are almost all lower than the estimates in DPD
  - Indicate input choices are endogenous
- Common factor restrictions are not rejected
- Over-identification restrictions are not rejected

Marginal productivity in IT inputs

- Short-run gross marginal product
  - Owned IT: 66.7%
  - Outsourced IT: 100%
- Long-run gross marginal product
  - Owned IT is stock variable
  - Marginal product of owned IT ranges from 152% to 177%.

- The value of owned IT capital would be substantially higher if it remained fully productive until the end of its useful life

DPD estimates by percent of outsourced IT

	Percent of $\leq$ 50%	outsourced IT 50%<X <80%	over total IT $\geq$80%
l_t	.773**	.665**	.709**
	(.028)	(.037)	(.038)
k_t	.144**	.192**	.127**
	(.020)	(.022)	(.025)
l_t^c	.024**	.014**	.025**
	(.007)	(.006)	(.005)
k_t^{cI}	.028**	.012**	0.014
	(.004)	(.005)	(.003)
k_t^{cO}	.004	.014**	.004
	(.005)	(.007)	(.006)

$* : p < 0.05, ** : p < 0.01$

Percent of outsourced IT over total IT

- Hospital with more than 50 percent and less than 80 percent of outsourced IT over overall IT had a significant gain from outsourced IT.
- Hospital with not too much of outsourced IT had a significant productivity gain from outsourced IT.

DPD estimates by Ownership

Variable	For Profit	Not For Profit	Government
Labor, l_t	0.927**	0.561**	0.471**
	(0.041)	(0.065)	(0.073)
Capital, k_t	0.062**	0.087*	0.109**
	(0.026)	(0.033)	(0.031)
IT Labor, l_t^c	0.030**	0.007*	0.040**
	(0.008)	(0.004)	(0.010)
IT Capital, Owned $k_{t_c}^I$	0.011**	0.008**	0.018**
	(0.005)	(0.004)	(0.005)
IT Capital, Outsourced $k_{t_c}^O$	0.008	0.007	0.017
	(0.006)	(0.006)	(0.013)

$* : p < 0.05, ** : p < 0.01$

Interpretation-Ownership

- Hospital ownership influenced the outsourced IT investment, but this different IT adoption behavior may not lead to productivity.
- Owned IT was positively associated with hospital productivity, but not outsourced IT in all three ownership.
  - Government hospitals have the largest effect of owned IT on productivity

DPD estimates by bed size and time frame

	$\leq$ 173 beds	>173 beds	$\leq$ 2001	$\geq$ 2002
l_t	.668**	.826**	.460**	.784**
	(.075)	(.044)	(.148)	(.047)
k_t	.139**	.112**	.220**	.145**
	(.033)	(.026)	(.093)	(.027)
l_t^c	.022**	.007**	.012**	.020*
	(.007)	(.005)	(.028)	(.007)
k_t^{cI}	.009**	.021**	-0.012	.020**
	(.005)	(.004)	(.017)	(.004)
k_t^{cO}	.013**	.007	.050*	.016**
	(.007)	(.006)	(.025)	(.006)

$* : p < 0.05, ** : p < 0.01$

Bed size and Time frame

- Bed Size
  - Smaller hospitals have a significant productivity gain from outsourced IT capital, which is bigger than owned IT capital.
  - Larger hospitals have productivity gain only from owned IT capital, not from outsourced IT.
  - Information Technology is an attractive candidate for outsourcing for many small and medium sized firms
- Time frame
  - Outsourced IT was more productive in earlier than later period.
  - Owned IT did not lead to productivity gain in the early period,
  - The early period is mitigating practice because the learning is slow, supplier capabilities are not fully tested.

Conclusions - IT value and Percent of outsourced IT

- Outsourced IT is significantly associated with hospitals productivity
  - Short term marginal product of outsourced IT is almost two times larger than that of owned IT.
  - Long-run marginal product of owned IT is large than that of outsourced IT
- It implies that hospital may invest more outsourced IT to improve productivity in the short run
- Percent of outsourced IT over total IT
  - Hospital with not too much of outsourced IT had a significant productivity gain from outsourced IT.

Conclusions - Ownership, Bed size and Time frame

- Ownership
  - Owned IT was positively associated with hospital productivity, but not outsourced IT in all three ownership.
- Bed Size
  - Smaller hospitals have a significant productivity gain from outsourced IT capital
  - Larger hospitals have productivity gain only from owned IT capital, not from outsourced IT.
- Time frame
  - Outsourced IT was more productive in earlier than later period.
  - Owned IT did not lead to productivity gain in the early period,

Questions?

Thank you

IT labor and IT capital Variables in OSHPD Data

- $L_c = SW_t + B_t + F_t$
  SW : Salaries and Wages
  B : Employee Benefits
  F : Professional Fees

- $K_c^I = OE_t + PC_t$
- $K_c^O = PS_t + LR_t$
  PS : purchased service
  LR : leases and rentals
  OE : other direct expenditure
  PC : physical IT capital

System Generalized Method of Moment

We can obtain a consistent GMM estimator of β by minimizing the following;

$J_N = (\frac{1}{N}\sum_{i=1}^{N} u_i' z_i) W_N^{-1} (\frac{1}{N}\sum_{i=1}^{N} z_i' u_i)$

where $W_N = \begin{pmatrix} W_1 & 0 \\ 0 & W_2 \end{pmatrix}$, $W_1 = \sum z_{1i}' \Delta v_i \Delta v_i' z_{1i}$ and $W_2 = \sum_1^N z_{2i}' z_{2i}$.

$$z_{1i} = \begin{pmatrix} y_{i1} & x_{i1} & 0 & 0 & 0 & .. & 0 & .. & 0 & 0 & .. & 0 \\ 0 & y_{i1} & y_{i2} & x_{i1} & x_{i2} & .. & 0 & .. & 0 & 0 & .. & 0 \\ . & . & . & . & . & .. & . & .. & . & . & .. & . \\ 0 & 0 & 0 & 0 & 0 & . & y_{i1} & .. & y_{iT-1} & x_{i1} & .. & x_{iT-1} \end{pmatrix}$$

$$z_{2i} = \begin{pmatrix} \Delta y_{i1} & \Delta x_{i1} & 0 & 0 & 0 & .. & 0 & 0 \\ 0 & 0 & \Delta y_{i2} & \Delta x_{i2} & 0 & .. & 0 & 0 \\ . & . & . & . & . & .. & . & . \\ 0 & 0 & 0 & 0 & 0 & .. & \Delta y_{iT-1} & \Delta x_{iT-1} \end{pmatrix}$$