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Stock Price Reaction To Data Breaches

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Abstract

Data Breaches occur in many forms that include bad security practices, hacking, insider attacks, stolen or lost equipment and computer or data theft. Data breaches happen to organizations of all types. In this paper, we present an analysis of the stock market's assessment of the cost of data breaches through the examination of 467 heterogeneous data breach events that occurred at 261 publicly traded companies between year 2005 and 2014. Our event study findings indicate that publicly traded firms in the U.S. lost, on average, .37% of their equity value when a data breach occurs. Particularly, we find that breaches resulting from payment card fraud contributed more to negative announcement returns than the other breach types. Such negative announcement effects are most heavily felt when firms with card breaches are larger than the average, resulting in a 3% decline in firm equity value. Contrary to previous studies, we find that repeated breaches do not impact firm stock value differently than first-time-breaches. However, we find that there is a high correlation between firm size and the existence of multiple, repeat, data breaches. This implies that large firms hit by a data breach are more likely to experience subsequent breaches than small firms.

I. Introduction and Study Context

As computer and online activity continues to increase, it is imperative that managers understand more fully what financial consequences occur with different types of data breaches. Data breaches include computer hacking, lost or stolen computer equipment, and employee data theft. The costs to companies of data breaches include both direct costs like reimbursement of customer losses and indirect costs like loss of consumer/investor confidence. In addition, potential litigation may be incurred, which will additionally incur direct and indirect costs associated with the litigation. The Ponemon Institute reports that U.S. companies incurred $5.4 million in direct costs, on average, for each data breach that occurred. The urgency for U.S. firm mangers to understand the costs of data breaches is borne out by the fact that direct costs per breach incurred by U.S. firms is higher than the direct costs incurred by companies domiciled in any other country in the world (Ponemon 2015, Spiderlab 2015).

This paper analyses the consequences associated with data breaches in a large sample of heterogeneous publicly traded firms. Particularly, the paper examines stock price announcement effects associated with a data breach to determine the direct and indirect costs stemming from the loss of investor confidence. Examining the stock price behaviour is important because stock price reflects current, expected future costs and risk associated with a data breach from the investor's point of view. It is also important to the affected firm's management teams because stock price reflects firm value, which indicates overall strength and health of a company, the factors that is critical in determining firm's future cost of capital, credit ratings, employees' and manager's compensation, management team's firing decision and etc. Most importantly, publicly traded companies' management teams are hired

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to represent the owners, whom are the shareholders. Hence, increase (decrease) in share price often indicates an owner's value increasing (decreasing) behaviour by the management.

The paper has three goals. Our primary goal is to determine the average announcement effect on the stock market of all types of data breaches on a wide variety of publicly traded firms. Our secondary goal is to determine what, if any, types of data breaches are worse for the average firms in the market. Our tertiary goal is to determine the influence of repeat breaches, firm size and size of data breach on firm value. This should help managers determine the degree of their risk exposure and the level of effort that should be expended on cyber security in their firms.

The motivation for this paper is similar to previous papers in that we wish to determine the impact of data breaches on firm value. However, our research extends the prior literature on data breaches with a larger and longer-period data set. With its large heterogynous sample of data breaches, we provide results that are more representative of all data breaches than previous studies. Additionally, with a larger sample size, it is possible to have greater confidence in any second order effects that are found to differentiate firms within the sample. We also include different types of data breaches, which makes the analysis more interesting by examining the impact on stock values depending on the type of breaches and whether the corresponding announcement effects are different from one another. In addition, our study controls for other confounding effects to solely recognize the data breach event effect on the stock price, which has been rarely done in prior data breach event study papers.

II. Literature review

Previous literature looking at the impact of data breaches on firm value has provided mixed results. Some of the studies have found significant negative impacts and some have only found little to no support for the idea that data breaches impact firm value. For a summary of these results, see Table I below. Previous studies have mostly focused on breaches that were reported in major news publications such as the Wall Street Journal and USA Today. Some studies found overall negative effects (Garg et al., 2003; Cavusoglu et al., 2004; Gatzlaff et al., 2010; Acquisti et al., 2006) while others find no significance associated with data breach announcements (Campbell et al., 2003; Hovav et al., 2003; Kannan et al., 2007). However, these studies have used relatively a small number of data breaches to draw conclusions, as can be seen in Table I in sample size column.

Table I. Summary of Previous Data Breach Event Studies

Paper	PublicationDate	Sample Size	Data Years	Window	CAAR Entire Sample
Acquisti et al.	2006	79	2000-2006	2 day	-.58%
Campbell et al.	2003	43	1995-2000	3 day	insignificant
Cavusogluet al.	2004	66	1996-2001	2 day	-2.1%
Garg et al.	2003	22	1996-2002	3 day	-5.3%
Gatzlaff et al.	2010	77	2004-2006	2 day	-.46%
Hovav et al.	2003	23	1998-2002	3 day	Insignificant
Kannan et al.	2004	102	1998-2002	4 day	Insignificant
This paper		467	2005-2014	3 day	-.37%

III. Hypothesis development

The first goal of this paper is to discover the extent to which data breaches impact the value of firms. The previous literature indicates that the overall impact on firms experiencing data breaches is either negative or zero. Hence, our first hypothesis, stated in the null, becomes:

H1: The average abnormal return associated with the 3-day event breach window is zero on average for the firms in the sample.

We also develop three categories of hypotheses about how the impact of data breaches varies across firms based on firm type, breach type, and the possible unique characteristics of the data breach. For firm type, firms were first split into financial and insurance services, retail/merchant and others. These groupings are provided by Privacy Rights Clearing House, 2014, which provided the data breach dates and information. Other potential grouping of firms was considered but the grouping provided by privacy rights clearing house clearly separated firms that are financial intermediaries from those which primarily provide goods and service. To examine how different breach types impact firm's variables used for data breaches are split into 7 breach types as classified by the Privacy Rights Clearing House, 2014. Finally, breach/firm characteristics are potentially thought to influence the size of any data breach impact on firm wealth. These characteristics are whether the breach has been experienced repeatedly by the firm (REPEAT), whether a firm has a market capital above 10billion (LARGECAP), and how large the breach size is (BREACH_SIZE). Table II below shows the definition of independent variables used in the three groups of hypotheses.

Table II. Definition of Independent Variables

Variables	Expected Result	Definition
Firm Type		
BSF	Negative	Businesses - Financial and Insurance Services - US publicly listed firms in the financial and insurance services
BSR	Negative	Businesses - Retail/Merchant - US publicly listed firms in the retail industry
OTH	Negative	Businesses - Includes a wide variety of firms that cannot be classified as either retail or financial.
Data Breach Type		
CARD	Negative	Payment Card Fraud- Fraud involving debit and credit cards that is not accomplished via hacking. For example, skimming devices at point-of-service terminals.
DISC	Negative	Unintended disclosure - Sensitive information posted publicly on a website, mishandled or sent to the wrong party via email, fax or mail.
HACK	Negative	Hacking or malware - Electronic entry by an outside party, malware and spyware.
INSD	Negative	Insider - Someone with legitimate access intentionally breaches information - such as an employee or contractor.

PHYS	Negative	Physical loss - Lost, discarded or stolen non-electronic records, such as paper documents
PORT	Negative	Portable device - Lost, discarded or stolen laptop, PDA, smartphone, portable memory device, CD, hard drive, data tape, etc
STAT	Negative	Stationary device - Lost, discarded or stolen stationary electronic device such as a computer or server not designed for mobility.
Firm and breach Characteristics		
REPEAT	Neutral	A proxy for breaches that represent a repeated occurrence for the individual firm.
LARGECAP	Negative	A proxy for the size of the firm based on its market capital. This represents large companies with a market capital above $10 billion
BREACH_SIZE	Negative	A proxy for the size of the breach based on the number of records affected. This represents breaches affecting over a hundred thousand records

Stated as the null hypothesis:

H2: Firm type do not matter. That is, financial and insurance firms are not significantly different from other firms in the sample. And retail and merchant firms are not significantly different from other firms in the sample.

H3: Breach characteristics don't matter. That is CARD, DISC, HACK, INSD, PHYS, PORT, STAT breaches are no different from other breaches in the sample.

H4: Firm and breach characteristics don't matter. That is, REPEAT breaches are no worse than original breaches, LARGE CAP firms are no more heavily impacted than small cap firms and the amount of information breached, BREACH SIZE, doesn't matter.

IV. Event Study Research design

The sample used for this study consists of instances of data breaches in publicly traded entities over 10 years. This sample was derived by collecting a list of all data breach announcements from the privacy rights clearing house. The privacy rights clearing house is non-profit organization that "educates and empowers" individuals to protect their privacy. This organization acquires observations from sources such as the Open Security Foundation, DataBreaches.net, PHI Privacy, and NAID. By closely monitoring several media outlets, government websites, and blog posts, these sources are combined to provide the most comprehensive dataset for privacy breach events. The reported breaches in database from the privacy rights clearing house consists of breach reports that have been reported because the personal information compromised includes data elements useful to identity thieves, such as Social Security numbers, account numbers, and driver's license numbers. We chose this medium for selecting our sample because we wanted to develop a sample that was representative of the population of all information security breaches. This research relies on the most comprehensive data set available that extends beyond the traditional use of newspapers as the sole source of breach announcement dates and related data.

Our search for information security breaches covers the period January 2005 through December 2014. The raw dataset obtained from Privacy Rights Clearing House, 2014, contained 1,715 data breach events in sectors including business, educational institutions, government/military, healthcare/medical providers, and non-profit organizations. This list was then sorted for publicly traded companies in the United States, and narrowed our initial selection down to 497 data breach events. Additional sample selection criteria are the availability of sufficient returns history (i.e., a minimum public trading history) on the Center for Research in Security Prices (CRSP) database for the estimation period necessary for our event study, continuity in the corporate entity's identity over the period, and elimination of multiple events where estimation periods overlap earlier events for the same firm. When there was an overlap in the estimation period with a prior event for the same firm, we used the earlier event reporting date and dropped an observation. Using these criteria eliminated thirty breaches, leaving us with 467 data breach events in 261 unique publicly listed US firms. Table III Panel A provides a breakdown of the sample of breaches by breach type and firm type. Clearly all types of firms have experienced a wide variety of data breaches with no obvious grouping within a given sector. Table III Panel B provides a breakdown of the sample by year. Over the 10-year period there appears to be significant variability in the number of breaches reported. However, there does not appear to be a clear upward or downward trending in the number of breaches over time.

Table III

Panel A: Data Breaches by Firm Type and Breach Type

	CARD	DISC	HACK	INSD	PHYS	PORT	STAT	UNKN	Total
BSF	13	32	29	29	8	43	6	11	171
BSR	8	22	38	39	10	33	5	5	132
Others		24	35	12	2	52	6	5	136
Total	21	78	102	80	20	128	17	21	467

Panel B: Data Breaches by Year

	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	Total
No. of Breaches	23	64	63	28	75	10	57	61	66	20	467

V. Test of Market Reaction

The first hypothesis is tested by examining the overall industry market reaction to the reporting date of each data breach event. The market reaction was determined by measuring daily abnormal returns (ARs), i.e., the difference between actual and expected returns. To control for the effects of market-wide fluctuations, the market model is used to measure expected returns:

$$R_{it} = \alpha_i + \beta_i R_{mt} + e_{it}$$

where R_{it} is the return for the ith data breach event on day t, α_i is the intercept for the ith data breach event, β_i is the slope coefficient for the ith data breach event, R_{mt} is the return on an equal-weighted market portfolio on day t, e_{it} is the error term with mean zero.

Following the findings of Brown and Warner (1980, pp. 242–243); Brown and Warner (1985, p. 12); and Binder and Summer (1985, p. 173), an equal-weighted market index is used as a proxy for the market rate of return. The parameters α_i and β_i were estimated for the event by using 255 trading days of daily return data ending 30 days prior to the breach

being reported. Generally speaking, in event studies, we want the parameters of the model to be estimated over a short time period before the event occurs. This involves a trade-off. The closer the estimation period is to the event period; the less likely it is that sample firm betas have changed due to changes in leverage, management strategy, and firm investments, etc. But, estimation data from a period too close to the event period may be contaminated by abnormal returns that were caused during previous regulatory announcements or proceedings. We choose to estimate the parameters of the model using 255 days of data ending 30 days prior to the breach being reported. We did this to, as much as possible, avoid confounding information about the data breach event that could potentially bias the estimates. Once the parameters α_i and β_i have been estimated for each firm, the daily prediction errors (abnormal returns) for firm *i* was calculated as follows:

$$AR_{it} = R_{it} - [\alpha_i + \beta_i R_{mt}]$$

where AR_{it} is the abnormal return for firm *i* on day *t*.

We examine abnormal returns for the three-day window that includes the event day and the two trading days immediately before and after the event. Inclusion of the trading days prior to the event controls for information leakage that may occur if some market participants are privy to the information prior to public announcement of policy actions. Inclusion of the trading days after the event accounts for late arrival of information to the market or adjustment to information that requires time for market participants to interpret. A window that is too large will include extraneous information. Conversely, a window that is too small will not fully capture the effects of information leakage or slow market adjustment. We choose a window of 3-days. Thus, our results are reasonably conservative and should cover a significant amount of the impact of the data breach. While there is nothing unique about the choice of this 3-day window it seems to fall within the realm of that used by previous researchers see Table I. The three day cumulative abnormal returns for each firm were computed as below:

$$CAR_i = \sum_{t=-1}^{+1} AR_{it}$$

where CAR_i is the cumulative abnormal return for data breach event *i,* AR_{it} is the abnormal return for data breach event *i* on day *t,* and *t*=0 is the day the data breach is reported to the government.

To determine the average overall impact of the events on the industry, we calculate the three-day cumulative average abnormal return by summing across the *n* firms in the sample and dividing by the number of firms in the sample as below:

$$CAAR = \sum_{i=1}^{n} CAR_i/n$$

where *CAAR* is the cumulative average abnormal return across all events in the sample, and CAR_i is the 3-day cumulative return for data breach event *i* around the event. CAAR is the 3-day cumulative average abnormal returns for the sample of *n* data breach events. To examine whether each informational event had a significant average return effect on the industry, a test of the null hypothesis that the three-day cumulative average abnormal return across firms equals zero is performed using a Z statistic.

VI. Cross-sectional analysis

Cross-sectional analysis is employed to test the three groups of hypotheses that differences in abnormal returns across firms are explained by the firm type, breach type, and the characteristics of the data breach. Specifically, multiple regression analysis is used to examine the relationship between the market reactions to each data breach event based on the variables in these three separate categories.

The first category is firm type. Two variables are used to represent each firm type and a dummy variable that equals one for the corresponding variable and zero if it is not. We estimate the following multiple regression model for the total sample:

$$CAR_i = \gamma_0 + \gamma_1 BSR_i + \gamma_2 BSF_i$$

where CAR_i is the 3 day cumulative return for firm *I,* BSR_i is a dummy variable that equals one if the firm involved in the breach is a retail firm, and BSF_i is a dummy variable that equals one if the firm involved in the breach is a financial and insurance services firm. γ_0, γ_1, γ_2,, are the estimated intercept and two slope coefficients. γ_1 , γ_2,, provides a potential estimate of the additional impact that may exist for re the estimated intercept and two slope coefficients, respectively.

The second category is the breach type. Seven variables are used to represent each breach type and a dummy variable that equals one for the corresponding variable and zero if it is not. We estimate the following multiple regression model for all available observations in the sample:

$$CAR_i = \gamma_0 + \gamma_1 CARD_i + \gamma_2 DISC_i + \gamma_3 HACK_i + \gamma_4 INSD_i + \gamma_5 PHYS_i + \gamma_6 PORT_i + \gamma_7 STAT_i$$

where CAR_i is the 3 day cumulative return for firm *I,* $CARD_i$ is a dummy variable that equals one if the type of breach is a payment card fraud, $DISC_i$ is a dummy variable that equals one if the type of breach is an unintended disclosure, $HACK_i$ is a dummy variable that equals one if the type of breach is a hack breach, $INSD_i$ is a dummy variable that equals one if the type of breach is an insider breach, $PHYS_i$ is a dummy variable that equals one if the type of breach is a physical loss, $PORT_i$ is a dummy variable that equals one if the type of breach is a portable device breach, and $STAT_i$ is a dummy variable that equals one if the type of breach is a stationery device breach. γ_0, γ_1, γ_2, γ_3, γ_4, γ_5, γ_6, γ_7, are the estimated intercept and seven slope coefficients, respectively. Our second hypothesis predicts that the estimated coefficient on *CARD*, γ_1, will be negative and less than the other coefficient.

The third category is the characteristics of the data breaches. Four variables are used to represent each characteristic and a dummy variable that equals one for the corresponding variable and zero if it is not. We estimate the following multiple regression model for all available observations in the sample:

$$CAR_i = \gamma_0 + \gamma_1 REPEAT_i + \gamma_2 LARGE\_CAP_i + \gamma_3 BREACH\_SIZE_i$$

where CAR_i is the 3 day cumulative return for firm *i,* $REPEAT_i$ is a dummy variable that equals one if the a repeated occurrence for the firm, $LARGE\_CAP_i$ is a dummy variable that equals one if the involved firm's market capital is above $10 billion, and $BREACH\_SIZE_i$ is a dummy variable that equals one if the number of records involved is over a hundred thousand records. γ_0, γ_1, γ_2, γ_3, are the estimated intercept and four slope coefficients, respectively. Our hypothesis predicts that the estimated coefficient on REPEAT, γ_1, LARGE_CAP, γ_2, and BREACH_SIZE, γ_3, will be non-zero. The results of the cross-sectional analysis are discussed in Section VI.

VII. Results

Table IV presents our test of hypotheses H1, which tests whether there is a significant negative effect on stock returns from data breaches. H1 was first tested by examining the overall industry market reaction to the reporting date of each data breach event with CAAR, the Cumulative Average Abnormal Return, which is an average of individual firm CARs. The CAAR is -0.37% for the entire sample of publicly traded firms as shown in Panel A of Table IV. The p-value for the appropriate test statistic, Patell Z, is .0019. Therefore, we conclude that the effect, while small, is significant and negative for any reasonable decision criteria. Also, as can be seen from Panel B of Table IV, there is no difference in market reaction to data breaches.

Table IV. Cumulative Average Abnormal Return (CAAR)

Panel A: over a 3-day event window

Event Tested	*n* (Number of Events)	3-Day CAAR[1]	Pos:neg[2]	Generalized Z-Statistic[3] (p-Value)	Patell Z-Statistic[4] (p-Value)
Data Breaches	467	-0.37%	203:264	-2.053 (0.0200)	-2.893 (0.0019)

1. CAAR is the average abnormal return for the of *an* event breaches in our sample over the three day event window, day before, day of and day after each data breach event. Abnormal returns are calculated using an equal weighted market index. 2. The number of firms with positive CAR versus a negative CAR in the sample. 3. Generalized Z-Statistic, one of the most commonly used one-tail test of significance different from zero. 4. Patel Z-Statistic, one of the most commonly used, in event studies, one-tail test of significance different from zero.

Panel B: change in market reaction: 2005-2009 vs 2010-2014

t-Test: Two-Sample Assuming Unequal Variances		
	CAAR	*CAAR*
	2005 to 2009	*2010 to 2014*
Mean	-0.004370222	-0.00317
Variance	0.001044889	0.00102
Observations	197	270
Hypothesized Mean Difference	0	
df	420	
P(T<=t) one-tail	0.3457172	
t Critical one-tail	1.648489713	
P(T<=t) two-tail	0.6914344	
t Critical two-tail	1.965628284	

In Figure I, we visually present the cumulative average abnormal return for the entire sample from 7 days before the announcement to day x, represented in the horizontal axis. We do this to help us look for the possibility of inefficiency with respect to the market incorporating the breach news. That is, the CAAR drops off quickly around the event and does not rebound. Hence, information leakage, over-reaction and under-reaction do not appear to be present in the study.

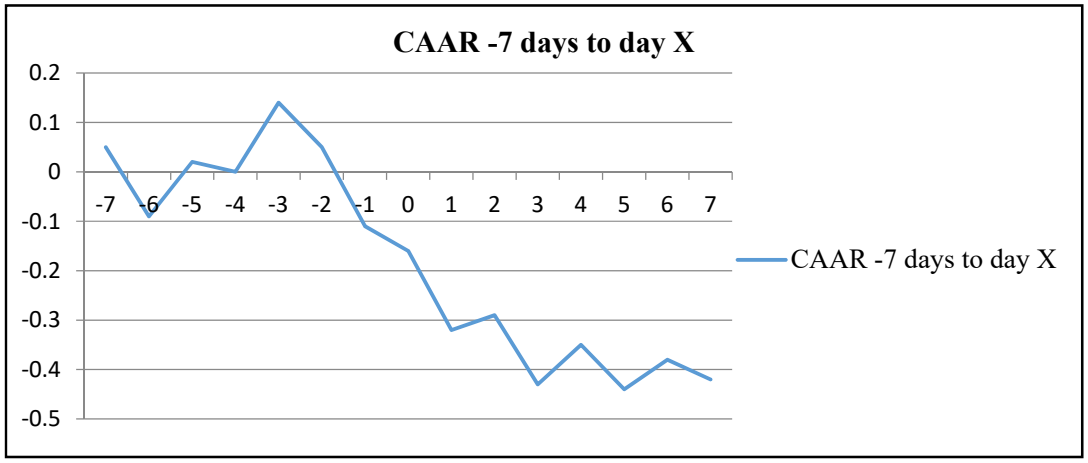

Figure I. CAARs starting 7 days before- and ending 7 days after- the event day

Table V Panel A presents the mean, standard deviation, maximum and minimum values for the dependent variable CAAR grouped by firm type, data breach type and firm characteristics. Visually there appear to be differences between the different groups but it is not obvious whether or not these differences are significantly different. It is worth noting that all but one of the subgroups experienced a negative CAAR associated with data breaches and that none of the subgroups reveal a zero effect. In fact, INSD, insider revealing information, may have very little effect on firms. We also not that standard deviation with between groups varies from 2.4% to 6.1%. This may indicate that the spread of outcomes is different between groups in the sample. Panel B of Table V presents correlation among the independent variables, except the dummy variables, used in the cross sectional regression analysis. It may be worth noting that the correlation between all of the independent variables is relatively low with the highest correlation existing between Large Cap and Repeat. This seems to say that Large Cap firms may be more likely to have multiple breaches after they have experienced their first breach.

Table V. Descriptive Statistics

Panel A: Descriptive Statistics for CAAR by firm type and breach type.

	Mean Percent Cumulative Abnormal Return	Minimum Percent Cumulative Abnormal Return	Maximum Percent Cumulative Abnormal Return	Standard Deviation Cumulative Abnormal Return
Firm Type				
BSF	-0.256	-14.292	8.097	3.171
BSR	-0.675	-22.813	13.893	3.689
OTH	-0.146	-9.892	9.036	2.574
Data Breach Type				
CARD	-1.673	-21.304	4.8722	6.090
DISC	-0.400	-12.214	6.893	2.748
HACK	-0.587	-22.813	13.894	3.910
INSD	0.0566	-8.129	7.578	2.448
PHYS	-0.714	-6.15	7.703	2.668

PORT	-0.269	-5.985	9.036	2.446
STAT	-0.629	-5.556	6.344	2.463
Firm Characteristics				
REPEAT	-0.310	-8.129	13.894	2.614
LARGE_CAP	-0.405	-22.813	8.097	2.777
BREACH_SIZE	-1.860	-14.292	3.968	4.868

Panel B: Correlation coefficients between breach type and firm characteristics.

	CARD	*DISC*	*HACK*	*INSD*	*PHYS*	*PORT*	*STAT*	*REPEAT*	*LARGE CAP*	*BREACH SIZE*
REPEAT	0.078	0.065	-0.042	0.203	-0.018	-0.179	-0.104	1		
LARGE_ CAP	0.016	-0.014	0.017	0.067	-0.128	-0.002	-0.063	0.321	1	
BREACH _SIZE	0.060	-0.005	0.049	-0.065	-0.044	0.044	-0.040	-0.052	-0.092	1

Table VI provides the results of four different cross-sectional regressions. The first regression, in Panel A, examines firm type, retail and financial. There is no support for the idea that either type of firm is likely to have greater than average value effects from a data breach. The regression in Panel B indicates that data breach incidents that occur as a result of payment card fraud (CARD) more negatively affect the firms in our sample than any other type of data breach. This result is significant at a 3.3% level and supports hypothesis. This implies that the average firm experiencing a CARD incident suffers a -1.67% change in firm value (sum of intercept and slope).

The regression in Panel C indicates data breach incidents that affect over a hundred thousand records (BREACH_SIZE) have a negative effect on the returns of the afflicted firms such that the average firm with large breach size experienced a CAAR of -1.79%. This result is significant at a 3.6% level. The regression also indicates that if a firm experiences multiple data breaches (REPEAT), the subsequent breaches are not more or less costly than the initial breach. Finally, in Panel D the regression is rerun with the only independent variables from Panels A, B and C that were significantly different than zero. We find that both slope coefficients remain significant at the 10% level and are qualitatively of similar size and magnitude as those in the previous regressions. The regression indicates that card data breaches with large loss of data might be expected to exhibit a 3% negative CAAR. This result helps to explain how previous studies have had such a wide range of CAAR estimates. Clearly, firms with the attributes mentioned above experience very large, negative, CAARs while most firms experience very small negative CAARs associated with data breaches.

Table VI. Multiple regression of 3-day CAR_i[1,2].

Panel A			
	Coefficient	t-Statistic[3]	P-value
Intercept	-0.00146	-0.53181	0.59511
BSR	-0.00529	-1.41514	0.1577
BSF	-0.00110	-0.29908	0.76501
R^2= 0.00500			

Adjusted R^2= 0.00071			

Panel B			
Intercept	0.00445	0.63625	0.52493
CARD	-0.02118	-2.14088	0.03281
DISC	-0.00845	-1.07260	0.28402
HACK	-0.01032	-1.34350	0.17977
INSD	-0.00389	-0.49429	0.62134
PHYS	-0.01159	-1.15739	0.24771
PORT	-0.00714	-0.94594	0.34468
STAT	-0.01074	-1.02682	0.30505
R^2= 0.01541			
Adjusted R^2= 0.00040			

Panel C			
Intercept	-0.00211	-0.76692	0.44352
REPEAT	0.00138	0.43673	0.66251
LARGE_CAP	-0.00225	-0.66706	0.50506
BREACH_SIZE	-0.01586	-2.10562	0.035775
R^2= 0.01027			
Adjusted R^2= 0.00386			

Panel D	Coefficient	t-Statistic[3]	P-value
Intercept	-0.00250	-1.62830	0.10414
CARD	-0.01283	-1.79858	0.07274
BREACH_SIZE	-0.01475	-1.97121	0.04930
R Square= 0.01606			
Adjusted R^2= 0.01182			

1. CAR_i is the three day cumulative abnormal return for data breach event *i* around the date of reporting the data breach to the government.
2. The regression was also performed with CAR regressed on all 14 independent variables in one regression equation. The results were qualitatively very similar to the individual regressions slope coefficients and p-values.
3. This is a two-tailed t-test of the hypothesis that the slope coefficient is not equal to zero. P-values give the level of confidence for the t-test.

VIII. Summary and conclusions

We examined the market reaction of 467 heterogynous data breaches and found that the average decline in firm value from a data breach was .37%. Unlike some previous studies, we find that firm type is not a major determinant in the effect of data breaches on stock price. Our cross-sectional regression results show that breaches resulting from payment card fraud contributed more to negative returns than the other breach types and that the most heavily hit firms were those where the card breaches were larger than average. In fact, when Card breaches were large the average firm experienced a 3% decline in value. Contrary to previous studies we find that repeat, versus first time breaches, do not impact firms differently than first time breaches. However, we find that there is a high correlation between firm size and the existence of multiple, repeat, data breaches. That is, large firms hit by a data breach may be more likely to experience subsequent breaches than small firms.

The implications of our results for managers are many. First, we find that managers should be alarmed about data breaches. Under the wrong circumstances the impact of a data breach can be quite large. Managers need to be aware that the majority of data breaches do not have extremely large impacts on firm value (-.37% on average). Thus, managers can take most data breaches in stride and deal with them when they arise. However, Managers should be aware that the real value changer for the firm is card breaches and that large card breaches are the most damaging. Strangely, larger firms may be more susceptible to card breaches and therefore managers of large firms may need to expend more energy more resources on data security that small firms. This correlational result may be due to the profit motive of those who wish to obtain such information. That is larger targets may have larger value to steal. Finally, managers should not become complacent after a breach has occurred because subsequent breaches appear to be just as costly, but no more costly, as first time breaches.

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Financial Performance and Compensation Alignment of CEOs - Evidence from the USA

Shahnaz Abdullah and Lal C. Chugh

Abstract

Largest U.S, companies have for years sought to tie executive pay to financial and stock market results. Using data from selected Fortune 500 companies over a decade, this paper documents CEOs' compensation is positively related to firm's accounting based performance. However, the study finds CEO compensation and market based performance still lacks alignment.

Additionally, the study investigates the financial performance of U.S companies both with and without women on their board. This in-depth study explores the theories of agency problem and empirically argues that increasing female directors on board composition can partially resolve agency problem as our results indicate adding women to the board maximizes the shareholder's value.

I. Introduction

The fierce debate among professionals and researchers about how well companies tie pay to performance became more intense at the brink of a financial crisis that began in 2007. In 2008, the crisis in the subprime market, the bankruptcy of the Lehman Brothers, and the collapse of the world's largest insurance company AIG caused a financial crisis in the US and is considered by most economists to be the worst financial crisis since the Great Depression. At times of financial crisis, corporate America's governance, chief executive officer (CEO) performance and leadership ability received paramount importance. The corporate compensation committee typically considers stock market performance when determining pay (Core et al., 2003). With the volatile stock market performance during the course of financial crisis, the alignment between CEOs pay and firm's performance became a question. In the corporate sector, shareholders are deemed to be the owners. Board of directors is selected/elected to enhance the wealth of owners, whereas, management including CEOs and other executives are the agents of owners. The agents are expected to maximize shareholder wealth. Although in some cases managers have their self-interests to maximize their remuneration, and perks, for example, personal use of corporate jets, payment of false relocation expenses, investment in luxury corporate hangers and empire building (Markham, J.W., 2007). It creates what has been called agency problem. In addition to the ongoing controversy of agency problem, some public corporations attracted a lot of media attention by hiring female CEOs during or after the crisis in 2007.

Using compensation data of selected Fortune 500 companies over a decade, the present article investigates the following issues: (1) whether or not the present compensation structure is tied to financial performance of the company (2) whether or not companies with female CEOs perform better (worse) than the companies without female CEOs. (3) The impact of board gender

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diversity on the performance of firm's financial performance. Since, the stock market and public corporations are extremely sensitive to the business cycle, an unique approach has been used in this paper to evaluate the CEOs pay for performance in two separate time periods, before the housing market crash (Pre- Lehman crisis 2003-2007) and after the crash (Post - Lehman crisis 2007-2013).

Previous research identifies two opposing views related to an agency problem. The first view, optimal contracting theory emphasizes designing compensation schemes to maximize shareholders value. The agency theory suggests that the most effective means for shareholders to ensure that managers take optimal actions is to tie executive pay to the performance of their firms (Aggarwal, R.K. and Samwick, A.A., 1999). The second view, the managerial power approach (Arye and Fried, 2003), asserts that CEOs and management teams may have considerable influence over the boards because of the important role CEOs play in reappointing the board of directors, directorship offers a well-paid salary along with valuable business and social connections. Thus, CEOs may have the discretion to negotiate their own compensation with the approval of a board; the board also have an incentive to favor the CEO. Under this approach, the high- powered managers influence their own compensation package; reflecting managerial rent seeking rather than the provision of efficient incentives (Yermack, 1997). According to this managerial power approach compensation is not only an instrument to solve the agency problem – but also could be a part of agency problem itself. Turning to the predictions of their managerial power model, Bebchuk, L. A., & Fried, J. M. (2004) asserts that managers may use their influence not only to claim more pay, but also to structure a compensation package that is less sensitive to performance. This type of compensation practice may increase the agency cost, managerial gains may exceed shareholders loss.

An optimum compensation package reflects CEO's power, and that CEOs with more power get more pay, but this does not necessarily lead to the conclusion that CEO pay is not optimized for shareholders (Core et al., 2005). Previous research in agency theory suggest that CEO compensation should be tied to financial performance so that CEOs will be encouraged to simultaneously maximize shareholder's as well as their own wealth (Stroh et al., 1996) and it will therefore minimize agency cost (Coombs et al., 2005).

Improved financial performance is the desired upshot of sound corporate governance. Irrespective of the composition of the board, who sits on the board and the CEO's gender, a failure to achieve an improved financial performance will have no practical value of appointing women either on the board or as a CEO of the company (Brown 2002). Again, regardless of the gender, a CEO or a board member should be selected based on their qualifications and, a systematic exclusion of the most able candidate based on their gender has the effect of damaging the financial performance of the firm (Brammer et al., 2007).

In this paper, we add a new dimension in the agency theory – the role of woman CEOs and female directors on company's performance. To date, there has been little empirical analysis of the cross-sectional structure of corporate performance, CEO gender and compensation policies.

The remainder of the article is organized as follows. Section I reviews the related literature on managerial compensation, agency theory and impact of CEO gender to compensation parameters. Section II presents the empirical results showing an association between CEO compensation and company performance thus examining the alignment of CEOs pay to performance. It also presents results about the impact CEO's gender as well as board's diversity on the company's financial performance. Section III presents the conclusions and policy recommendation.

II. Literature Review

A. Agency theory revisited

Agency theory predicts that compensation policy will be structured to give managers incentive to identify and implement actions that increase shareholders wealth, as such, compensation policy can provide value increasing incentives including performance based bonus and salary revisions (Jensen, M.C. and Murphy, K.J., 1990). However, it is not always the case. Recently Wall Street Journal reported that the companies that perform best do not always pay the CEOs the most (Theo, 2017). Using stock market return and CEO compensation data of 423 U.S companies over the period of 2006 to 2015, investment research firm MSCI Inc., found a weak correlation between stock market performance and CEO compensation; also identify that many of the best and worst performers simply paid average compensation.

The factors influencing the performance of a company have been the focal point of many studies. The last few decades witnessed an increase in the volume of empirical research and theories in the field of agency theory. When manager incentives are based on their companies' accounting performance, it may be in their self-interest to magnify the better performance through earnings management. In public companies, CEOs are compensated both directly (salary and bonus) and indirectly (in terms of prestige, negotiation for better compensation, and job security) depending on a firm's earnings performance relative to some pre-established benchmark (Xie, B. et al, 2003). The management's discretion over reported earnings and the effect these earnings have on their compensation leads to a potential agency problem.

As outlined in the optimal contract theory, agency problem may exist when the board does not know exactly what the agent has done in-terms of future investment. Given the self-interest of the agent, the CEO may or may not have behaved as agreed. Previous research also finds that weak corporate governance creates misalignment of performance and incentives resulting in excessive executive compensation (Brick et al., 2006).

The board of directors is most influential in making decisions to hire and fire a CEO, monitor the CEO's performance and determine CEOs compensation levels. However, managerial power approach dictates, greater the manager's power, greater their ability to rent - seeking, and negotiating higher pay package. Previous research also shows an alignment between the board and CEOs for various reasons.

The second line of research emphasizes the relationship of compensation to the stock price, which is the goal of stockholders. Some papers find a positive relationship between the executive compensation (including options and restricted stock) and stock returns, proving that

incentive compensation can be a useful vehicle for aligning shareholder interests and interests of management. However, recently there have been academic papers, which dispute these findings (Cooper et al., 2014).

B. Agency problem, CEO's Gender and Gender Diversity of Board of Directors

The overall percentage of Fortune 500 board seats occupied by women is 21% in 2016 vs. 19.6% in 2015. The percentage of companies with just one female board member in 2016 is 22% vs. 28% in 2015. Women still only hold 4.6% of CEO positions in S&P 500 companies (Catalyst 2016).

Previous research show stockholders respond more negatively to the announcement of female CEO appointments than to male CEO appointments (Lee, P.M. and James, E.H., 2007). Usually a board member is selected from the ranks of existing CEOs, however, as most of the CEOs are men (Gutner, 2001), selection of board members leans more towards men.

A firm can achieve competitive advantage through proper alignment of managerial preferences and actions towards shareholder-beneficial results. It can positively affect firm's performance and therefore reduce agency cost (Nyberg et al., 2010). Viewed this way, agency cost could be reduced by the gender- inclusive policy. If hiring a woman CEO or inclusion of women in the board of directors (diversity, on one side) significantly enhances firm's performance and maximizes shareholders wealth (shareholders benefit, on other side) agency costs would be reduced.

Previous academic studies, and popular media reports show an inconsistent pattern of relationship between woman CEOs and inclusion of women on boards on the performance of the company. The phenomenon of the CEO gender and the inclusion of women in corporate boards encompass at least two significant, and interrelated propositions. The first viewpoint holds that women are appointed to the leadership positions when company's performance is in turmoil. The second proposition suggests that gender of the CEO and gender diversity of the board results in better (worse) governance, which causes the business to be more (less) profitable or stock price performance.

Using data from London Stock Exchange, Ryan and Haslam (2005) found that companies, which appointed men to their boards, the performance of those companies was relatively stable, both before and after the appointments. Ryan et al., (2005) in the same study found that in a time of a general financial downturn in the stock market, companies that appointed women had experienced consistently poor performance in the months preceding the appointment, nevertheless, their stock market performance improves after the appointment. On the contrary, when the stock market was stable, companies that appointed women to their boards experienced positive but fluctuating stock performance after the appointment. Ryan and Haslam (2005, 2007) raised the possibility that, rather than women's appointment in leadership position causing poor performance of a company, a poor performing company might deliberately choose to appoint a woman to leadership position. Ryan et al., (2005, 2007) introduced a new theory

called "glass cliff" where women are hired to the leadership positions in times of corporate stress and hence it was more difficult for them to perform well.

The theory was challenged by Adams, Gupta and Leeth (2009) using data from US stock market over twelve year period. The study analyzed three key indicators of performance – return on assets (ROA), returns on equity (ROE) and earnings per share (EPS) and found no reliable evidence of the difference in companies' performance before or after the appointment of women and men. Adams et al (2009) concluded that poor financial health of the firm was not one of the factor that influences a board to appoint a woman CEO and thus providing no support for the glass cliff hypothesis that proclaim that female leader are over-represented at firms in times of financial crisis.

Haslam et al (2010) conducted another study using data from UK stock market and examined the impact of women board members on ROE, ROA and Tobin's q. The study found no significant relationship between gender of board members on ROE and ROA, however, the findings displayed a significant negative correlation between both the presence and percentage of women on company boards and Tobin's q. Haslam et al (2010) concluded that companies with male-only boards enjoyed a valuation premium of 37% over otherwise similar firms with one or more women on the board. Presence of women in the board is perceived by investors as a signal of organizational crisis and declining value of the company, and may set a precipitation of falling stock price. In same line of research, Carter et al (2010) using data from the S&P on 5,500 directors of both genders found significant and positive relationship between women on the boards and ROA without adversely affecting Tobin's q. The findings of the study do suggest that inclusion of women on the board may improve financial performance of a firm.

Another study (Adams and Ferreira, 2009) finds that women directors are more likely to sit on corporate governance committees than male directors, and less likely to sit on compensation committees and thus have less influence over the design of compensation package than their male counterparts. Interestingly, this study found that diverse boards are more likely to hold CEOs accountable for poor stock price performance and align with shareholder's interests. CEO turnover was found to be more sensitive to stock price performance in firms with relatively more women on the corporate board. However, an earlier study of appointing females either on the board or as a CEO of the company suggests that it does not improve the performance of a firm (Bertrand and Shoar 2003). This study infers that past experience and managerial style, not gender is important for success.

A study by McKinsey (2007) on 89 European countries found that companies with most gender diverse boards have higher financial performance in terms of return on equity (ROE), Earning Before Interest and Tax (EBIT) and stock price growth compared to the average of the entire sector. Another study by Lückerath-Rovers, M., (2013) using 116 Dutch companies found a statistically significant positive relationship between the presence of one or more women on the board and return on equity. Interestingly, using a of the 2500 largest Danish firms over the period 1993-2001 Smith et al., (Smith, N., Smith, V. and Verner, M., 2006) show the a positive performance effect of female CEOs for Danish firms. However, this positive effect gets stronger for the female executives and directors who also have higher education as compered to female executives who have less or no education. As different countries have different policies and agendas regarding appointing of female directors, it is therefore prudent to have a cross country

analysis to find the impact of board diversity on performance. A study by Terjesen et al., (2016) using data from 3,876 public firm in 47 countries asserts that firms with more female directors have higher firm performance by market (Tobin's q) and accounting measures (return on assets).

Evidence from empirical studies regarding board diversity and firm performance around the globe has been positive (study in Turkey by Kılıç, et al., 2016, study in Mauritius by Mahadeo et al. (2012). However some studies have found negative or inconclusive results (Ahern and Dittmar 2012 in Norway; Shrader et al. 1997 in US; Rose 2007 in Denmark; Haslam et al. 2010, UK, Wellalage et al., 2013 in Sri-Lanka). Using data from German firms Joecks and Vetter (2013) indicates a positive link between gender diversity and firm performance, only when a firm reached board composition of 30 percent of women as compared to no women on the board.

III. Data and sample selection

This study analyzes the link between CEO compensation and the firm's performance using sample of 34 firms with female CEOs from Fortune 500 companies and *a* pooled matching data with male CEOs in the same industry. All data was extracted from the Center for Research in Security Prices (CRSP), Value Line and Compustat databases, using the time period of 2003-2013.

Executive compensation has received an additional examination by the academic researchers and popular business press during the time of Lehman Crisis in 2008, which created a substantial drop in stock prices and widening pay gap between the highest and lowest paid employee. To examine if compensation alignment with performance varies after and before the financial crisis, this study divides the sample into two-time periods Pre (2003-2007) and Post (2008-2013) Lehman crisis. Same methodology was used by Erhardt et al., (2003), indicating inclusion of performance indicators from two different points in time can be helpful to control the changes in the market and bring a smoothing effect on the data.

Research methodology

Hypothesis 1: Higher percentage of women on the board of directors can positively affect the company's performance in both pre and post - Lehman periods.
Hypothesis 2: Gender of CEO may affect firm performance in both pre and post - Lehman periods.
Hypothesis 3: On average, firms will demonstrate financial alignment in the form of a positive relationship between CEO compensation and firms accounting as well as market based performances.

The following 4 models are tested to identify the impact of CEO compensation and gender of CEO and board members on firm's accounting and market performance indicators.

$$ROA = \alpha_i + \beta_{1i}Gender + \beta_{2i}Compensation + \beta_{3i}EBIT + \beta_{4i}Sales + \beta_{5i}\ EBITDA + +\beta_{6i}Beta + \beta_j \sum_{j=1}^{N} Year\_dummy_j + \varepsilon_i \quad (1)$$

$$ROE = \alpha_i + \beta_{1i}Gender + \beta_{2i}Compensation + \beta_{3i}EBIT + \beta_{4i}Sales + \beta_{5i}EBITDA + +\beta_{6i}Beta + \beta_j \sum_{j=1}^{N} Year\_dummy_j + \varepsilon_i \quad (2)$$

$$TSR = \alpha_i + \beta_{1i}Gender + \beta_{2i}Compensation + \beta_{3i}EBIT + \beta_{4i}Sales + \beta_{5i}EBITDA + +\beta_{6i}Beta + \beta_j \sum_{j=1}^{N} Year\_dummy_j + \varepsilon_i \quad (3)$$

$$Tobin\ Q = \alpha_i + \beta_{1i}Gender + \beta_{2i}Compensation + \beta_{3i}EBIT + \beta_{4i}Sales + \beta_{5i}EBITDA + \beta_{6i}Beta + \beta_j \sum_{j=1}^{N} Year\_dummy_j + \varepsilon_i \quad (4)$$

Measurement of the dependent variables

In this context, it is appropriate to provide the definitions of the dependent variable used in the above four models: return on assets (ROA), return on equity (ROE), total stockholder returns (TSR), and Tobin's q. The former two variables are based on the firm's accounting performance whereas the latter two variables are based on the firm's market performance.

Accounting based performance measures

According to agency theory, managers are likely to dissipate profits and mishandle earnings, thus leaving fewer returns for the shareholders. It is measured through several methods such as return on assets (ROA). The return on asset shows capacity and capability of the management to use the corporate assets. A lower rate of ROA will reflect the inefficiency in managing operations (Javed et al, 2013); on the contrary a higher rate will show optimum utilization of the assets. Maximizing shareholders wealth should be the goal of a public limited company; the ROE is a measure to indicate the return on shareholder investment that a firm generates. It is calculated by dividing net income by the book value of equity. Return on equity (ROE) is commonly used accounting measure in performance evaluation.
Where,

$$ROE_{it} = \frac{Net\ Income_{it}}{Common\ Equity, Total_{it}} * 100$$

$$ROA_{it} = \frac{Net\ Income_{it}}{Total\ Assets_{it}} * 100$$

Market based performance measures

The study uses two indicators TSR and Tobin's q as the dependent variables.

$$TSR_i = \frac{price_{end} - price_{beg} + dividends}{price_{beg}} * 100$$

Tobin's q is calculated as firm's market value divided by the firm's book value (Adams and Ferreira 2009). Firm's market value is defined as firm's total assets minus book value of common equity plus market value of common equity. The return data is taken from CRSP and includes dividends.

Measurement of independent variables

Our variable of interest, *female CEO* is a dummy variable, which takes a value of 1 if the CEO is a female and 0 for a male CEO. *Woman ratio* is the gender diversity index of the board and is calculated as the number of female members/board size.

Total compensation (TDC1), taken from ExecuComp, is defined as "Total compensation for the individual year, comprised of the following: Salary, Bonus, Other Annual, Total Value of Restricted Stock Granted, Total Value of Stock Options Granted (using Black-Scholes), Long-Term Incentive Payouts, and All Other Total." EBIT stands for earnings before interest and tax (EBIT) and EBITDA is earnings before interest, tax depreciation and amortization (EBITDA). In order to control for different sizes of earnings we use natural logarithm of both variables. Sales are natural log annual sales. Beta measures the firm's systematic risk with the overall market and is defined as follows:

$$Beta_{it} = \frac{COV(Firms\ Daily\ Return, S\&P\ 500\ Daily\ Return)}{Var(S\&P500\ Daily\ Return)}$$

Following the common practice in finance and accounting literature, all continuous variables are winsorized, which reduces the impact of large outliers on the regression results (Gul et al., 2011). It is widely distributed set of firms across various industries SIC (list with SIC codes is in the appendix).

IV. Results and Discussion

Table 1 reports the distribution of female CEOs according to year and industry. Panel A reports female CEO distribution by year. In total, we have 283 firm-years including 62 female CEO firm-years. 2012 has the highest number of CEO presence in our sample. 10 CEOs in 2012 are employed, whereas only 2 female CEOs were employed in 2005, the lowest number of female CEO employment in our sample period. Panel B shows the industry wise distribution of female CEOs. The research uses Fama-French industry classification in dividing industries in ten categories. Female CEOs have the highest presence in business equipment (computers, software and electronic equipment) industry (19 out of 68 observations). However, as percent of overall data consumer non-durable industry has the highest percentage of female CEOs (37.50%) years. Industries such as consumer durables and oil, gas, and coal extraction & products have no presence of female CEOs in our study period.

Table 1: Distribution of CEOs

Panel A: Distribution of female CEOs by year

Year	Female CEO	Total	Female CEOs (%)
2003	3	25	12.00%
2004	3	24	12.50%
2005	2	24	8.33%
2006	3	28	10.71%
2007	5	26	19.23%
2008	6	29	20.69%
2009	7	27	25.93%
2010	7	27	25.93%
2011	7	28	25.00%
2012	10	29	34.48%
2013	9	16	56.25%
Total	62	283	21.91%

Panel B: Distribution of female CEOs by industry

Fama-French industry code (10 industries)	No. of firm-years	% of firm-years	Female CEO	% of firm-years for industry
Consumer Non-Durables	48	16.96	18	37.50%
Consumer Durables	6	2.12	0	0.00%
Manufacturing	20	7.07	2	10.00%
Oil, Gas, and Coal Extraction & Products	20	7.07	0	0.00%
Chemicals and Allied Products	31	10.95	9	29.03%
Business Equipment -- Computers, Software and Electronic Equipment	68	24.03	19	27.94%
Telephone and Television Transmission	15	5.3	5	33.33%
Utilities	45	15.9	1	2.22%
Wholesale, Retail, and Some Services	19	6.71	6	31.58%
Healthcare, Medical Equipment, and Drugs	11	3.89	2	18.18%
Total	283	100	62	21.91%

For industry classification, see http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_49_ind_port.html.

Table 2: Sample Statistics for The dependent and Independent Variables

Panel A: Pre-Lehman Crisis Period (2003-2007)

Variable	N	Mean	Std. Dev.	Min	Max
(1) Dependent Variable ROA	127	7.516	6.709	-26.020	22.260
ROE	127	25.903	28.961	-72.390	179.050
TSR	102	9.324	24.075	-49.073	99.363
Tobin's q	127	2.202	1.330	0.976	8.645
(2) Control Variable Female CEO	127	0.126	0.333	0.000	1.000
Woman ratio	127	0.195	0.104	0.071	0.545
Ln of TDC1	127	8.840	1.815	-6.908	10.798
Ln of EBIT	123	7.998	1.153	4.405	10.962
Ln of EBITDA	127	8.253	1.249	4.030	11.155
Ln of sales	127	10.015	1.378	5.778	12.790
Beta	127	0.871	0.311	0.220	1.960

Panel B: Post-Lehman Crisis Period (2008-2013)

Variable	N	Mean	Std. Dev.	Min	Max
(1) Dependent Variable ROA	156	7.596	6.936	-33.890	24.290
ROE	156	72.242	562.222	-56.380	7038.460
TSR	154	5.507	34.668	-85.709	190.693
Tobin's q	156	1.841	0.858	0.894	4.976
(2) Control Variable Female CEO	156	0.295	0.457	0.000	1.000
Woman ratio	156	0.238	0.110	0.063	0.500
Ln of TDC1	155	8.553	3.232	-6.908	10.763

Ln of EBIT	155	8.271	1.153	6.241	11.102
Ln of EBITDA	155	8.601	1.090	6.715	11.273
Ln of sales	156	10.245	1.163	7.658	12.980
Beta	156	0.812	0.286	0.210	1.700

Table 2 describes the descriptive statistics of the sample as presented by panel A. Pre Lehman time period (2003 – 2007) and panel B, the Post- Lehman time period (2008-2013). The number of observations in Post Lehman time period is slightly higher than in Pre-Lehman time period. The average value of women being CEOs and Woman ratio both are slightly increasing in Post Lehman time period. Average value of accounting indicators are higher in Post – Lehman time but the mean value of market based indicators are lower in Post – Lehman time period indicating a better Accounting performance and deteriorating market performance in general during the Post Lehman period. The declining market value of stock based indicators show the general fall in stock price during Post Lehman time period. Mean value of Tobin's q is higher than one 1 both Pre and Post Lehman time period which is consistent with the values obtained by Campbell and Minguez- Vera (2007) in Spanish market and Demsetz and Villalonga (2002) for the US market both are higher than 1. However, the value of Tobin's q is less in Post- Lehman time period than in Pre-Lehman time period showing a declining market value of the firms under the study; this could be due to after effect of financial crisis.

Table 3: Regression Estimate of the Relationship between Percent of Women Directors and Firm Performance: Pre-Lehman Crisis Period (2003-2007)

Independent Variable	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Woman ratio	10.096**	64.558***	-35.321	2.488***
	(2.58)	(2.84)	(-1.43)	(2.90)
Total Compensation	-0.12	0.618	-4.224***	-0.180***
	(-0.52)	(0.46)	(-3.17)	(-3.57)
Ln of EBIT	17.970***	52.486***	-10.521	3.590***
	(8.62)	(4.34)	(-0.67)	(7.86)
Ln of EBITDA	-14.878***	-53.112***	5.525	-3.218***
	(-6.99)	(-4.30)	(0.35)	(-6.90)
Ln of Sales	-1.257*	1.523	8.718*	-0.207
	(-1.69)	(0.35)	(1.76)	(-1.27)
Beta	0.941	-6.938	-12.094	0.248
	-0.59	(-0.75)	(-1.13)	(0.71)
Constant	-0.79	22.685	12.08	3.037***
	(-0.23)	(1.12)	(0.54)	(3.99)
Year Dummies	Yes	Yes	Yes	Yes
R-squared	0.502	0.27	0.169	0.488

N	123	123	99	123

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

Table 4: Regression Estimate of the Relationship between Percent of Women Directors and Firm Performance: Post Lehman Crisis Period (2008-2013)

Parameter	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Woman ratio	3.268	23.048	-44.719	1.939***
	(0.88)	(1.01)	(-1.89)	(3.82)
Total Compensation	-0.037	1.599**	-0.79	-0.043**
	(-0.30)	(2.15)	(-1.04)	(-2.61)
Ln of EBIT	19.419***	72.867***	17.985	2.785***
	(9.20)	(5.61)	(1.35)	(9.66)
Ln of EBITDA	-15.631***	-73.928***	-18.918	-2.275***
	(-7.37)	(-5.66)	(-1.40)	(-7.85)
Ln of Sales	-2.320***	1.815	-1.613	-0.460***
	(-3.24)	(0.41)	(-0.35)	(-4.70)
Beta	0.668	-22.425**	2.748	0.336*
	(0.48)	(-2.61)	(0.31)	(1.76)
Constant	4.962	41.122	69.359**	2.929***
	(1.16)	(1.56)	(2.48)	(4.99)
Year Dummies	Yes	Yes	Yes	Yes
R-squared	0.542	0.294	0.321	0.574
N	154	154	152	154

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

A. Impact of female directors on board and firm performance

We first analyze whether adding women on board of directors position have any impact on firm performance. Table 3 provides the results of the multivariate models for each of the dependent variable in Pre Lehman Crisis time period. Results show Woman ratio is positive and significant to all performance indicators except TSR indicating a higher percentage of female board of directors can improve firm's market and accounting based performances.

Table 4 provides the results of the multivariate models for each of the dependent variable in Post Lehman crisis period. Woman ratio is positive and significant to Tobin's q and positive but not significant to ROA and ROE.

Table 7 provides regression results of the multivariate models for each of the dependent variable in combined time period over a decade from 2003 to 2013. Again, Woman ratio is positively related to ROA (consistent with the findings by study by Vo, D. et al., 2013 conducted in Vietnam), ROE and Tobin's q but negative and significant to TSR. The finding of our paper that higher proportion of women in board increases the firms Tobin's q is consistent with the findings by Campbell and Minguez – Vera (2007).

B. Impact of Women CEOs and firm performance

Table 5: Regression estimate of Impact of CEO gender on Firm Performance
Pre-Lehman Crisis Period (2003-2007)

Independent Variable	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Female CEO	0.415	-0.127	-4.236	0.106
	(0.48)	(-0.03)	(-0.78)	-0.84
Total Compensation	-0.227	0.791	-0.96	-0.063***
	(-1.96)	(1.26)	(-1.35)	(-3.77)
Ln of EBIT	10.142***	35.521***	-4.431	1.622***
	(6.73)	(4.32)	(-0.48)	(7.42)
Ln of Sales	-0.594	8.321*	3.356	-0.218*
	(-0.84)	(2.17)	(0.76)	(-2.13)
Ln of EBITDA	-7.954***	-42.308***	2.075	-1.373***
	(-4.81)	(-4.69)	(0.20)	(-5.72)
Beta	0.157	-21.876**	-6.33	0.317
	(-0.11)	(-2.75)	(-0.70)	(1.50)
Constant	0.892	29.572	-29.55	2.619***
	(0.26)	(1.61)	(-1.41)	(5.34)
Year Dummies	Yes	Yes	Yes	Yes
R-squared	41.60%	20.60%	29.20%	39.10%
N	167	167	164	167

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

Table 6: Regression estimate of Impact of CEO Gender on Firm's Performance: Post-Lehman Period (2008-2013)

Independent Variable	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Female CEO	0.169	14.572*	-11.451	-0.097
	(0.17)	(2.40)	(-1.44)	(-0.31)
Total Compensation	-0.01	0.455	-3.036***	-0.079*
	(-0.10)	(0.71)	(-3.87)	(-2.40)
Ln of EBIT	21.340***	51.039***	5.997	5.267***
	(11.44)	(4.61)	(0.39)	(9.32)
Ln of Sales	-0.986	3.883	5.041	-0.636***
	(-1.71)	(1.14)	(1.05)	(-3.65)
Ln of EBITDA	-19.555***	-55.319***	-8.001	-4.811***
	(-9.89)	(-4.72)	(-0.50)	(-8.03)
Beta	0.808	-12.732	-8.251	0.936**
	(0.70)	(-1.86)	(-0.85)	-2.67
Constant	9.178***	47.759**	14.011	6.598***
	(3.55)	(3.12)	(0.68)	(8.43)
Year Dummies	Yes	Yes	Yes	Yes
R-squared	56.00%	23.30%	17.90%	47.40%
N	146	146	117	146

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

Table 5 provides the results of the multivariate models for each of the dependent variables in Pre Lehman time period. In Pre Lehman time period no significant relationship is reported between Female CEO and any of the company's performance variables. Our result is consistent with the finding by Albanesi (2015) suggests no significant difference in firm performance led by female executives.

Table 6 provides the multivariate regression estimate shows the impact of CEO gender on company's accounting and market-based performance in Post Lehman time period. The likelihood of adding a Female CEO is positive and significantly related to ROE. The evidence in table 6 suggests that an inclusion of a female CEO in C suite could increase the ROE of the company.

Table 7: Regression Estimate of the relationship Between Firm Performance and Percent of Women Directors Combined time period 2003-2013.

Independent Variable	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Woman ratio	6.893**	40.694**	-42.05**	2.129***
	(2.66)	(2.59)	(-2.20)	(4.53)
Total Compensation	-0.092	1.221**	-1.217*	-0.063**
	(0.91)	(2.01)	(-1.73)	(-3.44)
Ln of EBIT	18.07***	61.79***	5.47	3.07***
	(12.88)	(7.28)	(0.49)	(12.10)
Ln of EBITDA	14.58***	62.35***	7.33	-2.624***
	(10.27)	(7.26)	(0.65)	(10.20)
Ln of Sales	-1.7338***	2.237	1.347	-0.377***
	(3.46)	(.74)	(0.36)	(4.15)
Beta	0.382	-16.686***	-1.359	.335
	(0.38)	(2.75)	(0.18)	(1.84)
Fiscal Year	-0.017	-.363	0.799	-0.017***
	(3.88)	(0.68)	(1.14)	(3.88)
Constant	339.73	752.23	-1572.88	126.73***
	(1.93)	(.71)	(1.12)	(3.98)
R-squared	0.512	0.2552	0.321	0.49
N	251	277	251	277

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

Table 8 provides the regression results of the multivariate models for each of the dependent variables in the combined time period from 2003 to 2013 replacing Woman ratio is replaced with Female CEO in the list of independent variables. Result shows no significant relationship between the Female CEO dummy and the company's performance variables. This disproves our hypothesis 2 that gender of CEO may affect firm performance in both pre and post - Lehman periods.

Table 8: Regression Estimate of the impact of CEO gender on Firm's Performance Combined time period 2003-2013

Independent Variable	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Female CEO	1.047	6.173	-3.32	0.221
	(1.58)	(1.54)	(.69)	(1.8)
Total Compensation	-0.082	1.28*	-1.32	-0.058**
	(0.81)	(2.10)	(-1.86)	(3.10)
Ln of EBIT	18.64***	65.118***	0.822	3.258***
	(13.37)	(7.73)	(0.07)	(12.62)
Ln of EBITDA	-15.32***	-66.73***	-0.884	-2.88***
	(11.03)	(7.95)	(0.08)	(11.21)
Ln of Sales	-1.689**	2.50	0.79	-0.352
	(3.33)	(0.82)	(0.21)	(3.74)
Beta	0.369	-16.757*	-2.089	.355
	(0.36)	(2.72)	(0.28)	(1.88)
Fiscal Year	-0.139	-0.1189	0.49	-0.048
	(1.57)	(0.35)	(0.69)	(2.93)
Constant	283.04	416.90	-970.53	100.40
	(1.59)	(.39)	(0.68)	(3.05)
R-squared	0.50	0.24	0.0238	0.446
N	277	277	251	277

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

A. Impact of CEO Compensation and firm performance

To capture the impact of CEO compensation on firm performance, we analyze both regressions estimates in Pre Lehman and Post Lehman time period. First, table 3 and table 5 present the findings of the impact of CEO compensation (TDC1) on firm performance in Pre Lehman time period. Table 3 indicates CEO Compensation is negative and significant to both TSR and Tobin's q. Although, CEO compensation is negative and significant to market based performance, it has no significant relation to any of the firm's accounting based performance. The regression result from table 5 also suggests a negative relation between CEO compensation and Tobin's q at 10% level of significance. In summary, in Pre Lehman time period CEO compensation has no meaningful impact on accounting based performance indicators and suggests higher compensation may worsen firm's market based performance. Second, Table 4

and Table 6 show the impact of CEO compensation (TDC1) on firm performance in Post Lehman time period. Table 4 exhibits in Post Lehman period, CEO Compensation is positive and statistically significant to return on equity at 10% level of significance indicating higher compensation can partially improve firm's accounting based performance. However, results also demonstrates that CEO compensation (TDC1) has a negative relation to Tobin's q at 10% level of significance indicating higher CEO compensation may lower company's market value in Pre Lehman time period. The results of table 6 also reveal a negative and significant relation between companies market based performance and CEO compensation.

Table 7 shows the combined regression estimate over the entire time period under study, indicating CEO compensation or executive compensation is positively related to ROE but negatively related to both of the market based indicators TSR and Tobin's q.

Table 8 shows the impact of CEO compensation on firm performance over the entire the decade of the study (2003-2013). The CEO compensation or executive compensation is positively related to return on equity at 1% level of significance, but negatively related to both of the market based indicators TSR and Tobin's q. Again, the results partially disproves the hypothesis 3 that on average firms will demonstrate financial alignment in the form of a positive relationship between CEO compensation and firms accounting as well as market based performances. Results show compensation is aligned with accounting based performance, however, higher compensation does not improve the firm's market based performance.

Table 8: Regression Estimate of the impact of CEO gender on Firm's Performance Combined time period 2003-2013

Independent Variable	Model 1 ROA Dependent Variable	Model 2 ROE Dependent Variable	Model 3 TSR Dependent Variable	Model 4 Tobin's Q Dependent Variable
Female CEO	1.047	6.173	-3.32	0.221
	(1.58)	(1.54)	(.69)	(1.8)
Total Compensation	-0.082	1.28*	-1.32	-0.058**
	(0.81)	(2.10)	(-1.86)	(3.10)
Ln of EBIT	18.64***	65.118***	0.822	3.258***
	(13.37)	(7.73)	(0.07)	(12.62)
Ln of EBITDA	-15.32***	-66.73***	-0.884	-2.88***
	(11.03)	(7.95)	(0.08)	(11.21)
Ln of Sales	-1.689**	2.50	0.79	-0.352
	(3.33)	(0.82)	(0.21)	(3.74)
Beta	0.369	-16.757*	-2.089	.355
	(0.36)	(2.72)	(0.28)	(1.88)

Fiscal Year	-0.139	-0.1189	0.49	-0.048
	(1.57)	(0.35)	(0.69)	(2.93)
Constant	283.04	416.90	-970.53	100.40
	(1.59)	(.39)	(0.68)	(3.05)
R-squared	0.50	0.24	0.0238	0.446
N	277	277	251	277

***, **, * represent 10%, 5%, and 1% statistical significance, respectively.

In summary, the impact of Women directors on firm's performance in Pre- Lehman time period as suggested from table 3 show a positive link between percentage of female board members and company's market based performance. Result shows a positive and statistically significant relationship between percent of females on the board of directors and all performance indicators in Pre-Lehman Crisis period except TSR. Also from table 7 it shows that over ten years sample period higher percentage of female board of directors may also improve firm's accounting and market based performance and therefore satisfies our hypothesis 1 that higher percentage of women on the board of directors can positively affect the company's performance in both pre and post - Lehman periods.

Taking all results together Tables 5, 6 and 8 show that gender of CEO has no effect on any of the performance variables, (except ROE in the Post-Lehman period) confirming that gender of the CEOs generally does not improve or worsen firm's performance. Table 6 shows positive and statistically significant relationship between female CEO and ROE during the Post-Lehman period. Previous research regarding "glass ceiling effect" and "presumed risk aversion" of females would predict lower financial performance for female CEO's in Post-Lehman time period. However this study suggests that gender of CEO may not matter much for stock price performance, as it does not influence the market based performance; however, having a female CEO may improve a company's accounting based performance.

Overall result suggests that there is a positive and significant relationship between compensation and ROE in both Pre – Lehman and Post Lehman periods (table 4) as well as in the combined time model (table 7, table 8). A study by Bertrand, M. and Schoar, A., (2003) found the same pattern that higher total compensation as well as the incentive pay increase firm's return of asset and therefore suggest that managers with higher performance receive higher salary compensation and these managers are more likely to be found in well- managed firms.

The results from table 7 show CEO compensation is negatively related to total stock return (TSR) and Tobin's q over the decade. Again, whereas managerial compensation including incentive payments intended to increase value for stockholders, however, our findings suggest to reduce Tobin's q. This can mean that stock price declines and /or book value increases, as the CEO's may be prone to empire building and acquire inefficient assets. This is consistent with the results found by Cooper et al, (2014) in their extensive study.

Before concluding we wish to acknowledge few limitations that point to future research directions. First, the study undertook relatively a small number of sample firms. In future we

may use the same framework, however, include all firms in S&P 500 and S&P 1500. Increasing sample size may provide greater insights into the proposed relationship. Inclusion of other control variables for example age, size of employees and education can add a new dimension into the research. Second, the present study did not take into account the qualitative variable to examine the interplay of power dynamics, gender roles, conflict as well as exploratory factors initiating women to take more leadership position, for example, women come from single headed households, ethnicity etc.

V. Discussion, implications and conclusion

The empirical findings of the present study suggest that gender diversity variable is important in determining the corporate performance in both Pre and Post-Lehman Crisis periods. Findings from the combined time period (2003-2013) show gender diversity in board has a positive impact on all three indicators return on asset, return on equity as well as Tobin's q. Overall findings suggest that greater gender diversity of the boards of directors in the corporate sector is not only a desirable goal by itself, but it ensures more efficient use of corporate resources.

The paper also examined the relationship between the impact of CEO gender and firm performance. It finds that gender of CEO has a neutral effect on firm's performance. In other words, female CEOs are equally likely to influence firm's performance as their male peers. It conforms the previous research by Abdullah et al., (2014) that finds no difference in the relative performance of female CEOs and male CEOs. However, it rejects the imbedded institutional mindset that women are too "risky" to promote to a top leadership position

Overall, the results indicate that CEO compensation is generally not aligned with firm's performances both in Pre and Post Lehman time. Actually, since Lehman Crisis, compensation packages have tended to reduce Total Stock Returns and Tobin's q. It reinforces the conclusion that current high compensation packages, which, consist of mostly convex payouts (options) do not provide incentives to maximize /increase shareholder wealth and agency problem persists.

In summary, the findings of this study confirm that gender diversity of the board of director's increases the firm's accounting and market based performances over the period of 2003-2013.

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Advertising Intensity in the U.S Property and Liability Insurance Industry: Market Power or Profits?

B. Paul Choi

Abstract

This study aims to investigate the conduct of the U.S. Property and Liability insurers on the market in relation to the structure-conduct-performance (SCP) paradigm. Advertising activities constitute the conduct of the industry and the relationship between advertising intensity and market structure is empirically tested over 14-year period. The results indicate a positive and non-significant relation between concentration and advertising and a negative and significant relation between performance and advertising. Thus, the conduct as measured by advertising intensity does not provide an additional value to the performance of insurers in this highly competitive market. These results are consistent with all three different types of concentration measures in two different profit equations.

I. Introduction and Purpose

Insurance industry is one of the largest financial sectors with over $5 trillion in assets. Insurance companies use different marketing channels to attract their customers in this competitive market. The property and liability (P/L) insurance industry spent over $6 billion in advertising, and its ratio of advertising to premium accounts for 2.27% in year 2013 (SNL Financial, 2014). According to data compiled by SNL Financial, the lead advertiser spent $1.18 billion or $6.7 on advertising for every $100 of premium they wrote in year 2013.

The general concern about the advertising issue is whether insurers operate efficiently, profitably, and safely, and, whether they expose the industry to excessive risk. The never-ending advertising competition changes the market structure and the performance of the insurers in the P/L insurance market. Especially, an insurer would like to achieve its brand's long-run competitive position or short-run market share increase.

The structure-conduct-performance (SCP) paradigm suggests that performance of the industry is affected by the conduct of the participants in the market, which is influenced by the companies' market structure (Bain, 1951 and Stigler, 1964). That is, the SCP hypothesis suggests a positive relationship between performance and concentration. (Performance is typically measured as price or profit.) Weiss (1974) argues that market concentration may foster collusion among firms in the market since higher concentration lowers the cost of collusion, resulting in monopoly rents. In other words, market structure affects a firm's conduct and determines the profits of the firm. Consequently, the traditional SCP hypothesis and some existing structure-performance studies provide an argument for antitrust policy prohibiting actions leading to a reduced number of viable competitors.

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Advertising activities constitute the conduct of the industry and the relationship between advertising intensity and market structure had been a debate for long periods of time (Leahy, 1997, Lee, 2002, Nazari and Tajdini, 2011, and Hong and Li, 2017). Related to this issue, this study is interested in finding performance effect and market concentration in the U.S. property and liability insurance industry. That is, whether advertising generates profit by spending more or they take share from other competitors to grow in the market. Economic theory suggests that profit margins are higher in concentrated market (Ramaswamy et al., 1994, Berger, 1995, and Lipczynski and Wilson, 2001).

Insurers can increase their market share in two principal ways: by achieving superior efficiency and providing broader and higher quality services (efficient market structure), or by lowering prices below competitive levels, even at their own loss in order to attract new customers. Under the former strategy, consumers are likely to benefit from a wider set of products and more favorable prices. Under the latter approach, however, aggressive insurers would exercise price undercutting and would take unwarranted risks, in order to drive out their competitors. In this scenario, regulators must take steps to limit the insolvency risk faced by those insurers and to maintain a level playing field. Hence, it would be useful to determine which of these two strategies is the dominant mode of operation in the U.S. property and liability insurance industry and how the relative efficiency of those insurers enters the picture. To this end, the current study aims to investigate the conduct of the P/L insurers on the market. A study shows that advertising intensity do affect firm efficiency (Choi and Weiss, 2005).

The results of this paper are of interest to insurers, regulators, consumers, investors in insurance stocks, and academicians. Since there have been no prior studies on the impact of advertising of P/L insurers in the U.S. market structure, the findings here can shed new light on the relative performance and risk of these firms caused by advertising.

II. Data and Methodology

Performance data are from the National Association of Insurance Commissioners (NAIC). Annual Statements from NAIC are used to calculate the changes in the market shares of the P/L U.S. insurers. From this potential sample, insurers with negative values of surplus, assets, premiums, inputs, or outputs are deleted to conduct a meaningful empirical test. After applying the selection criteria, we have a sample with 24,788 firm-years of data for the 1999-2013 period. Insurers are allowed to enter and exit the U.S. market over the sample period in order to avoid problems associated with survivor bias for the regression test.

The following model is designed to examine the association between advertising intensity and market concentration and profitability, including insurer characteristics and three dummy variables:

$$\begin{aligned}\text{Advertising Intensity}_{it} = {} & \alpha_0 + \beta_1 \text{Concentration}_{it} + \beta_2 \text{Profitability}_{it} + \beta_3 \text{Assets}_{it} + \beta_4 \text{Investment}_{it} \\ & + \beta_5 \text{Leverage}_{it} + \beta_6 \text{Reinsurance Utilization}_{it} + \beta_7 \text{Personal Lines}_{it} \\ & + \beta_8 \text{Business Diversification}_{it} + \beta_9 \text{Geographic Diversification}_{it} + \beta_{10} \text{Group Dummy}_{it} \\ & + \beta_{11} \text{Stock Dummy}_{it} + \beta_{12} \text{Agent Dummy}_{it} + \beta_{13} \text{Hard Market Dummy}_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

In this model, the *Advertising Intensity* is measured as a ratio of advertising expenses over premiums written, subscript *i* represents the *i*th insurance company, *t* is a time index, and ε_{it} is a random error term with zero mean and a constant variance. Two key independent variables are *Concentration* and *Profitability*. Consistent with many industrial organization studies, the Herfindahl index is used to measure market concentration in the P/L insurance industry.[1] The Herfindahl index is defined as the sum of the squared market share of each insurer in the US market. Market share is defined as the proportion of total premiums accounted for by insurer *i* in total market at time *t*, and is computed based on direct premiums written. Two other Concentration variables are used to check the robustness of the model. Market shares by top three insurers (Concentration Top3) and markets shares by the top five insurers (Concentration Top5) are analyzed in different models. A conventional return on equity (ROE) is used for the profit measure of insurers. In addition to this, *Profit Margin* is used in other set of models. *Profit Margin* is defined as one minus losses and loss expenses incurred over premiums earned[2].

The control variables follow the existing literature. They include asset size (Assets), Investment Ratio, Leverage, Reinsurance Utilization, Proportion of Personal Lines (Personal Lines), Business Diversification, Geographic Diversification, and dummies for membership in an insurance group (Group Dummy), stock vs. mutual organization (Stock Dummy), independent agency system vs. other distribution systems (Agent Dummy), and hard market vs. soft market (Hard Market Dummy).

Financial conditions of the firm are influenced by, among other factors, the size of the firm. Hence, total assets in logarithm form are used as a control variable in the model. Prior studies find that as size gets bigger scale economies decline (Cummins, and Weiss, 2000).

Investment ratio is defined as net investment income over premiums written. As it is the major business activities of insurance companies, investment income could impact on the advertising intensity and the testing model controls for the investment activities. It is expected that insurers with higher investment income are more likely spend on advertising. Since investment is one of the core business activities of insurers, it is essential to their overall financial performance. Insurers' asset portfolio and their ability and willingness to invest could affect the performance of the firm. It is expected to have a positive relationship between this variable and advertising if the insurers reflect increased investment as enhancing firm value. Otherwise, we expect a negative relationship if the market views the aggressive investment activities as a risky factor.

Next, we control for risk-taking behavior of insurers since risk is closely related to the decision of the level of capital holding. *Leverage* is used to identify the capital adequacy of an insurer and a Kenney ratio is obtained for this variable (Kenney, 1957, Cummins and Weiss, 1992, Cummins and Nini, 2002, Doherty and Phillips, 2002, and Klein et al., 2002). It is defined as the ratio of premiums written to surplus and is the most widely used leverage ratio in insurance. This ratio is used by the NAIC as an indicator of financial stability, where a higher value indicates that the insurer may have an insufficient cushion to absorb unexpected losses.

[1] Stigler (1964) argues that the Herfindahl index is superior to the concentration ratio (e.g., four-firm concentration ratio) for measuring concentration to assess the likelihood of effective collusion.

[2] For more discussion and use of this price variable, refer to Winter (1994), Cummins and Danzon (1997), and Choi and Weiss (2005).

Therefore, as the Kenney ratio increases, the insurer's ability to cover unexpected losses is reduced. So, an increase in the Kenney ratio is associated with higher risk.

Reinsurance utilization (the ratio of reinsurance ceded to the sum of reinsurance assumed and direct premiums written) may affect the overall riskiness and efficiency of the insurer because it effectively expands the capacity of the firm to offer insurance services, stabilizes loss experience, and protects the firm from catastrophe. Effective use of reinsurance transaction can affect the revenues and costs due to better management and/or scale economies. Thus, reinsurance transactions are related to underwriting risk and capacity, and could affect advertising behavior.

The model also controls for the lines of business. Proportion of personal lines is defined as the proportion of personal lines to total insurance business written. This measure shows whether the insurer's focus is on a more standardized set of personal lines of products (less complexity), or in commercial line products (high complexity). The complexity variable reflects the effect of specialization in personal lines of business on advertising intensity. We expect to have a positive relation between this variable and advertising intensity since insurers tend to advertise more on personal lines than commercial lines.

We have two business diversification variables as control variables. First, the lines of business an insurer writes can affect the overall risk, performance of the firm, and advertising behavior. *Business Diversification* is measured using a Herfindahl index which is defined as

$$\sum_{i=1}^{34}\left(\frac{PW_i}{TPW}\right)^2 \tag{2}$$

where PW_i is the value of premiums written in each line of business in the insurer's annual statement and *TPW* represents the insurer's total premiums written[3].

A higher value of the Herfindahl index indicates a more specialized (less diversified) company. The highest level of diversification (i.e., lower value) would indicate that the insurer's operation is well spread over various lines of business, while the lowest level of diversification (i.e., higher score) indicates the insurer's operation is fully devoted to single line of business. Insurers that specialize in a few lines may gain greater expertise in administering these lines leading to a positive relationship between diversification and advertising. On the other hand, it may be more difficult to achieve economies of scope or cross-sell business so that advertising intensity might be reduced for such an insurer. We used data on the lines of business in which the insurers were active to develop a measure of their product line concentration.

Another control variable related to the insurers' diversification strategy is the Herfindahl index of geographical operations (*Geographic Diversification*). This variable is calculated as follows:

$$\sum_{i=1}^{58}\left(\frac{PW_i}{TPW}\right)^2 \tag{3}$$

[3] We use the data in the NAIC annual statement – Underwriting and Investment Exhibit, Part 1B-Premiums Written.

where PW_i is the value of premiums written in each state and *TPW* represents the insurer's total premiums written. As in the line of business diversification, the higher value indicates that firms operate in one state or small number of states, while the lower value indicates higher diversification in terms of geographical operations. Insurers with greater diversification in product mixes or geographic mixes are expected to have a more diversified revenue flow and thus a greater stability in capital inflow from premiums.

Binary variables for group membership, organizational form, and agency, control for the effect of affiliation with an insurance group, mutual vs stock ownership, and agency character (independent agency vs direct writer system) on efficiency. They take the unit value if a company is a member of an insurance group, is a stock organization, or is an independent agent. Controlling for group membership allows for the differential efficiencies between group members and non-group members in insurance operations and marketing strategy.

Each organizational form is effective in solving specific incentive conflicts among the contractual parties (Mayers and Smith, 1994). In mutual organizations the conflicts between policyholders and owners are eliminated while the conflict between owners and managers is greater, since, among other things, managers of a mutual firm are monitored less than those of stock firms (Baranoff and Sager, 2003). Controlling for organizational form allows for the possibility of differing levels of advertising impact among stock and mutual firms. Insurance distribution systems are generally divided into two types; independent agency system, and direct writer system (e.g., Regan, 1997 and Seog, 1999).

Lastly, to reflect the business cyclical economic fluctuation, a cyclical variable is included in the testing model. The model controls for the underwriting cycle which exists in the property and liability insurance industry. The property-liability insurance industry is notorious for its underwriting cycles. An underwriting cycle is associated with several periods of increasing profitability followed by declines in profitability (e.g., Cummins and Danzon, 1997 and Weiss and Chung, 2004). It is expected to be negatively related to the dependent variable since insurance is relatively less available during the hard market period. It is also expected that this variable captures the riskiness of the firm at different points in the business cycle (see Bassett and Brady, 2002). Years 2000 ~ 2003 are assigned to a hard market and all other years are deemed to be a soft market (Hartwig, 2016).

III. Empirical Results

Table 1 presents summary statistics for our sample of insurers used for the regression model. Table 2 contains the information to test the hypothesis as in Equation (1) for the entire sample period with a profit variable (ROE). To capture the effects of different concentration variables, further testing models are estimated with Herfindahl Index (Model 1), Concentration Top 3 (Model 2), Concentration Top 5 (Model 3), and Market Share (Model 4). Results with the second profit variable (Profit Margin) are reported in Table 3 for the same models. No evidence of multicollinearity among variables is found. However, testing for heteroscedasticity shows that it exists in this sample, and so heteroscedastic-consistent estimators following the method of White (1980) are used.

Table 1 shows that U.S. property and liability insurance industry is highly competitive market with the Herfindahl index of 0.00866 on average during the sample period. In addition,

the three largest insurers own 12 percent of the market and the five largest firms control about 14.7 percent of the market, on average. So, overall, U.S. P/L insurance industry represents a relatively unconcentrated and fairly competitive market[4]. On average, the sample insurers return 2.68 percent on equity (ROE), while the mean of the profit margin (0.232) shows that every $1 of premium sample insurers spend $0.768 on losses and loss adjustment expenses. On average, insurers transfer their risks to reinsurers 42.5 percent of their total premiums written.

Table 1 also presents that sample insurers write about 38 percent in the personal lines and 62 percent in the commercial lines. Sample insurers are more likely members of a group (71.3 percent), are in stock form of ownership (71.7 percent) and utilize independent agency system, which is generally consistent with previous studies.

Table 1. Summary Statistics for Variables

Variables	Mean	Standard Deviation	Minimum	Maximum
Advertising Intensity	0.0086	0.0404	0.0001	1.2321
Herfindahl Index	0.0087	0.0008	0.0078	0.0106
Concentraion Top3[1]	0.1200	0.0098	0.1074	0.1420
Concentraion Top5[2]	0.1467	0.0109	0.1329	0.1698
Market Share	0.0005	0.0022	0.0000	0.0736
ROE	0.0268	0.3036	-9.9579	8.7867
Profit Margin	0.2319	1.2259	-61.5477	0.9999
Asset (log)	18.4018	1.9279	11.9440	25.7466
Investment Ratio	0.0356	0.0528	-0.6223	3.3865
Leverage	1.0368	1.0275	0.0000	39.8246
Reinsurance Utilization	0.4251	0.3075	0.0000	8.4612
Proportion of Personal Lines	0.3800	0.3763	0	1
Business Diversification	0.4774	0.3013	0.0840	1
Geographic Diversification	0.5546	0.3859	0.0307	1
Group Dummy	0.7131	0.4523	0	1
Stock Dummy	0.7167	0.4506	0	1
Agent Dummy	0.7877	0.4090	0	1
Observation	24,788			

[1]Market concentration ratio by the top three insurers

[2]Market concentration ratio by the top five insurers

[4] E.g., top four market shares of the concentrated industries such as Search Engines, Wireless Telecommunications Carriers, and Tire Manufacturing are over 90 percent.

The results in Table 2 indicate that the coefficients on three concentration variables are not significant and that they are positive in Models 1~3. Thus, these results do not support the long-debated economic theory on the relationship between conduct and performance (see Leahy, 1997, Lee, 2002, Nazari and Tajdini, 2011, and Acar and Temiz, 2017 for more discussion).

The coefficients on Profit (ROE) are all significantly and negatively related to advertising intensity. These results indicate that insurers spending more on advertising do not gain additional advantages in this market. Those insurers spending more on advertising are negatively affected by the additional expenses on their financial statements.

Table 2. Advertising Intensity Regressions: ROE

	Model 1			**Model 2**			**Model 3**			**Model 4**		
Independent Variable	Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.	
Intercept	-0.0065	0.0050		-0.0060	0.0053		-0.0069	0.0056		-0.0070	0.0037	*
Herfindahl	0.1765	0.3803										
Concentration Top3				0.0088	0.0309							
ConcentrationTop5							0.0130	0.0279				
Market Share										-0.2719	0.1298	**
ROE	-0.0021	0.0009	**	-0.0021	0.0009	**	-0.0021	0.0009	**	-0.0021	0.0009	**
Asset (log)	0.0007	0.0002	***	0.0007	0.0002	***	0.0007	0.0002	***	0.0008	0.0002	***
Investment Ratio	0.0057	0.0049		0.0058	0.0049		0.0057	0.0049		0.0059	0.0049	
Leverage	-0.0006	0.0003	**	-0.0006	0.0003	**	-0.0006	0.0003	**	-0.0006	0.0003	**
Reinsurance Utilization	-0.0145	0.0009	***	-0.0145	0.0009	***	-0.0145	0.0009	***	-0.0144	0.0009	***
Personal Lines	0.0049	0.0008	***	0.0049	0.0008	***	0.0049	0.0008	***	0.0051	0.0008	***
Business Diversification	-0.0011	0.0010		-0.0011	0.0010		-0.0011	0.0010		-0.0011	0.0010	
Geographic Diversification	0.0062	0.0008	***	0.0062	0.0008	***	0.0062	0.0008	***	0.0061	0.0008	***
Group Dummy	0.0030	0.0007	***	0.0030	0.0007	***	0.0030	0.0007	***	0.0030	0.0007	***
Stock Dummy	0.0066	0.0006	***	0.0066	0.0006	***	0.0066	0.0006	***	0.0065	0.0006	***
Agent Dummy	-0.0041	0.0007	***	-0.0041	0.0007	***	-0.0041	0.0007	***	-0.0042	0.0007	***
Hard Market Dummy	-0.0013	0.0007	**	-0.0013	0.0007	*	-0.0013	0.0007	**	-0.0011	0.0006	*
Observations	24,788			24,788			24,788			24,788		
Adjusted R^2	0.0236			0.0236			0.0236			0.0238		

*** significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Note: Standard Errors are heteroscedastic-consistent estimators following the method of White (1980).

The results from Table 3 show a similar outcome on three concentration variables. The relation between advertising intensity and market structure is positive but it is not significant.

Moreover, the results on the Profit Margin variable are turned out to have a negative and significant relation with advertising as well in Table 3. Thus, U.S. P/L insurers are not getting benefits from advertising in terms of underwriting profits during the sample period. Advertising may impact on the barriers to entry, but it was not statistically significant. Insurers in the U.S. market could not take an advantage of advertising in this highly competitive market.

Both Table 2 and Table 3 present that the coefficients on the Market Share variable are negatively related to advertising intensity. That is, insurers with higher market share tend to spend relatively less on advertising, while insurers with smaller market share spend relatively more on advertising to attract their customers.

Table 3. Advertising Intensity Regressions: Profit Margin

	Model 1			**Model 2**			**Model 3**			**Model 4**		
Independent Variable	Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.	
Intercept	-0.0049	0.0050		-0.0042	0.0053		-0.0051	0.0056		-0.0055	0.0037	
Herfindahl	0.1548	0.3800										
Concentration Top3				0.0063	0.0308							
Concentration Top5							0.0109	0.0279				
Market Share										-0.2711	0.1297	*
Profit Margin	-0.0013	0.0002	***	-0.0013	0.0002	***	-0.0013	0.0002	***	-0.0013	0.0002	***
Asset (log)	0.0006	0.0002	***	0.0006	0.0002	***	0.0006	0.0002	***	0.0007	0.0002	***
Investment Ratio	0.0047	0.0049		0.0048	0.0049		0.0047	0.0049		0.0049	0.0049	
Leverage	-0.0004	0.0003	*	-0.0004	0.0003	*	-0.0004	0.0003	*	-0.0004	0.0003	*
Reinsurance Utilization	-0.0148	0.0009	***	-0.0148	0.0009	***	-0.0148	0.0009	***	-0.0147	0.0009	***
Personal Lines	0.0049	0.0008	***	0.0049	0.0008	***	0.0049	0.0008	***	0.0051	0.0008	***
Business Diversification	-0.0013	0.0010		-0.0013	0.0010		-0.0013	0.0010		-0.0013	0.0010	
Geographic Diversification	0.0060	0.0008	***	0.0060	0.0008	***	0.0060	0.0008	***	0.0059	0.0008	***
Group Dummy	0.0029	0.0007	***	0.0029	0.0007	***	0.0029	0.0007	***	0.0028	0.0007	***
Stock Dummy	0.0065	0.0006	***	0.0065	0.0006	***	0.0065	0.0006	***	0.0065	0.0006	***
Agent Dummy	-0.0041	0.0007	***	-0.0041	0.0007	***	-0.0041	0.0007	***	-0.0042	0.0007	***
Hard Market Dummy	-0.0014	0.0007	**	-0.0013	0.0007	*	-0.0014	0.0007	**	-0.0012	0.0006	**
Observations	24,788			24,788			24,788			24,788		
Adjusted R^2	0.0250			0.0250			0.0250			0.0251		

*** significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Note: Standard Errors are heteroscedastic-consistent estimators following the method of White (1980).

Similar results are found on other control variables in Tables 2 and 3. Assets size is positively and significantly related to advertising intensity in all models. Thus, for the insurance

industry, the larger size of firms spend relatively more advertising. Investment ratio shows no significant relation to advertising.

Leverage is negatively related to advertising for the all groups, indicating that insurers faced with higher risks tend to have less advertising, as expected. The coefficients on reinsurance utilization are negative and significant for models. That is, insurers who transfer their risks to reinsurers more tend to spend less on advertising. P/L insurers who write more on personal lines, as opposed to commercial lines, of business are more likely to utilize advertising. So, this result implicates that advertising is more important to penetrate in the personal insurance market. In the commercial insurance, insurers are more connected with brokers to place their businesses. Further, maintaining relationship with brokers is important to keep their business and grow in the market due to the fact that the risks for large commercial insurance buyers are complex and that brokers provide an important role in terms of the coverage design, pricing and evaluating the risk (Cummins and Doherty, 2006).

Diversification variables present a mixed result. Insurers who diversified in terms of line of business do not show significant relationship with advertising. However, the results from the empirical tests indicate that geographic diversification variable is positively and significantly correlated with advertising intensity. That is, more diversified insurers in terms of regional operation tend to spend less on advertising. In other word, it is more likely that insurers who focus on a smaller number of state markets utilize advertising more to reach out to their customers.

Group and stock dummy variables are positively related to adverting intensity. So, firms that are affiliated with a group tend to use more advertising expenses. Stock companies relatively use more advertising than mutual companies. Insurers using an exclusive agency system, compared to the independent agency system, are more likely to spend on advertising, which is consistent with previous studies (e.g., Marvel, 1982, Grossman and Hart, 1986, and Sass and Gisser, 1989, and Regan, 1997).

To check time varying effect and underwriting cycle impact, we include hard market dummy. The results show that this variable is negatively correlated to advertising intensity. So, insurers tend to use less advertising during the hard market period, as expected.

IV. Conclusions

The purpose of this paper is to examine the impact of advertising intensity on the profitability as measured by accounting profit (ROE) and typical insurers profit (Profit Margin), and market structure as measured by market concentrations. Since the literature shows inconclusive and conflicting empirical results, our paper adds value to the existing literature by providing new information on the relationship between advertising and market structure in the U.S. P/L insurance industry.

The results show a positive and non-significant relation between concentration and advertising and a negative and significant relation between performance and advertising, indicating that advertising does not provide an additional value to the performance of insurers in

this highly competitive market. These results are consistent with all three different types of concentration measures in two different profit equations.

The relationship between performance and advertising empirically tested by this study shows that additional spending on advertising does not generate benefits to the insurers in terms of profitability. The results from this study suggest that U.S. P/L insurance market exhibits a highly unconcentrated and competitive market and that there are low barriers to entry into this market.

This study also suggests that insurers with lower market share tend to use more advertising to penetrate in the U.S. P/L insurance market, while advertising appears to be an important tool for large companies' marketing channel. Insurers operating with relatively higher risks are less likely to have the availability of adequate budgets to invest in advertising. In addition, P/L insurance companies that do more business in personal lines rely more on advertising.

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Price Dispersion in Competitive Markets: A Real Options Explanation

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Abstract

This paper employs a real option model to analyze price dispersion in highly competitive markets. Explanations of price dispersion typically assume monopolistic competition, so these fail to explain price ranges in markets closely approximating the conditions of perfect competition. Here the price is a real option given by the producer to consumers to demonstrate how price dispersion is possible under minimal conditions: stochastic prices; price rigidity; and differential cost structures.

I. Introduction

As markets become more efficient, we expect price dispersion to decrease. Physical markets may be unlikely to attain this ideal, but with the advent of e-commerce and the consequent lessening of search and transaction costs, informational asymmetries, etc. economists anticipated price ranges to narrow in accord with the law of one price. This has not, however, occurred even in those markets[1] that approximate perfect competition. Producers[2] should either lower their price to match that minimum price or exit the market, and prices should converge to the market equilibrium price, i.e., the minimum price. Thus, the question of price dispersion resolves into the question of overpricing:[3] If a range of prices exists in perfect competition, the issue is not why there are *different* prices, but why *any* price is *greater than* the minimum price. Explanations of price dispersion typically assume some form of monopolistic competition: either products or producers or consumers can be distinguished along such dimensions as quality, reputation, or information. But if monopolistic competition does not occur and the market is even approximately perfectly competitive, it is difficult to understand how rational price dispersion is possible…yet there remains strong empirical evidence for price dispersion in such markets.[4]

This model of price dispersion that does not appeal to monopolistic competition; instead, it demonstrates how price dispersion may emerge when the products offered are identical and hence perfect substitutes and there exist no distinctions among either consumers or producers (other than the assumption that different producers have different costs of production). The result

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[1] Excluded are markets in financial products for which there is little evidence of price dispersion.

[2] I use the term 'producer' for any agent offering a product for sale whether or not they actually 'produce' it. I reserve 'seller' for the seller of an option, that is, an agent who takes a short position in an option contract. Analogously, I use 'consumer' for the agent buying a product and restrict 'buyer' to agent who takes a long position in an option contract

[3] In the following, the market equilibrium price is taken to be the minimum price on offer.

[4] This discussion is limited to intra-firm, or spatial, price dispersion, that is, different prices for the same product *at the same time*. The existence of temporal price dispersion, that is, price dispersion over time is a separate issue involving such price setting phenomenon as sales (Varian, 1980).

is to demonstrate that price dispersion only requires three conditions: 1) prices are stochastic; 2) there is some degree of price rigidity; and 3) producers face different cost structures.

The producer's price as a real option, i.e., an option on a real asset, specifically, a call option granted to consumers granting the right to buy the product at a fixed price for a specified period. The underlying 'security' is the (stochastic) equilibrium price for the product. If the equilibrium price remains below the producer's price, the consumer does not make the purchase (does not exercise the option), but, if the equilibrium price rises to the producer's price, the consumer makes the purchase (exercises the option). Thus, it can be rational to set a price above the equilibrium price if at any time during the 'life' of that price a new equilibrium price may exceed it.

Section 2 reviews previous theoretical work on price dispersion. Section 3 documents the existence of significant price dispersion both in markets in general and in internet markets. Section 4 delineates the assumptions of the model and reviews empirical evidence that these conditions obtain in the actual economy. Section 5 develops the real options model as an explanation of price dispersion/overpricing. Section 6 draws out the implications of the real option analysis for pricing-setting behavior. Section 7 concludes the paper.

II. A Brief Literature Review

It is worthwhile to review the range of explanations for intra-firm price dispersion[5] in markets approximating perfect competition[6] (discussion of the empirical evidence for price dispersion is deferred to the next section).[7] We may structure the typology along the four elements that interact in market transactions: product, consumer, producer, and the macroeconomic environment. Most obviously, differences in products motivate price dispersion, whether these are directly observable, or only signaled (Gabor & Granger, 1966; Milgrom & Roberts, 1986). More interesting are theories permitting price dispersion among homogenous products. Such dispersion can be motivated by differences among consumers: Informational asymmetries and differing search costs which divide consumers into informed and uninformed pools have an extensive literature (Stigler, 1961; Grossman & Stiglitz, 1976; Salop, 1977; Salop & Stiglitz, 1977; Pennerstorfer *et al*., 2015; Menzio & Trachter, 2017). Other consumer differences include reservation prices (Anderson & De Palma, 2005) and single versus multiple product purchases (Richards *et al*., 2016). Further, price dispersion can be motivated by differences among producers: advertising (Butters, 1977), service capacity (Dana, 1999; Arnold 2000; Chen & Kong, 2004), or profiling technologies (Belleflamme. Lam, & Vergote, 2017). Finally, there are macroeconomic explanations of price dispersion, e.g., inflation (Head &

[5] As mentioned in footnote 4 intra-firm (spatial) price dispersion is the existence of different prices for the same product *at the same time*.

[6] As an illustrative example of how closely some electronic market model perfect competition, we may consider the market for books, CDs, and DVDs in the Amazon.com Marketplace, which is a very close approximation to a perfectly competitive product market: 1) it is a large, liquid market in which individual sellers cannot influence the equilibrium price; 2) there are no significant entry, exit or participation costs; 3) all participants have equal market access and information; 4) the goods on offer are, except for condition, perfect substitutes; and, 5) transaction costs are equal across all sellers. Only price significantly distinguishes products, yet noteworthy price dispersion is typical for products offered in this market.

[7] This is only intended to illustrate the broad range of explanations. Papers such as Barron, Taylor, and Umbeck (2004) give a more extensive overview of these theories.

Kumar, 2005). There remains, however, the complication that near perfect markets lack the conditions required by these explanations.

III. Evidence for Price Dispersion

Price dispersion occurs between various aggregations of products, different countries and across time. Our concern is intra-firm price dispersion: differences among prices for the *same* product in the *same* market at the *same* time. This is well documented both in markets in general and in internet markets (where we would expect minimal price dispersion). While there are myriad studies of individual markets supporting intra-firm price dispersion, we shall only note some comprehensive studies of dispersion in general markets (Abbott, 1992; Lach, 2002; Silver, 1988).

Internet markets should be characterized by notably less intra-firm price dispersion if more competitive markets are expected to narrow dispersion. Pan, Ratchford, and Shankar (2004), however, reviewing twelve studies conclude 1) significant price dispersion exists in internet markets, 2) internet price dispersion is no less than in traditional markets, and 3) though internet price dispersion has slightly declined over time it remains persistent. Nelson, Cohen, and Rasmussen (2007) study online price dispersion for 542 homogeneous products in 13 different product categories and find an average coefficient of variation of 11.69%. Baye, Morgan, and Scholten (2006) consider 36 homogeneous products in online electronics sales and find no convergence after 18 months. Adjusting for product and producer differences they find 28% of price variation for homogeneous products is left unexplained. The results are similar in many other markets, e.g., digital cameras (Haynes & Thompson, 2008), textbooks (Arnold & Saliba, 2003), books and CD's (Clay *et al*., 2002) and (Brynjolfsson & Smith, 2000).

IV. Assumptions of the Model

Herein a 'minimalist' model is developed requiring three relatively uncontroversial economic conditions. But initially it is equally important to note the assumptions which are *not* required by this model. *First*, the model does not require any between exemplars of a given product distinctions. *Second*, there is no need for informational asymmetries either between or among producers and consumers. *Third*, no distinction is required among consumers–each may have the same taste preferences, budget constraints, etc. *Fourth*, no distinction is necessary between different producers, *except* that some face different costs of production[8] (Note that this does not introduce an informational asymmetry: these varying cost structures may be observable to both consumers and each producer's competitors). *Fifth*, no specific macroeconomic circumstances are required and, *sixth*, no differential transaction costs are needed.

[8] It is not even necessary that different producers face different costs *at the same time*, only that over time the costs of production may change.

The goal is to justify rational price dispersion under perfect competition relying on a minimum set of conditions. The model requires three assumptions: stochastic prices, price rigidity, and differing production costs.[9] *First*, product prices must be stochastic, so future prices are not fully predictable.[10] A stochastic price is a natural expectation since many of factors determining the equilibrium price are uncertain, e.g., factor costs, technology shocks, consumer preferences, etc. But the model does not depend on accepting any specific rationale for stochastic prices. Further, the degree of price volatility (as with price rigidity and differing production costs) is not crucial– so long as it is economically significant. Only the existence of stochastic prices is required, not any specific theoretical explanation.

Second, there must be some price rigidity. At least some producers cannot immediately adjust prices to respond to changes in the equilibrium price. For some producers setting a price is a commitment to maintain that price over a certain period, so that pricing behavior must be optimized, not instantaneously, but for the time horizon during which that price will be in force. Importantly, the rational for such rigidity is not relevant to the model. Only the existence of price rigidity for some producers need be assumed and empirical studies well justify this. While much controversy remains about both the reasons for the rigidity (e.g., adjustment costs, explicit, and implicit contracts, coordination failures, etc.) and the sensitivity of rigidity to other factors (e.g., product unit price, firm size, macroeconomic conditions, etc.), the existence of price rigidity is clear. In a survey of 170 Canadian firms (Amirault *et al*., 2004/2005), about 75% maintained a price for at least one month and 35% for one year or more. Using unpublished data from the U.S. Bureau of Labor Statistics for 350 categories of consumer goods and services, Bils and Klenow (2004) found more frequent price changes than other studies but still about 13% of firms maintained a price for one year or more. Aggregating the results of surveys conducted in 2003 and 2004 by nine central banks (Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal, and Spain), Fabiani, *et al*. (2007) found that across all countries (except Germany and Luxembourg) about 70% of firms adjusted prices at most once yearly. Finally, Wolman (2007) summarizing over 50 studies concludes that this research "leaves no doubt that the prices of many goods change infrequently." While prices may change more quickly on the internet, they remain 'sticky' (Gorodnichenko, Sheremirov, & Oleksandr, 2016).

Third, there must be a disparity between the production costs over time; that is, the total cost of producing (inclusive of all tangential costs associated with the sale of the product, such as shipping) must differ over time, though cost structure need not be different in every period. While explanations of these differences seem obvious, e.g., different production technologies, the actual reasons for the differences are not germane, as in the previous two conditions, only the

[9] While price rigidity contains an element of controversy (and hence we shall briefly examine the evidence for it), we shall take it as common knowledge that prices are stochastic and the production costs may vary between different producers.

[10] Note that this assumption does not beg the question and surreptitiously and exogenously introduce price dispersion, since there can be stochastic prices (price dispersion *across time*) without intra-firm price dispersion; that is, there could be only one price at any point in time but that price may randomly change over time. This is what we witness in the pricing of financial securities if arbitrage is not possible.

existence of differing cost structures is needed, not any specific theoretical explanation. In fact, one might even argue that this follows from the first assumption of stochastic prices for if the costs of the producer's input factors change over time it follows that their cost structures likewise change.

The model requires minimal assumptions: stochastic product equilibrium prices, price rigidity and differential production costs: it does not necessitate any specific explanation for these assumptions.

V. A Real Options Analysis

The model offered here involves a real option analysis of price setting behavior. The relevant characteristic is that, given some price rigidity, price setting involves a commitment to offer a product at an established price for some time interval during which the underlying market/equilibrium price (P) is stochastic. This is effectively to give a 'price option' to consumers to purchase the product at that price (S), i.e., the strike price, for that period of time. If it were practical for the producer to adjust prices to the equilibrium price instantaneously (or even with great frequency), then this real option approach would not apply. But price rigidity implies that price setting behavior must be a function of not just the spot price, but of the expected price path over the duration of the price. This gives a price the configuration of a call option; that is, setting a price (S) is analogous to selling a call option on the stochastic market equilibrium price (P). The option is given to the (generic) consumer, because the consumer receives the right but not the obligation to purchase the product at the specified price for some period,[11] and the consumer exercises the option if they do, in fact, purchase the product from that producer. The scale of price dispersion is the spread between the spot/equilibrium price (P) and the exercise price (S) of the price option, i.e., the price offered by the producer.

The one anomaly in this correspondence concerns the premium (or the price) typically paid by the buyer of the option to the seller[12]. Oddly, it would seem, the producer, as option seller, freely gives the call option to consumers without exacting a premium. There is even a (small) negative premium, since the transaction costs associated with offering a product for sale are paid by the seller. Thus the seller incurs a cost in freely giving the consumer the call option. This would be irrational in the case of a financial option, since the premium is the only possible cash flow to the seller. The key difference between a financial option and a price as option is that all sellers of financial options face the same 'production costs', e.g., an equity share has the same value to all sellers.[13] But in a price option, producers face different production costs. Producers can incorporate their normal required rate of return into the price and need not obtain a separate 'pre-paid' premium. The inclusion of the 'premium' in the price places the producer, *qua* seller of a call option, in a peculiar position: unlike the seller of a financial option, the producer *wants*

[11] Technically, this is an American option, since the owner has the right to exercise it at any time up to and including the maturity date.

[12] See n. 2.

[13] This suggests an explanation of why price dispersion does not exist in financial markets.

the market price to rise and the consumer to exercise the option, since only then does the producer receive a profit. [14]

Since different producers face different production costs, they will set different prices, so we should expect the range of prices typical of the empirical price dispersion literature. Should the equilibrium price rise, new producers (facing higher production costs) will enter the market as the value of setting higher prices increases, and these producers will offer products for sale above the new equilibrium price. Should the equilibrium price fall and after their current prices have expired, producers with outstanding price offers, depending on their production costs, may either leave the market or set a new price.[15] The decision to enter or exit the market will be the trade-off between the transaction (and possibly inventory) costs of offering the product for sale and the option value of the price.

Finally, we have used a call option as a preliminary archetype, but the structure of price setting is rather more complex.[16] Its characteristics are more closely approximated by an 'up and in' barrier option, i.e., an option whose payoff (V) depends upon reaching or exceeding a specified price barrier (S) at any time during the life of the option. We may broadly describe the real option characteristics of price setting as the producer offering consumers an up and in barrier option in which the underlying security is the market equilibrium price (P), the barrier (S) is the price set by the producer, the maturity is the time horizon (T) over which the price is in effect, and premium, i.e., the transaction costs (of offering the product for sale), is paid by the seller, not the buyer.[17]

[14] There are other transactions, which also follow a real options paradigm in which the seller may receive a positive premium. If, for example, the seller requires a deposit to hold a product and the deposit is forfeit if the consumer does not complete the sale, the deposit functions like a premium paid for the option to hold the product for a particular consumer. Transactions with a real options structure and positive premium are, in fact, common: purchases stipulating a termination or cancellation fee, a re-shelving or restocking fees, etc. (cf. Scott & Triantis, 2004; Bodily, 2006). For low-price guarantees as real options, cf. Marcus and Anderson (2006).

[15] Note that this analysis even allows dispersion among the prices on offer by the *same* producer. If price offers were made asynchronously, a new (and different) price could be set prior to the expiration of a previous offer.

[16] There is no gain to specifying the exact structure of this price option beyond the following general analysis. First, making the structure more specific would remove the general applicability and introduce arbitrary factors; for example, the price option of a producer holding one product in inventory has different characteristics that that of one holding multiple products. Second, it would be infeasible to calibrate the model to the characteristics of individual sellers. Thus a more detailed specification of the option structure or a precise price algorithm would yield no significant gain.

[17] It is important to note that this is only an approximation and that no standard option captures all the nuances of a price option. For example, the value of the up and in barrier option described above is not a function of *when* that barrier is breached, but an early sale is, to the seller, more valuable than a later sale simply because of the time value of money.

VI. Price Behavior Implications

The analysis of price setting as a real option has, as we have seen, offered an explanation of price dispersion, but this approach has the further advantage of yielding predictions about the scale of price dispersion and the parameters determining that scale. The greater the value of the price option, the more price dispersion should be expected in a market. If the price option were valueless, then producers would only offer products at the market equilibrium price. As the value of the price option rises, producers with higher production costs will enter and set prices farther above the market equilibrium. Price dispersion is a function of the value of the price option. Here we can apply the standard[18] comparative statics of financial call options:[19] *First*, the value of the price option is increasing in the volatility of the market equilibrium price, since volatility increases the probability of exercise. There should be more price dispersion in markets whose equilibrium price has greater volatility. *Second*, the price option increases in value with longer maturity, so greater price rigidity, i.e., the longer horizon over which the firm must maintain the same price, increases the value of the price option. The longer the horizon, the more likely a higher equilibrium price will be attained, so there should be more price dispersion in markets with greater price rigidity.

VII. Conclusion

Given standard economic principles, we expect price dispersion to decrease and prices to converge to an equilibrium price as markets become more efficient. Unfortunately, the empirical evidence strongly contradicts this conclusion–while prices may narrow they certainly do not converge. Economists have offered a range of explanations for intra-firm price dispersion, but these rarely apply to markets whose characteristics approximate perfect competition. This model offers an explanation of price dispersion in such markets by relying on only three assumptions: stochastic prices, price rigidity, and differing production costs. It analyzes price setting as a real option: if prices are rigid, setting a price is giving consumers a real option to purchase the product at that price for some period of time. This Implies That producers set prices as a function of the price path of the expected market equilibrium over the 'life' of the price–not just the initial ('spot') price of the product. If prices are stochastic, it is then rational to set prices above the market price, i.e., to initiate price dispersion, because the equilibrium price has some possibility of rising to the producer's price. If different producers have different production costs, then we would expect prices to be set at different levels above the current market price. Finally, the real option analysis of price setting projects when price dispersion will occur: price dispersion should increase when the equilibrium price has greater volatility, and there is greater price rigidity.

Most economists see price dispersion as a 'problem' or market failure to be explained by product differences, informational asymmetries, macroeconomic conditions, etc., so it is especially thorny to explain why price dispersion occurs in perfectly competitive markets. This

[18] In the case of financial options, it is standard to consider the sensitivity of the option price to a change in the risk free rate of interest, but this factor is likely to be a little significance in understanding price dispersion.

[19] The following comparative statics may seem unusual until one recalls that the producer only gains value if the option is exercised by the consumer.

model suggests, rather, that price dispersion is a natural phenomenon associated with market uncertainty requiring only a minimal and generally accepted set of assumptions that apply to approximately competitive markets.

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