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Audit Fees, Patent Litigation, and Long-Term Performance

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ABSTRACT

Purpose:
The business risk of patent litigation contributes to auditors' professional skepticism and thereby results in different audit pricing decisions. Patent infringement is viewed as a specific news and thereby results in different economic consequences. This study examines the association among auditor reaction, patent litigation, and long-term economic consequences by exploring the different patent infringement cases.

Design/methodology/approach:
This study adopts a regression model to examine my research issues.

Finding:
The empirical results suggest that, (1) auditors consider patent settlement as a risk factor in the evaluation of business risks and lead to higher audit fees and lower business risk; (2) overseas patent litigation may affect auditors' perceived risk of patent litigation and lead to higher audit fees and lower business risk; (3) relative to Plaintiff companies, auditors perceive Defendant companies have a higher business risk and lead to higher audit fees and lower business risk; (4) relative to companies without overseas litigation, auditors perceive companies with overseas litigation have a higher business risk and lead to higher audit fees and lower business risk; (5) Defendant companies have the advantage of long-term growth performance within 3 years after settlement negotiations of patent litigation; (6) settlement negotiations would be a significant moderator for overseas patent litigation, and companies are more likely to obtain a favorable long-term performance.

Research limitations/implications:
Research data is obtained from three different sources: First, the lawsuit information was hand-collected from the Market Observation Post System (*MOPS*). Second, the patent-related information was hand-collected from the Taiwan Patent Search System (*TPSS*). Third, audit fees and accounting data were obtained from the Taiwan Economic Journal (*TEJ*) database. Therefore, hand-collected data and lack of audit fees data restrict the research sample to a manageable size. The number of observations during the period 2010-2020, which totals 307 observations.

Originality/value:
This study differs from previous studies in focusing on patent litigation cases to examine the association among auditor reaction, patent litigation, and long-term economic consequences by investigating whether auditors and market participants charge risk premiums for companies with the potential business risk of uncertain patent litigation, because potential business risk for patent litigation matters to market participants, and assessments of the perception of business risk can potentially provide useful and timely information to investors, auditors, and regulatory.

1. INTRODUCTION

In today's business environment, the patent plays a critical role in creating competitive advantage and sustaining economic growth in the future. Patents not only bring new opportunities for profitable development, but also attract more potential risk for infringement damages. Patent litigation cases are increasing rapidly in today's competitive environment and incurring a huge litigation cost. Such patent litigation not only harms the patent holder, but also harms the innovation development. Moreover, patent litigation is one of the most costly and controversial forms of business risk. Business risk is related with the financial structure, and the litigation risk for patent infringement can

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be seen as a warning sign. The following excerpts illustrate the potential relation between patent litigation and business risk:

> March 13, 2012 -- Yahoo Inc sued Facebook Inc over 10 patents that include methods and systems for advertising on the Web, opening the first major legal battle among big technology companies in social media.……Yahoo's patent lawsuit follows Facebook's announcement of plans for an initial public offering that could value the company at about $100 billion. (*Reuters.com*).

> May 25, 2018 -- Samsung Electronics Co Ltd should pay $539 million to Apple Inc for copying patented smartphone features, technology publication CNET reported, bringing a years-long feud between the technology companies into its final stages. (*Reuters.com*).

Business risk not only affects the company's prospect for sustainability and growth, but also affects the auditor's perspective for the acceptable audit risk and the investor's perspective for the long-term performance. Although previous studies (Almeida and Silva 2020; Anantharaman et al. 2016; Bryan and Mason 2016; Junjian and Dan 2015; Carpenter and Reimers 2013; Krishnan et al. 2013) have found that auditors are more likely to adopt different approaches to manage risky clients, few have focused on patent litigation risk to investigate whether and how auditors respond to audit risks arising from patent infringement when making audit pricing decisions. Although prior studies (Ball and Brown 1968; Basu 1997; Kim and Zhang 2014) have focused mainly on the release of good news and their short-term performance (price reactions), few have focused on the release of bad news (patent infringement) and subsequent long-term performance. This study differs from previous studies in focusing on patent litigation cases to examine the association among auditor reaction, patent litigation, and long-term economic consequences by investigating whether auditors and market participants charge risk premiums for companies with the potential business risk of uncertain patent litigation, because potential business risk for patent litigation matters to market participants, and assessments of the perception of business risk can potentially provide useful and timely information to investors, auditors, and regulatory.

2. RELATED LITERATURE

According the definition of prior studies (Bell et al. 2002; Arens and Loebbecke 2000; Johnstone 2000; Colbert et al. 1996; Huss and Jacobs 1991), business risk can be divided into client and auditor business risks. Client business risk is typically defined as the risk that the client's economic condition will deteriorate in either short or long term (Arens and Loebbecke 2000; Huss and Jacobs 1991), and such risk may increase auditor's litigation risk and harm the reputation of audit firm (Tang et al., 2017; Lyon and Maher 2005). Auditor business risk is typically defined as the risk that an auditor will suffer loss resulting from the client's engagement (Johnstone 2000; Bell et al. 2002), and such risk may harm the performance and reputation of audit firm. In general, the public is difficult to differentiate between client and auditor business risks, because such risks are closely related to the auditor-client relationship and the client financial condition.

Client business risks may increase auditor business risk and bring potential litigation costs to auditors. When auditors perceive an increase in business risk, they are more likely to tend to charge the expected costs of litigation risk in response to increased business risk in order to mitigate potential litigation costs. Prior studies (Almeida and Silva 2020; Bryan and Mason 2016; Junjian and Dan 2015; Krishnan et al. 2013; Peel and Roberts 2003; Niemi 2002; Bell et al. 2001; Johnstone 2000; Pratt and Stice 1994) indicate that auditors are more likely to charge higher fees into effort and risk portions when the business risk is higher. Auditors adjust their audit pricing decisions not only in response to the increased risk, but also as a means to mitigate potential litigation concerns. Some studies indicate that auditors respond to an increased business risk by issuing unfavorable opinions (Anantharaman et al. 2016; Krishnan and Krishnan 1997), adjusting audit plans (Bell et al. 2002; Pratt and Stice 1994), increasing professional skepticism (Carpenter and Reimers 2013; Payne and Ramsay 2005), and resigning from risky clients (Krishnan et al. 2013; Krishnan et al. 1996).

As discussed above, there are many previous studies have investigated the relationship between business risk and auditor reaction, moreover, these studies particular focus on the situation of company financial distress and auditor detection failure. This study extends the previous studies, which focus on patent litigation cases, by investigating whether auditors charge risk premiums for companies with the potential business risk of uncertain patent litigation.

Patents play an increasingly important role in market establishment and economic development (Griliches 1981; Hall 2005; Jeong and Kim 2017; Lee 2020). In today's competitive environment, patents have already become a vital role of companies (Hirshleifer et al. 2013; Kogan et al. 2017). When a company suffers harm due to a patent-related litigation, the company's auditor is more likely to suffer reputation damages and performance deterioration. Patent litigation not only brings harm to companies and auditors, but also may bring considerable damages across countries. Therefore, understanding the impact of patent litigation concerns on the determinants of audit pricing decisions is a particular important issue in today's world. This study investigates the effect of patent infringement on auditors' pricing strategies. As engaging in cases with higher patent litigation risk signals higher challenging and risky audit areas that requires more audit efforts and audit fee premiums, I thus predict that auditors tend to charge the expected costs of potential litigation risk in response to increased patent litigation risk. This leads to the first research hypothesis:

H1. There is a positive relation between the patent litigation and audit fees.

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According to positive accounting theory in economics, various information has the potential to significantly impact the market reaction. For example, bad news is more likely to attract market participants' attention (Ball and Brown 1968; Mendenhall and Nichols 1988; Hong et al. 2000; Heston and Sinha 2017), because it may hamper the growing prospect of long-term performance and the value of the company (Brown et al. 2006; Kothari et al. 2009; Godfrey et al. 2010). Patent litigation brings risks and uncertainty, and market participants view it as a negative signal or bad news (Santanam et al. 2008; Kiebzak et al. 2016; Wang and Chen 2017; Billings et al. 2021). Prior studies (Ball and Brown 1968; Basu 1997; Kim and Zhang 2014) focus mainly on the release of good news and their short-term performance (price reactions), and finding that stock prices reflect good news. In general, patent infringement is viewed as a specific bad news and its nature is involved in too many economic activities or events. Therefore, this study further conjectures that bad news drift may occur in subsequent months or years (Chan 2003; Parello and Spinesi 2005; Wang and Chen 2017; Bao et al. 2021) and bring economic consequences of patent litigation. This study differs from previous studies in focusing on bad news (patent litigation cases) to examine the release of patent litigation and subsequent long-term performance by exploring the different patent infringement cases. When a company suffers the event of patent infringement, it means the uncertain litigation risk inputs in a company is more likely to convert into company's perspective with a material adverse effect. Because the event of patent infringement signals higher operating risk in the future, I predict a negative relationship between the patent litigation and long-term performance. This leads to the second research hypothesis:

H2. There is a negative relation between the patent litigation and long-term performance.

3. METHODOLOGY AND DATA

The electronics industry has a large number of patents, and the possibility of patent litigation is higher than other industries. Thus, focusing on the electronics industry can help this study exploring the relationship between audit fees and patent litigation. Research data is obtained from three different sources: First, the lawsuit information was hand-collected from the Market Observation Post System (*MOPS*). Second, the patent-related information was hand-collected from the Taiwan Patent Search System (*TPSS*). Third, audit fees and accounting data were obtained from the Taiwan Economic Journal (*TEJ*) database. Hand-collected data and lack of audit fees data restrict the research sample to a manageable size. Therefore, research sample comprised 307 firm-year observations of the electronics firms listed on the Taiwan Stock Exchange (*TSE*)[1]. The number of observations during the period 2010-2020, which totals 307 observations (see Table 1).

Table 1: Distribution of Patent Litigation[a] Observations by Case Year and Long-Term Performance[b]

Year	Performance Period	Number of Observations	Percent of Sample
2010	2011~2015	52	16.94
2011	2012~2016	59	19.22
2012	2013~2017	49	15.96
2013	2014~2018	50	16.29
2014	2015~2019	52	16.94
2015	2016~2020	45	14.66
Total		307	100

[a] Patent litigation denotes companies involved in patent-related lawsuits.

[b] This study calculates the three-year and five-year stock performance following patent litigation as the measurement of long-term performance.

Plaintiffs who file lawsuits for patent protection, and they claim their rights for patent infringement. Defendants who may involve in violations of patent rights, and they may face charges for patent infringement claims. In patent infringement cases, plaintiffs and defendants may consider settlement negotiations to minimize litigation costs and risks. As for distribution of plaintiff and defendant by settlement of patent-related lawsuits, Table 2 shows there are 53 (17.26%) plaintiff companies and 254 (82.74%) defendant companies, and there are 218 (71.01%) no settlement companies and 89 (28.99%) settlement companies. These findings indicate that defendant companies are less likely to engage in further settlement negotiations. A possible reason is that, in general, defendant companies feel inappropriately high penalties and fines to impose on them.

Table 2: Distribution of Plaintiff and Defendant[a] by Settlement[b]

	Plaintiff	Defendant	Total
No Settlement	29 (9.45%)	189 (61.56%)	218 (71.01%)
Settlement	24	65	89

[1] Taiwan's electronics industry plays an important role in global competitive markets. Taiwan's electronics industry has the complete supply chain and it plays a dominant role in improving Taiwan's economic growth. Taiwan's electronics industry effectively produces high quality products and its products are ranked in the top three in the world (e.g., TSMC, UMC and Foxconn). In this study, I thus use Taiwan's electronics industry as research samples to examine my research questions.

	(7.82%)	(21.17%)	(28.99%)
Total	53 (17.26%)	254 (82.74%)	307

[a] Plaintiff (Defendant) denotes companies are involved in patent-related lawsuits as a plaintiff (Defendant).
[b] Patent litigation denotes companies have been negotiated settlements.

To test whether patent infringement affects auditors' pricing strategies, this study first estimates Equations (1) and (2). This study further estimates Equation (3) to determine whether long-term performance is affected by the effect of patent infringement.

$$LNAF_{i,t} = \beta_0 + \beta_1 SETTLEMENT_{i,t} + \gamma YEAR + \varepsilon_{i,t}. \quad (1)$$

$$LNAF_{i,t} = \beta_0 + \beta_1 CASES_{i,t} + \gamma YEAR + \varepsilon_{i,t}. \quad (2)$$

$$LR_{i,t} = \beta_0 + \beta_1 SETTLEMENT_{i,t} + \gamma YEAR + \varepsilon_{i,t}. \quad (3)$$

where, for firm i and year t:

$LNAF$ = the natural logarithm of audit fees;[2]
$SETTLEMENT$ = 1 if plaintiffs and defendants have been negotiated settlements, else 0;
$CASES$ = the natural logarithm of number of patent-related lawsuits;
LR = the holding period raw return for 1 year/3 years/5 years;[3]
$YEAR$ = fiscal year dummies;
ε = error term.

4. RESULTS AND DISCUSSION

Table 3 presents the regression results of audit fees adjustment. As shown in Column (1), the coefficient on *SETTLEMENT* is positively significant ($t = 3.22$, $p < 0.01$), indicating that auditors perceive the patent settlement as a business risk and incorporate such risk when determining audit fees. This study further partitions 307 observations into two groups: (1) Plaintiff companies (n = 53) and (2) Defendant companies (n = 254). As shown in Columns (2) and (3), the coefficients on *SETTLEMENT* are positively significant ($p < 0.01$), indicating that auditors perceive no difference between patent settlement of plaintiff and defendant companies. These results are consistent with H1. These findings generally support the idea that auditors consider patent settlement as a risk factor in the evaluation of business risks, and high audit fees reflect auditors' assessment of risk.

Table 3: Audit Fees and Patent Litigation - Considering Litigant

$$LNAF_{i,t} = \beta_0 + \beta_1 SETTLEMENT_{i,t} + \gamma YEAR + \varepsilon_{i,t}. \quad (1)$$

		(1)		(2)		(3)	
		All		Plaintiff [a]		Defendant	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**	**Coef.**	***t*-value**
CONSTANT		8.4024	63.21***	8.1044	28.75***	8.4511	56.57***
SETTLEMENT	?	0.3606	3.22***	0.5632	2.69***	0.3394	2.58***
YEAR		Included		Included		Included	
Adj. R^2		2.59%		3.33%		2.27%	
N		307		53		254	

[a] Plaintiff (Defendant) denotes companies are involved in patent-related lawsuits as a plaintiff (Defendant).
[b] The definition of the variables reported in this table are: *LNAF* = the natural logarithm of audit fees; *SETTLEMENT* = 1 if plaintiffs and defendants have been negotiated settlements, else 0; *YEAR* = dummy variables controlling for years.
[c] Asterisks *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

The overseas patent litigation is complex and multi-faceted, involving not only patent infringement concerns, but the law of extraterritorial patent enforcement. Therefore, overseas patent litigation may have higher litigation risk which in turn, increases business risk and audit fees. Table 4 presents the regression results of audit fees adjustment after considering cases of overseas litigation. After partitioning the sample into groups in which patent litigation is included and excluded overseas cases, Table 4 shows that the coefficient on *SETTLEMENT* is significant

[2] According to the audit fees literature (Craswell and Francis 1999; Francis et al. 2005), *LNAF* is measured as natural logarithm of audit fees as it provides a convenient interpretation.
[3] The measure of long-term performance is buy-and-hold returns (BHR). According prior literature (Ritter 1991; Ritter and Welch 2002), this study computes buy-and-hold returns from event month 1 to event month t (12/36/60), defined as: $LR_i = [\Pi(1+r_{it})-1]$. Where, r_{it} is the monthly actual return on security i in event period t.

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and positive (t = 2.58, p < 0.01) only in the overseas cases, which implies that overseas patent litigation may affect auditors' perceived risk of patent litigation and thereby results in higher audit fees.

Table 4: Audit Fees and Overseas Patent Litigation

$$LNAF_{i,t} = \beta_0 + \beta_1 SETTLEMENT_{i,t} + \gamma YEAR + \varepsilon_{i,t}. \quad (1)$$

		(1)		(2)	
		No Overseas [a]		Overseas	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**
CONSTANT		7.9172	87.05***	8.6514	50.26***
SETTLEMENT	?	0.0621	0.69	0.3559	2.58***
YEAR		Included		Included	
Adj. R^2		1.49%		2.47%	
N		83		224	

[a] No Overseas (Overseas) denotes companies aren't (are) involved in international patent-related lawsuits.

[b] The definition of the variables reported in this table are: *LNAF* = the natural logarithm of audit fees; *SETTLEMENT* = 1 if plaintiffs and defendants have been negotiated settlements, else 0; *YEAR* = dummy variables controlling for years.

[c] Asterisks *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Auditors may perceive that an increase in the number of litigation cases may lead to an increase in patent litigation risk. This study further analyzes the impact of the number of litigation cases on the determination of audit fees. As shown in Column (1) of Table 5, the coefficient on *CASES* is positively significant (t = 7.26, p < 0.01), indicating that auditors are more likely to charge higher audit fees when clients are involved in more patent litigation cases. This study partitions the sample into Plaintiff and Defendant companies. As shown in Columns (2) and (3), the coefficients on *CASES* are positively significant (p < 0.01), indicating that auditors tend to charge higher audit fees when clients are associated with more patent litigation cases, no matter who prompts the patent litigation. Notably, the coefficient of *CASES* in Column (3) is larger than the coefficient of *CASES* reported in Column (2), implying that auditors perceive a higher business risk to be present in Defendant companies than in Plaintiff companies. These results imply that auditors tend to charge the expected costs of litigation risk in response to increased business risk.

Table 5: Audit Fees and Litigation Cases

$$LNAF_{i,t} = \beta_0 + \beta_1 CASES_{i,t} + \gamma YEAR + \varepsilon_{i,t}. \quad (2)$$

		(1)		(2)		(3)	
		All		Plaintiff [a]		Defendant	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**	**Coef.**	***t*-value**
CONSTANT		8.2333	64.71***	7.9760	29.15***	8.2684	57.99***
CASES	?	0.4425	7.26***	0.4325	3.61***	0.4673	6.58***
YEAR		Included		Included		Included	
Adj. R^2		14.26%		12.80%		14.58%	
N		307		53		254	

[a] Plaintiff (Defendant) denotes companies are involved in patent-related lawsuits as a plaintiff (Defendant).

[b] The definition of the variables reported in this table are: *LNAF* = the natural logarithm of audit fees; *CASES* = the natural logarithm of number of patent-related lawsuits; *YEAR* = dummy variables controlling for years.

[c] Asterisks *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 6 shows the result for patent litigation cases relate to the determination of audit fees by partitioning the sample into two sub-samples according to overseas cases. As shown in Table 6, the coefficients on *CASES* are positively significant (at least at the 5% significance level), indicating that companies involving more patent litigation cases are more likely to be charged higher audit fees by their auditors, no matter whether these patent litigation cases are associated with the foreign infringement or not. Notably, the coefficient of *CASES* in Column (2) is larger than the coefficient of *CASES* reported in Column (1), implying that auditors perceive a higher business risk to be present in companies with overseas litigation than those without overseas litigation, and then charge higher fees to companies with overseas litigation for insuring increased business risk.

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Table 6: Audit Fees and Litigation Cases-Considering Overseas Litigation

$$LNAF_{i,t} = \beta_0 + \beta_1 CASES_{i,t} + \gamma YEAR + \varepsilon_{i,t}. (2)$$

		(1)		(2)	
		No Overseas [a]		Overseas	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**
CONSTANT		7.9798	90.60***	8.4319	50.53***
CASES	?	-0.1871	2.40**	0.4293	6.00***
YEAR		Included		Included	
Adj. R^2		0.61%		13.75%	
N		83		224	

[a] No Overseas (Overseas) denotes companies aren't (are) involved in international patent-related lawsuits.

[b] The definition of the variables reported in this table are: *LNAF* = the natural logarithm of audit fees; *CASES* = the natural logarithm of number of patent-related lawsuits; *YEAR* = dummy variables controlling for years.

[c] Asterisks *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Patent Litigation may affect not only auditors' perceived risk but also the delivery of future performance. Table 7 presents the regression results of long-term performance (1 year, 3 years, and 5 years). As shown in Column (1), the coefficient on *SETTLEMENT* is significant and positive ($t = 1.96$, $p < 0.1$) only in the Panel B. This study further partitions the sample into Plaintiff and Defendant companies. As shown in Columns (2) and (3), the coefficient on *SETTLEMENT* is significant and positive only in Panels A and B. Notably, the coefficient of *SETTLEMENT* ($t = 2.58$, $p < 0.01$) in Column (3) of Panel B is larger than the coefficient of *SETTLEMENT* ($t = 1.83$, $p < 0.1$) reported in Column (1) of Panel A. These results are consistent with H2. Empirical results indicate that Defendant companies have the advantage of long-term growth performance within 3 years after settlement negotiations of patent litigation. These results imply that settlement negotiations successfully play a strategic role in moderating the negative effect of patent litigation and bringing the stability of performance development.

Table 7: Long-Term Performance and Patent Litigation

$$LR_{i,t} = \beta_0 + \beta_1 SETTLEMENT_{i,t} + \gamma YEAR + \varepsilon_{i,t}. (3)$$

Panel A- Long-term performance for 1 year

		(1)		(2)		(3)	
		All		Plaintiff [a]		Defendant	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**	**Coef.**	***t*-value**
CONSTANT		0.1142	1.93*	0.0260	0.20	0.1282	1.93*
SETTLEMENT	?	0.0748	1.48	-0.0007	-0.01	0.1095	1.83*
YEAR		Included		Included		Included	
Adj. R^2		23.46%		4.85%		25.87%	
N		274		52		222	

Panel B- Long-term performance for 3 years

		(1)		(2)		(3)	
		All		Plaintiff [a]		Defendant	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**	**Coef.**	***t*-value**
CONSTANT		0.2237	1.92*	0.7630	2.78***	0.2474	2.17**
SETTLEMENT	?	0.1942	1.96*	0.0336	0.16	0.3394	2.58***
YEAR		Included		Included		Included	
Adj. R^2		7.36%		5.02%		9.90%	
N		274		52		222	

Panel C- Long-term performance for 5 years

		(1)		(2)		(3)	
		All		Plaintiff [a]		Defendant	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**	**Coef.**	***t*-value**
CONSTANT		1.6373	6.96***	3.2368	7.40***	1.3164	4.97***
SETTLEMENT	?	0.1297	0.65	0.0671	0.21	0.1496	0.63
YEAR		Included		Included		Included	
Adj. R^2		9.10%		40.35%		6.35%	
N		274		52		222	

[a] Plaintiff (Defendant) denotes companies are involved in patent-related lawsuits as a plaintiff (Defendant).

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[b] The definition of the variables reported in this table are: *LR* = the holding period raw return for 1 year/3 years/5 years; *SETTLEMENT* = 1 if plaintiffs and defendants have been negotiated settlements, else 0; *YEAR* = dummy variables controlling for years.
[c] Asterisks *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Overseas patent litigation can broadly affect company's performance, because the spillover effect of patent-related litigation is stronger for overseas patent litigation. Table 8 shows the result for overseas patent litigation relates to the long-term performance (1 year, 3 years, and 5 years). As shown in Table 8, the coefficient on *SETTLEMENT* is significant and positive only in overseas cases; moreover, the coefficient of *SETTLEMENT* ($t = 2.40$, $p < 0.05$) in Column (2) of Panel B is larger than the coefficient of *SETTLEMENT* ($t = 2.04$, $p < 0.05$) reported in Column (2) of Panel A. These results suggest that settlement negotiations would be a significant moderator for overseas patent litigation, and companies are more likely to obtain a favorable long-term performance. Notably, the advantage effect of settlement negotiations on long-term performance will decrease over time.

Table 8: Long-Term Performance and Overseas Patent Litigation

$$LR_{i,t} = \beta_0 + \beta_1 SETTLEMENT_{i,t} + \gamma YEAR + \varepsilon_{i,t}. (3)$$

Panel A- Long-term performance for 1 year

		(1)		(2)	
		No Overseas [a]		Overseas	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**
CONSTANT		0.1714	1.71*	0.0886	1.20
SETTLEMENT	?	-0.0594	-0.58	0.1201	2.04**
YEAR		Included		Included	
Adj. R^2		23.20%		23.05%	
N		76		198	

Panel B- Long-term performance for 3 years

		(1)		(2)	
		No Overseas [a]		Overseas	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**
CONSTANT		0.5118	3.04***	0.0827	0.56
SETTLEMENT	?	-0.0487	-0.28	0.2863	2.40**
YEAR		Included		Included	
Adj. R^2		12.01%		8.72%	
N		76		198	

Panel C- Long-term performance for 5 years

		(1)		(2)	
		No Overseas [a]		Overseas	
Variables[b]	**Pred. Sign**	**Coef.**	***t*-value**[c]	**Coef.**	***t*-value**
CONSTANT		2.4732	6.42***	1.2269	4.22***
SETTLEMENT	?	-0.2994	-0.75	0.2836	1.22
YEAR		Included		Included	
Adj. R^2		25.04%		4.81%	
N		76		198	

[a] No Overseas (Overseas) denotes companies aren't (are) involved in international patent-related lawsuits.
[b] The definition of the variables reported in this table are: *LR* = the holding period raw return for 1 year/3 years/5 years; *SETTLEMENT* = 1 if plaintiffs and defendants have been negotiated settlements, else 0; *YEAR* = dummy variables controlling for years.
[c] Asterisks *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

5. CONCLUSION

The business risk of patent litigation contributes to auditors' professional skepticism and thereby results in different audit pricing decisions and subsequent performance. This study examines the implications of patent litigation, as a potential red flag of auditor business risk, to the auditor's concerns, audit pricing, and long-term performance. The empirical results suggest that, (1) auditors consider patent settlement as a risk factor in the evaluation of business risks and lead to higher audit fees and lower business risk; (2) overseas patent litigation may affect auditors' perceived risk of patent litigation and lead to higher audit fees and lower business risk; (3) relative to Plaintiff companies, auditors perceive Defendant companies have a higher business risk and lead to higher audit fees and lower business risk; (4) relative to companies without overseas litigation, auditors perceive companies with overseas litigation have a higher business risk and lead to higher audit fees and lower business risk; (5) Defendant companies have the advantage of long-term growth performance within 3 years after settlement negotiations of patent litigation; (6)

settlement negotiations would be a significant moderator for overseas patent litigation, and companies are more likely to obtain a favorable long-term performance. Collectively, the empirical results suggest that auditors tend to charge higher audit fees in response to increased business risk when the companies are exposed to greater patent litigation risk; moreover, settlement negotiations successfully play a strategic role in moderating the negative effect of patent litigation and bringing the stability of performance development.

In my view, empirical results of this study have a number of implications for research, policy, and practice. From a research perspective, empirical results extend auditing literature by examining the effect of patent infringement on auditors' pricing strategies and add to auditing related literature on the important role that auditors' pricing strategies play a moderating role on uncertain business risks in patent infringement cases. Empirical results also extend accounting literature by examining the effect of patent infringement on company's long-term performance and add to accounting related literature on economic consequences that the event of patent infringement signals higher operating risk and brings adverse effects on long-term performance. From a policy perspective, the regulators could remind auditors to maintain their professional skepticism and pay attention to patent infringement cases. Moreover, the policy-makers could consider increasing the company's mandated disclosures to provide greater transparency about infringement-related information by which market participants can evaluate the company's perspective in the future. From a practice perspective, this study approves that the effect of patent infringement is viewed as a material business risk in deteriorating long-term performance. This study suggests that the voluntary disclosure for litigation-related information to the public plays an effective communication role in moderating the adverse effect of patent infringement in capital markets.

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Corporate governance as the driver of economic growth in Sub-Saharan African Countries

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ABSTRACT

Purpose:
Corporate governance in essence is designed to lead to economic growth. Nevertheless, despite placing great emphasis on promoting corporate governance practices over the years, countries in Sub-Saharan Africa (SSA) have so far achieved insignificant or no economic growth. This, however, is inconsistent to the findings observed in developed countries.

Design/methodology/approach:
The study examined connections between corporate governance, macroeconomic fundamentals, the institutional environment and economic growth in Sub Saharan African countries. Panel Vector Autoregression (PVAR) models and impulse response functions were applied to analyse sets of panel data from 29 countries in Sub Saharan Africa for 7 years from 2008.

Findings:
The findings suggest that disaggregated variables of corporate governance, macroeconomic fundamentals and the institutional environment have a positive but insignificant relationship with economic growth. It was also found that aggregated composite; corporate governance, macroeconomic fundamentals and the institutional environment have a statistically strong significant relationship with economic growth. The results of the impulse response functions predict that, there will be a 0.01 per cent growth in the economies of Sub-Saharan African countries if there is a continued interaction between aggregated variables under the present conditions observed during the period of the investigation. The PVAR results showed that the future outcome of economic growth can be predicted from the past behaviour of aggregated composite corporate governance. The impulse response and variance deposition. The findings lead to the conclusion that aggregated corporate governance within both a given year and that of previous periods are major determinants of economic growth.

Research limitations/implications:
The implications of the findings for countries within Sub Saharan Africa is that promoting corporate governance only might be insufficient to stimulate growth of economies, rather it must be enhanced concurrently with macroeconomic fundamentals and the institutional environment. If past behaviour is a contributing factor of the future performance of corporate governance then, a reflection on the past governance behaviour can help to develop effective corporate governance practices that affect the present and future economic growth.

Originality/value:
This study contributes to literature by testing application the theoretical relevance of corporate governance theories to the context of Sub-Saharan African countries economies. The findings suggest that sound corporate governance on its owned is insufficient to stimulate and sustain to economic growth within countries under investigation. As, adduced by evidence corporate governance affect economic growth is context dependent. More attention can be paid to examining the link corporate governance linkages to economic growth in different contexts in future studies.

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1. Introduction

The concept of corporate governance is recognised as a foundational pillar for achieving economic growth through its contribution to improved firm performance. Several country and region specific codes were formed in an attempt to promote good principles of governance practices in corporation such as the Cadbury (1992), Organisation for Economic Co-Operation and Development (OCED) (1994, 2004, 2015), King Report (1992, 2002, 2009, 2016), New Partnership for African Development (NEPAD) (2016) Resultantly, there is a widespread acknowledgement of sound governance of firms as a foundation for economic growth, compelling the emphasis and advocacy of its the development all in firms within countries. Despite, this emphasis it appears corporate governance has yielded varied results across countries. The industrialised economies yielded substantial economic growth rates whilst the unindustrialised economies it has yielded negligible contribution to economic growth. The 10 years annual reports for the World Economic Forum (WEF) starting in the year 2006 to 2015 point to the improved corporate governance among western countries that enhanced firm productivity and competiveness and in turn promoted economic growth (WEF, 2010, 2011, 2013, 2014) whilst it appears to have no contribution to growth of Sub-Saharan African economies. This suggest that differences in economic growth between countries is determined by variances in corporate governance within companies. This study examines whether corporate governance in Sub Saharan Africa firms determines economic growth within countries.

Comparative studies that determine whether corporate governance contributes to economic prosperity in the Sub-Saharan African environment remains few. Most country specific studies focused on investigating corporate governance at firm level (Gerged and Agwili, 2020, Tshipa, Brummer, Wolmarans, and Du Toit, 2018, Nakpodia, 2018, Isingoma, 2018). Findings in Maune (2021) revealed that government effectiveness, control of corruption, regulatory quality, voice and accountability had a positive and significant effect on economic growth whilst regulatory quality had inconsequential effect. Empirical evidence from country studies are useful to a limited since their scope do not extent to Sub Saharan African countries contexts. There are several comparative corporate governance and economic growth studies that were conducted such as those by Claessens (2006), La Porta et al. (1997), Doidge et al. (2008) and Djnakov et al. (2008). The majority of these studies focused on developed countries context with no focus on the African environment. Although these studies overlooked focusing on countries in Sub Saharan Africa, their findings provide hindsight on how corporate governance affects economic growth however these findings cannot be generalised to the context of economies. The need to strengthen governance of corporations to enhance economic growth in Sub Saharan African countries was further highlighted by NEPAD (2016). Cross country studies such by Munisi et al. (2014). Adegbite et al. (2013) and Gutsavson et al. (2009) observed that weak legislative and institutional environment is an obstacle to corporate governance. Afolabi (2015) avers that multiple factors such as legal systems, good governance, financial development and macroeconomic environment are major determinant of corporate governance.

2 Literature and theoretical background

2.1 Theoretical Review

Corporate governance is widely held as a determinant of economic growth in all economies through its connection to increased firm productivity and efficiency. Corporate governance according to the King IV (2016:20) report encompasses "the exercise of ethical and effective leadership by the governing body towards the achievement of ethical culture, good performance, effective control and legitimacy". This definition takes into account the need to safeguard maximisation of shareholder wealth creation. Ethical and effective leadership highlighted in this definition embodies the idea that the management of the company must have a positive relationship with all the stakeholders of the entity. This is in line with the suggestions by the OECD (2015) and Claessens & Yortglou (2013) who view corporate governance as the effective management of a set of interactions that a corporation has with all its stakeholders. Hence an entity that practices good corporate governance is expected to contribute positively to all stakeholders. That is it should also have a positive economic contribution.

The King IV (2016:20) report also goes on to highlight that;

"Ethical leadership is exemplified by integrity, competence, responsibility, accountability, fairness and transparency. It involves the anticipation and prevention, or otherwise amelioration, of the negative consequences of the organization's activities and outputs on the economy, society and the environment and the capitals that it uses and affects. Effective leadership is results-driven. It is about achieving strategic objectives and positive outcomes. Effective leadership includes, but goes beyond, an internal focus on effective and efficient execution".

Thus, corporate governance is widely held to contribute to economic prosperity through its implications to firm performance and value creation. Theoretical principles underlying the resource dependence as well as the social capital theories embodies the central thinking of maximisation of firm value creation through efficient performance of the firm. Tricker (2009) posits that dependence theory together with social capital theory consider effectiveness of an organization as dependent the interrelationships and regulating interdependencies in order to survive in the environment. If follows that, whilst creating a balance among the wellbeing of all stakeholders, the efficient use of resources through the exercise of effective and ethical leadership beyond the borders of the organization constitute the functions corporate governance. Bansal and Desjardine (2014) regards the shareholder theory as focusing on maximizing shareholder wealth. According to Solomon (2011) the stakeholder theory ensues balancing the welfares of

all stakeholders. Hence, the promotion of corporate governance should among other things leads to creation of wealth for all and consequently the promotion of economic growth.

The principles underpinning the agency theory and the stewardship theory justify the need to maximise shareholder value creation as an essential goal for corporate governance. The stewardship theory emphasises the moral, fiduciary and legal obligations of directors to run firms in the interests of the shareholders and the corporation as the spirit and letter of corporate governance (García-Meca et al., 2014). This entails that efficient corporate governance should effectively minimise diverging interest between the agent and the principal. Berle and Means (1932), Jensen and Meckling (1976) as well as Smith (1776) long explained in the agency theory that since the management of firms lies in the hands of managers who are not the owners of that company conflict of interest between principal and agent were bound to arise. As such the need to manage the conflicts of interest so as to safeguard of investors' resources against expropriation by insiders and those in control of the company give rise to the need for sound governance of the firms. Enhancing firm performance essentially contribute to growth in productivity of economies through safeguarding the investor's resources and optimising productivity of firms by the way it is governed.

2.2 Previous studies

Sub Saharan African countries began to construct their national economic and social policies to accelerate their national wellbeing since getting their independence in the 1960s (Osman et al., 2011). Osman et al. (2011) observed in the mid-1960s to early 1970s the region experienced high economic and social development. This might be an indication that perhaps favourable conditions existed that prompted such economic growth to occur during this period. However, evidence from the United Nations Conference on Trade and Development (UNCTD) (2013) report for 2013 reveals that, since 1971 the many economies in the Sub-Saharan Africa region were underdeveloped countries. Furthermore, the UN LDC (2013), report shows that 31 of Sub-Saharan Africa countries formed part of the 48 less developing countries. It is evident that 63 % of least developed economies for the past five decades were from the Sub-Saharan Africa region. Moreover, UN World Economic Situation and Prospect, (2014) also asserts that Sub Saharan Africa as the region that consists of the majority of developing countries. The trends affirms the WEF survey reports which further reveal a continuous low economic growth that is associated with low corporate governance in Sub Saharan Africa for the past 10 years since 2006 to 2015.

Okeahalam and Akinboade (2003) clarify how through the Structural Adjustment Programmes (SAPs) efforts started international bodies such as IMF and World Bank lead to the emerging of corporate governance in Africa around the 1980s and early 1990s. Okeahalam and Akinboade (2003) explained that the idea of corporate governance was introduced to African countries through SAPs that emphasised free market economic systems like the converting of state-owned companies to private companies. Hence, it may be argued corporate governance was introduced by donor and funding agencies in African countries as a condition for granting financial credit and aid. Beck et al. (2003) assert that corporate governance systems in Africa countries were primarily inherited from colonisation.

The WEF annual surveys reports since 2006 to 2015 highlight the increased adaption of corporate governance among western countries and the United States of America. The WEF reports indicates that corporate governance appears to enhance productivity and competiveness in companies that to the end of achieving economic growth in developed economies whilst it appears to have insignificant contribution to growth of economies Sub Saharan Africa. It is apparent that putting in place corporate governance principles and practices does not necessarily culminate in economic growth but rather it depends on the nature of the interaction of variables that promote growth of economies within a particular environment.

There are certain factors that promote economic growth. It is the interaction of these specific factors that creates an enabling environment for economic growth to occur. Isuku and Chizea (2015), Wintoki et al. (2012) elucidates that corporate governance is affected by the interaction between the firms and the institutions. This leads to the presumption that economic growth is determined by corporate governance and its interactions with the institutional and macroeconomic environment. The formation of corporate governance that determine growth of the economy is influenced by the institutional environment (OECD, 2015). This suggest that sound institutional framework is a precursor harnessing a corporate governance system that fosters economic growth. The legal infrastructure affects the governance of individual companies by means of written laws and enforcement of such laws (Dallas, 2004). Empirical evidence reveals that sound legislation and regulatory frameworks as necessary predictors of the creation of effective corporate governance (Claessens and Yortoglou, 2013, Djankov et al, 2008, Doidge et al, 2008). Standard and Poor (2008) found evidence that the expense of setting up corporate governance structures and practices to exorbitant in countries with weak legal systems compared to those with strong legal systems. The WEF (2015) identifies the legal systems has got judicial independence, property rights, investor protection and the efficiency of the legal framework. Kaufmann et al. (2010) describe good governance as consisting of six variables namely; voice and accountability, government effectiveness, anti-corruption, political stability, regulatory qualities and rule of law. WEF (2015) identifies financial development as encompassing financing using the market as well as regulation of securities of exchange.

Evidence from studies by Isuku and Chizea (2015), Lounsbury (2005) Arslan and Alqatan (2020) reveals that the institutional environment affects the growth of formal and informal structures in the organization. This means the performance of institutions in a particular environment affects the formation of corporate governance. Arslan and Alqatan (2020) and Nhuta (2014) elucidates that institutions influence corporate governance practices by creating legitimacy, constrains and similarity of structure. Scot (1987) views institutions as enduring systems of social beliefs and socially organized practices and structures that save different functions in the society.

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3. Methodology

This study adapted a positivist philosophy which constructs knowledge through collecting and converting empirical data into numerical form so that statistical estimations and evaluation can be conducted and conclusions drawn. A quantitative approach was applied since all variables used in this study were numerically measured henceforth quantitative techniques informed this research. Panel data techniques was used to analyse the data.

3.1 Measurement of Study Variables

3.1.1 Dependent Variable

Economic growth is represented by Gross Domestic Product annual % (GDP) available at the World Development Indicator (WDI), available at World Bank database. The duration of the study was limited to 2014 by the availability of data due to scarcity of data in African countries.

3.1.2 Independent Variables

Corporate governance is presented by efficacy of board, disclosure and transparency, protection of minority shareholder, shareholder suit and director liability. The World Economic Forum Global Competitive Reports annual surveys provides data on efficacy of board, extent of disclosure and transparency. Annual data on protection of minority, director liability and shareholder suits was accessed from Easy of doing business an online data found on the World Bank Website. The legal systems are proxied by strength of investor protection, property rights, legal rights, efficiency of the legal system and judicial independence annual data accessed from the WEF online website. Good governance is represented by six composite indicators of voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law and control of corruption that provided by The World Governance Indicator annual data available on World Bank website. Owing to the scarcity data in Sub Saharan African countries the study used financing using local equity market and regulation of securities exchange annual data available on the WEF website as proxies of financial development. As proxies of the macroeconomic fundamentals this study incorporates foreign direct investment and inflation. Inflation deflator and foreign direct investment data found at the Wold Development Indicators database available on the World Bank website.

3.2 Analytical models

Using disaggregated and aggregated data the study specified and estimated Panel Vector Autoregression (PVAR) models to investigate whether corporate governance, institutional, macroeconomic fundamentals determine economic growth. The PVAR assumes that all variables are endogenous and interdependent (Verbeek, 2004). The PVAR model for estimating corporate governance and economic growth relationship is specified as follows:

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \cdots + Y_{it-p+1}A_{p-1+}Y_{it-p}A_p \ + X_{it}\beta + u_{it} + e_{it} \qquad (1)$$

$A = 1,..N, t = 1 \ldots$, where, Y_{it} represent the vector of explanatory variables that is GDP in this study, X_{it}, vector of exogenous explanatory variables u_{it} and e_{it} vectors of explanatory variable-specific fixed-effects and idiosyncratic errors, respectively. $A_1, A_{2,\ldots,}A_{P-1,}A_P$; β are parameters to be estimated of the endogenous variables.

Y_{it} representing lags of the explanatory variable on the variable itself that is present values of economic growth as represented by GDP. X_{it} proxies of lagged values of the explanatory or dependent variables. Model to be estimated is specified as follows.

Where;

$Corporate\ governance$ = f(GDP_{-t-1},$Prmsrty_{-t-1}$,$Sharsit_{-t-1}$ $Dirliab_{-t-1}$, $Disctranpar_{-t-1}$, $Effbrd_{-t-1}$)

Where GDP_{-t-1} = Gross Demostic Product in lag 1, $Prmsrty_{-t-1}$, proxies protection of minority shareholder in lag 1, $Sharsit_{-t-1}$ is shareholder suit in lag 1, $Dirliab_{-t-1}$ representing director liability, $Disctranpa_{-t-1}$ representing disclosure and transparency and $Effbrd_{-t-1}$ is efficacy of board lag 1

$Legal\ systems$ = f (GDP_{t-1} ,$comp\_Cgov_{t-1}$,$legrts_{-t-1}$,$prorit_{-t-1}$,$judicind_{-t-1}$,$inver_{-t-1}$, eff_{-t-1})

GDP_{-t-1} = Gross Demostic Product in lag 1, $comp\_Cgov_{t-1_{t-1}}$, represents composite corporate governance in lag 1, $legrts_{-t-1}$is legal right in lag 1, $prorit_{-t-1}$representing property rights lag 1 , $judicind_{-t-1}$ is judicial independence lag 1 and $inver_{-t-1}$investor rights, $efflf_{-t-1}$ representing the efficiency of the legal framework lag 1

$Good\ governance$ =f(GDP_{t-1},$comp\_cgov_{t-1}$, $polst_{-t-1}$, $gvteff_{-t-1}$, $voiacca_{-t-1}$, $ctnrcrrption_{t-1}$,$rull_{-t-1}$, $regqty_{-t-1}$)

GDP_{-t-1} = Gross Demostic Product in lag 1, $Aggc\_Cgov_{t-1}$ is composite corporate governance lag 1 , $polst_{-t-1}$ is political stability lag 1, $gvteff_{-t-1}$ is government effectiveness lag 1, $voiacca_{-t-1}$, voice and accountability lag 1, $ctnrcrrpt_{t-1}$ is control for corruption lag 1, $rull_{-t-1}$ is rule of law lag 1 , $regqty_{-t-1}$ is regulation quality lag 1

$Financial\ development$ = f(GDP_{t-1}, $comp\_cgov_{t-1}$, $fintmkt_{-t-1}$,$regsecsex_{-t-1}$)

GDP_{t-1} =Gross Domestic Product lag 1, $comp\_cgov_{t-1}$ is aggregated composite corporate governance lag 1, $fintmkt_{-t-1}$ is financing through the market lag 1, $regsecsex_{-t-1}$ is regulation of securities of exchange lag 1

$Macroeconomic\ fundamentals$ = f(GDP_{t-1}, $comp\_cgov_{t-1}$,$gross_{-t-1}$, $fdifm_{-t-1}$,$infl_{-t-1}$,)

GDP_{t-1} = gross domestic product lag 1, $compccgov_{t-1}$ proxies composite corporate governance lag 1$Aggcomp_legst_{t-1}$composite legal systems $comp\_ggov_{t-1}$,composite good governance lag 1, $comp\_fdmt_{t-1}$ is composite financial development lag 1, $comp\_mfls_{t-1}$ is composite macroeconomic fundamentals.

The pvar models that examine relationships using aggregated data is specified as follows:
$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \cdots + Y_{it-p+1}A_{p-1+}Y_{it-p}A_p + X_{it}B + u_{it} + e_{it}$
$Y_{it} = F(GDP_{t-1}, comp\_cgov_{t-1}, comp\_legrts_{t-1}, comp\_gg_{t-1}, comp\_fdmt_{t-1}, comp\_mfls_{t-1})$
Where, $comp\_cgov_{t-1}$, $comp\_legrts_{t-1}$, $comp\_gg_{t-1}$, $comp\_fdmt_{t-1}$, $comp\_mfls_{t-1}$)
Where, $comp\_cgov_{t-1}$, $comp\_legrts_{t-1}$, $comp\_gg_{t-1}$, $comp\_fdmt_{t-1}$, $comp\_mfls_{t-1}$

$GDP_{it} = GDP_{it-1}A_1 + GDP_{it-2}A_2 + \cdots + GDP_{it-p+1}A_{p-1+}GDP_{it-p}A_p + comp - cgov_{it}\beta + u_{it} + e_{it} = 1,..N, t = 1,2 \ldots T_i$ (PVAR1) (2)

$comp\ Cgov_{it} = comp_{cgov_{it-1}}A_1 + comp_{cgov_{it-2}}A_2 + \cdots + comp_{cgov_{it-p+1}}A_{p-1+}comp_{cgov_{it-p}}A_p$
$+GDP_{it}\beta + u_{it} + e_{it} = 1,..N, t = 1,2 \ldots T_i$ (PVAR2)
(3)

Applying the same specification, models for aggregated one of the other explanatory variables under investigation.

4 Results

Six models consisting of both disaggregated and composite data for corporate governance, legal systems, good governance, financial development, and macroeconomic fundamentals were estimated determine the linkages between corporate governance and economic growth. Schwarz (SIC) and Akaike (AIC) information criteria provided the basis for selecting the appropriate equations.

4.1.1 Corporate governance and economic growth

Results for PVAR estimates for the contribution of corporate governance on economic growth are reflected in Table 1. The PVAR analysis examines whether previous year corporate governance performance determines of the observed current economic growth. Corporate governance elements in the last 12 months have an insignificant contribution to economic growth.

Table 1: Corporate governance and economic growth PVAR estimate.

	GDP	protection of minority shareholders	Shareholder suits	Director liability	Disclosure & transparency	Efficacy of the board
GDP_{-t-1}	0.149	0.019	-0.005	-0.005	0.016	0.0791
	(0.582)	(0.944)	(0.987)	(0.953)	(0.953)	0.770
$Prmsrty_{-t-1}$	-0.698	0.461	-0.120	--0.305	0.305	1.7653
	-	-	-		-	-
$Sharsit_{-t-1}$	-0.912	0.498	-0.067	-0.667	0.315	2.2151
	(0.928)	(0.960)	(0.991)		(0.975)	(0.826)
$Dirliab_{-t-1}$	0.875	0.703	-0.092	-0.315	1.245	2.1230
	-	(0.703)		(0.975)	-	(0.826)
$Disctranpa_{-t-1}$	0.487	0.194	-0.920	-0.164	0.164	-0.8197
	(0.976)	(0.990)	(0.995)	(0.992)	(0.992)	(0.958)
$Effbrd_{-t-1}$	-0.494	-0.166	-0.014	--0.108	-0.109	0.5120
	(0.783)	(0.926)	(0.994)	(0.952)	(0.952)	(0.775)

GDP_{-t-1} proxies Gross Demostic Product in lag 1, $Prmsrty_{-t-1}$, proxies protection of minority shareholder in lag 1, $Sharsit_{-t-1}$ is shareholder suit in lag 1, $Dirliab_{-t-1}$ represents director liability, $Disctranpar_{-t-1}$ is disclosure and transparency lag 1$Effbrd_{-t-1}$ is efficacy of the board lag 1. ***, **, * representing significant level at 1%; 5% and 10%respectively.

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4.1.2 Corporate governance and legal systems impact on economic growth

PVAR estimates of composite corporate governance and legal systems and economic growth results are presented in Table 2. The composite corporate governance effect coefficient was found to be 2.867 with p=0.008, < 0.05 leading the study to reject H0 that β=0, suggesting that composite corporate governance in the last 12 months has significant impact on economic prosperity. It can be inferred that any adjustments in composite corporate governance in the past 12 months have a strong positive significant impact on economic growth. The economic growth effect coefficient is estimated at 0.034 with p=0.566, < 0.05 revealing the failure to reject the H0 that β=0, affirming that economic growth in the past one year no contribution to current economic growth. The property rights effect coefficient is -0.197 with 0.004<0.05, meaning we reject H0 indicating that legal rights in the past 12 months affect growth of the economy. The findings suggest that investor protection and property rights changes together with the effectiveness of the legal framework in the last 12 months period had adverse effect on economic growth.

An impulse response function and variance decomposition of economic growth to aggregated legal system was estimated in addition to the PVAR analysis. Findings of the study with the 95% confidence interval at 5% margin of error reflected that the composite legal system is predicted to make an insignificant contribution on the economic growth for the next 10 years.

Table 2: Aggregated composite corporate governance, legal systems and economic growth PVAR estimates

	GDP	comp_cgov	_legrts	prorit_	judicind_	inver_	efflf_
GDP_{t-1}	0.034	0.009	-0.111	-0.020	0.039	-0.024	0.041
	(0.566)	(0.270)	(0.001)	(0.797)	(0.102)	(0.216)	(0.383)
$comp\_cgov_{t-1}$	2.867	0.123	1.872	-0.853	-1.023	-0.772	-2.623
	(0.008)	(0.470)	(0.004)	(0.388)	(0.023)	(0.011)	(0.001)
$legrts_{t-1}$	0.239	0.028	0.623	0.074	0.132	0 .130	0.116
	(0.279)	(0.399)	(0.000)	(0.662)	(0.104)	(0.007)	(0.386)
$prorit_{t-1}$	-0.197	0.029	-0.067	-0.060	-0.066	0.089	0.012
	(0.004)	(0.033)	(0.113)	(0.831)	(0.040)	(0.001)	(0.863)
$judicind_{t-1}$	-0.249	0.046	0.068	0.711	0.86	0.091	0.809
	(0.393)	(0.227)	(0.639)	(0.011)	(0.000)	(0.206)	(0.000)
$inver_{t-1}$	0.695	-0.048	0.508	0.703	0.666	0.983	0.517
	(0.945)	(0.371)	(0.242)	(0.140)	(0.016)	(0.000)	(0.287)
$efflf_{t-1}$	-0.142	-0.027	-0.024	0.055	-0.024	0.113	0.377
	(0.945)	(0.371)	(0.662)	(0.102)	(0.016)	(0.029)	(0.006)

$Aggcomp\_cgov_{t-1}$, proxies composite corporate governance in lag 1, $legrts_{t-1}$ is legal right in lag 1, $prorit_{t-1}$ represents property rights lag 1 , $judicind_{t-1}$ is judicial independence lag 1 and $inver_{t-1}$ investor rights , eff_{t-1} proxies the efficiency of the legal framework lag 1, ***, **, * represents significant level at 1%, 5%, 10% respectively

4.1.3 Composite corporate governance and good governance impact on economic growth

Table 3 presents results for an estimation PVAR composite good governance practices on economic growth. The results reveal that aggregated composite corporate governance lag 1 effect coefficient of 1.116 with p=0.009, < 0.05 rejecting the H0 that β=0, meaning that composite corporate governance in the last one-year period has a positive significant effect on current economic growth. The government effectiveness lag 1 effect coefficient is 0.121 with p=0.001, < 0.05, leading us to rejecting the H0 that β=0, meaning that changes in effectiveness of government in the last 12 months has influence on economic growth. The voice and accountability effect coefficient is -1.335 with a p=0.001 < 0.05 whilst, that of rule of law effect coefficient is 0.057 with p=0.000, <0.05 leading us to accept the alternative hypothesis suggesting that voice and accountability in the last 12 months has a significant strong negative influence on economic growth. The rule of law effect coefficient is -0.057 with a p= 0.000, <0.05 leading us to rejecting the H0, meaning that rule of law in the last 12 months has effect on economic growth.

Economic growth impulse response and variance decomposition of composite good governance as proxied by aggregated elements of rule of law, political stability, voice and accountability and absence of violence/terrorism, government effectiveness, regulatory quality and control of corruption was estimated in addition the PVAR estimations. The findings detected the response of economic growth to one-unit standard shock of composite good governance. The impulse response results show that economic growth will in by 0.02% in the first five years in

response to unit change of aggregated corporate governance in the presence a unit change in aggregated good governance, after which in the last five years it will remains constant. The projection at a 95% confidence interval and 5% margin of error predicts that composite corporate governance in the next 10 years will make a negligible contribution to economic growth.

Table 3: corporate governance, good governance and economic growth PVAR estimates

	GDP	comp_cgov	polst_	gvteff_	voiacca_	ctnrcrrpt	rull_	regqty_
GDP_{t-1}	0.078	-0.002	-0.083	-0.019	0.018	-0.014	0.031	0.024
	(0.1740)	(0.769)	(0.002)	(0.657)	(0.007)	(0.587)	(0.200)	(0.235)
$comp\_cgov_{t-1}$	1.116	0.183	-0.866	-1.469	0.107	0.080	1.147	0.465
	(0.009)	(0.133)	(0.002)	(0.000)	(0.105)	(0.001)	(0.000)	(0.005)
$polst_{-t-1}$	0.040	-0.026	0.384	0.262	-0.028	0.327	0.055	0.042
	(0.694)	(0.205)	(0.010)	(0.016)	(0.181)	(0.001)	(0.403)	(0.476)
$gvteff_{-t-1}$	0.121	0.020	-0.111	-0.323	0.037	-0.017	0.101	0.193
	(0.001)	(0.213)	(0.189)	(0.003)	(0.081)	(0.210)	(0.080)	(0.000)
$voiacca_{-t-1}$	-1.335	0.096	2.247	0.361	0.754	0.319	-1.691	1.423
	(0.001)	(0.214)	(0.000)	(0.449)	(0.000)	(0.210)	(0.000)	(0.000)
$ctnrcrrpt_{t-1}$	-0.289	0.082	0.318	0.818	-0.081	0.248	0.129	-0.118
	(0.235)	(0.038)	(0.026)	(0.449)	(0.038)	(0.161)	(0.293)	(0.198)
$rull_{-t-1}$	-0.057	-0.015	0.030	0.006	-0.001	-0.014	-0.019	0.015
	(0.000)	(0.000)	(0.001)	(0.817)	(0.713)	(0.026)	(0.042)	(0.095)
$regqty_{-t-1}$	-0.258	-0.076	-0.214	0.671	-0.010	0.017	0.096	0.069
	(0.402)	(0.128)	(0.101)	(0.000)	(0.738)	(0.841)	(0.350)	(0.516)

GDP_{-t-1} represents Gross Demostic Product in lag 1, $compt\_cgov_{t-1}$ proxies composite corporate governance lag 1 , $polst_{-t-1}$ representing political stability lag 1, $gvteff_{-t-1}$ is government effectiveness lag 1, $voiacca_{-t-1}$, voice and accountability lag 1, $ctnrcrrpt_{t-1}$ is control for corruption lag 1, $rull_{-t-1}$ is rule of law lag 1 , $regqty_{-t-1}$ is regulation quality lag 1. $^{***, **, *}$ represents significant level at 1%, 5%, 10% respectively.

4.1.4 Corporate governance and financial development impact on economic growth

Table 4 presents results of PVAR for the estimation composite corporate governance in the presence of financial development and economic growth. Results reveals that composite corporate governance affects coefficient is estimated at 2.88 with p=0.120, > 0.05 leading to rejection the H0 that β=0, meaning that change in aggregated composite corporate governance in the previous period in the presence of change in financial development in the past year has an immaterial contribution to economic growth. The financing using the market effect coefficient is estimated at -0.443 with p=0.892, > 0.05 leading the study to reject the H0 that β=0, indicating that financing using the market in the last 12 months does not contribute to contribute to economic growth. The study found evidence of a negative insignificant effect of economic growth due to a one year previous a change in the financing through the market. Regulation of securities lag 1 effect coefficient is at 0.097 with p=0.892, > 0.05, leading to the rejecting the H0 that β=0, meaning that change that took place in regulation of securities of exchange in the past 12 months had no contribution to economic growth.

In addition to the PVAR analysis an impulse economic growth response to aggregated composite corporate governance in the presence of aggregate to financial development. The impulse response indicates the economic growth response to the unit standard change aggregated corporate governance in the presence of a change in unit change in aggregated financial development. The predication indicates in the first five years a unit change in aggregated financial development has positive effect on economic growth and subsequently it retains a negative but stale outcome. The projection at 95% confidence interval at 5% margin of error predicts in the next 10 years financial development will not economic growth.

Table 4: Corporate governance, financial development and economic growth PVAR estimates

	GDP	Aggcompo_cgov	finmkt	regsecsex_
GDP_{t-1}	0.082	0.008	0.199	0.018

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	(0.377)	(0.420)	(0.491)	(0.575)
$\text{Aggcomp\_cgov}_{t-1}$	2.880	0.250	-1.357	-0.989
	(0.120)	(0.420)	(0.059)	(0.166)
finmkt_{-t-1}	-0.443	0.084	0.698	0.124
	(0.892)	(0.052)	(0.000)	(0.412)
regsecsex_{-t-1}	0.097	0.097	-0.342	0.419
	(0.892)	(0.892)	(0.197)	(0.141)

GDP_{t-1} = Gross domestic product lag 1, comp_cgov_{t-1} is composite corporate governance lag 1, fintmkt_{-t-1} is financing through the market lag 1 , regsecsex_{-t-1} is regulation of securities of exchange lag 1.*, **, *** represent 1% ,5% and 10% significant level respectfully

4.1.5 Effects of aaggregated composite factors on economic growth

Table 5 shows the results for PVAR estimates for aggregated composite for; corporate governance legal systems, good governance, financial development and macroeconomic fundamentals on economic growth. The estimated composite corporate governance effect coefficient is 4.224 and p=0.000, < 0.05, thus H0 is rejected meaning that a change in aggregated composite corporate governance in the 12 months period has effect on economic growth. This indicates that both past and present aggregated corporate governance are determinants of growth of the economy due to the presence of enabling legal, good governance, financial development and macroeconomic environment.

Table 5: Corporate governance, legal systems, good governance, financial development and macroeconomic fundamentals on economic growth PVAR estimates

	GDP	comp_cgov	comp_legst	com_ggov	com_fdmt	com_mfls
GDP_{t-1}	0.136	-0.003	-0.008	0.029	0.029	-0.149
	(0.000)	(0.324)	(0.251)	(0.010)	(0.010)	(0.000)
$comp\ cpgov_{t-1}$	4.224	0.221	0.130	-1.459	-0.029	-0.149
	(0.000)	(0.004)	(0.375)	(0.000)	(0.350)	(0.550)
comp_legst_{t-1}	-0.998	-0.048	0.414	-0.029	-0.029	0.046
	(0.000)	(0.004)	(0.000)	(0.350)	(0.000)	(0.395)
comp_ggov_{t-1}	0.760	0.010	0.297	-0.212	-0.212	-0.635
	(0.000)	(0.634)	(0.000)	(0.000)	(0.000)	(0.000)
comp_fdmt_{t-1}	-0.503	0.070	-0.005	0.472	0.472	-0.090
	(0.000)	(0.000)	(0.005)	(0.000)	(0.035)	(0.144)
$\text{Aggcomp\_mfls}_{t-1}$	-0.142	0.017	-0.154	-0.041	-0.041	0.174
	(0.000)	(0.022)	(0.000)	(0.000)	(0.035)	(0.000)

GDP_{t-1} = gross domestic product lag 1, comp_cgov_{t-1} is composite corporate governance lag 1, $\text{Aggcomp\_legst}_{t-1}$ composite legal systems comp_ggov_{t-1} composite good governance lag 1, comp_fdmt_{t-1} is composite financial development lag 1, comp_mfls_{t-1} is composite macroeconomic fundamentals, ***,**,* representing significant level at 1%, 5%, 10% respectively

Economic growth impulse response to composite elements of; corporate governance, legal systems, good governance, financial development and macroeconomic fundamentals was estimated in addition to the PVAR analysis. Based on the analysis of the impulse response of economic growth has an insignificant response to a one standard unit shock of composite; corporate governance, legal systems, aggregated good governance, financial development and macroeconomic fundamentals. At 95% confidence interval and a 5% margin of error in the next 10 years aggregated corporate governance is predicted to make contribution of 0.01% to economic growth. Based on these predictions corporate governance together with the present and previous conditions of the environment of institutions in Sub Saharan Africa countries are predicted to have no effect on economic growth in the next decade.

4.2 Conclusion and Recommendations

Both the present and past composite corporate governance together with composite elements of legal environment, good governance, financial development and macroeconomic fundamentals leads to economic growth. A continuous reviewing and strengthening corporate governance practices performance every 12 months is necessary to promote economic growth. It is therefore, recommended that countries aiming at promoting growth in their economies focus strengthening aggregated composite of corporate governance, institutional and macroeconomic environment together and not in isolation.

5.1 Policy implications

Economic growth in Sub Saharan African countries can be enhanced through improved effective composite corporate governance countries. An insight into the contribution of corporate governance elements is important for strengthening growth of economies through improved governing of corporations. It is important to understand that that previous one 12 months period behaviour of composite corporate governance is a determinant of future economic growth. It implies that past behaviour of corporate governance has a role to play in shaping g economic productivity of a nation. It follows from the above that a reflection on the past behaviour of corporate governance practices may help to strengthen governance practices in forms that leads to increased productivity and growth of the economy. The findings revealed that both the current and previous one year aggregated corporate governance performance determines economic growth. Government effectiveness has a significant contribution to economic growth. However, the influence of the previous year government effectiveness on economic growth is weak. The observed evidence indicates to policy makers that a change in individual good governance indicators such as control of corruption, political stability, and regulation quality had negligible contribution to significantly cause economic growth, however the composite elements have a notable effect on economic growth.

Judging by this evidence, it can be inferred that, there is a possibility that, the extent of change in financial market was insufficient to contribute to development of sound corporate governance standard that is necessary to source finance from foreign market given the inefficiently functioning financial markets. In simple terms, if financing through the market is secured at high cost it reduces the income and decreases company performance and these results in negative economic growth. If this assumption is holds, then we can conclude that there is need to improve financial development, investor protection within country specific institutional and macroeconomic environment. Futures research may focus on comparative studies between the Sub-Saharan Africa and other economic regions such the Middle East and North Africa amongst many others.

5.2 Theoretical implication

The evidence found in this study are inconsistent to the property rights and agency theory which associate increase corporate governance and legal system with improved performance and economic growth.

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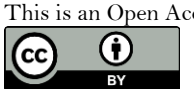

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Patent Claim's Impact on Stock Return Rate Based on China Stock Market's Empirical Study

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ABSTRACT

Purpose:
The main aim of this research was to discuss the relationship between the patents and the performance of listed companies, more particularly, to find out whether China patent's claim impacted on China listed company's stock return rate or not. It was because the claim played the most important role in a patent which being a key driving force for modern business.

Design/methodology/approach:
This research used a company integrated China patent database in which all subsidiary's patents were merged with their parent company's patents. Three China patent species of the invention publication, the invention grant and the utility model grant were all studied and compared. The average claim count per patent of each A-share was calculated for the whole stock market and four stock boards comprised therein. Five claim groups were divided by the percentile rank of all A-shares' claim counts. The annual stock return rates in four quarters of 2020 were observed. The research hypothesis was tested using the analysis variance (ANOVA).

Findings:
This research found that the average claim count per patent had a significant impact on China A-share's stock return rate. Though the stock market fluctuated seriously under COVID-19 pandemic, the average claim count of any patent species was still a good indicator for classifying A-share's stock return rate. The A-shares in the higher claim count groups showed the significantly higher stock return rate means while the A-shares in the lower claim count groups showed the significantly lower stock return rate means.

Research limitations/implications:
China companies listed in Shanghai stock exchange and Shenzhen stock exchange were observed while China companies listed in Hong Kong or overseas were excluded. China patents in which patent claim count being calculated in this research were discussed while other countries' patents were excluded. It was because the amount of China domestic patents played the majority part of China listed companies' patents. Patents with more claims were usually regarded as more valuable. Companies having more valuable patents were usually regarded as more competitive to have better financial performance. This research implicated and proved.

Originality/value:
This research provided a novel and creative analysis of the patent claim's impact on the stock return rate over whole China stock market. The finding of this research would improve the understanding of China patents and the innovation outcome of China A-shares. It would contribute a lot the art of the patent valuation and the listed company evaluation.

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1. Introduction

Innovation is an essential driver of economic progress that benefits individuals, businesses and the economy as a whole. Goniadis & Goniadis (2010) found a significant number of patentees started a new business with most of them being optimistic of new job creation. The technological innovation is a key driver of financial performance for most companies in most economies though the intellectual capital has no significant influence on performance of SMEs in some underdeveloped countries, e.g. Kenya (Murimi *et al.*, 2022).

The stock market principally reflects the economic and innovation conditions of an economy. China has been the largest domestic patent application country in the world for many years. China Intellectual Property Administration (CNIPA) is now the world's largest patent office. In the single year of 2020, there are more than three millions of patent published and/or granted by CNIPA, including 1,517 thousands of invention publications, 53 thousands of invention grants and 2,377 thousands of utility model grants. Meanwhile, China is now the world No.2 economy to have a stock market with the world No.2 transaction volume. China listed companies lead the development of China patents, which the unlisted companies and individuals follow.

With so huge amount of China patents, CNIPA faced the challenges in trying to process more patent applications in a shorter period of time and made some achievements (Liegsalz & Wagner, 2013). Based on patent information, Motohashi (2008) examined China's development of innovation capabilities from 1985 to 2005 by using more than 679 thousands of China invention patent. Motohashi (2009) proposed to see a substantial trend of Chinese firms catching up with Western counterparts via patent statistics in two high-tech sectors: the pharmaceutical industry and mobile communications technology. He found that these two fields show contrasting trends, the rapid catching up can be found in mobile communications technology, while Chinese companies are still lagging behind Western counterparts in the pharmaceutical industry. Hu & Jefferson (2009) used a firm-level data set that spans the population of China's large and medium-size industrial enterprises to explore the factors that account for China's rising patent activity. They found that China's patent surge is seemingly paradoxical given the country's weak record of protecting intellectual property rights. Lei *et al.* (2011) found that the inventive activities of China have experienced three developmental phases and have been promoted quickly in recent years. The innovation strengths of the three development phases have shifted from government to university and research institute and then industry. Liu & Qiu (2016) used Chinese firm-level patent data from 1998 to 2007 which featuring a drastic input tariff cut in 2002 because of China's WTO accession. They found that input tariff cut results in less innovation undertaken by Chinese firms. Boeing & Mueller (2019) proposed a patent quality index based on internationally comparable citation data from international search reports (ISR) to consider foreign, domestic, and self-citations. They found that all three citation types may be used as economic indicators if policy distortion is not a concern. They also suggested that the domestic and self-citations suffer from an upward bias in China and should be employed with caution if they are to be interpreted as a measure of patent quality.

Dang & Motohashi (2015) proposed that China patent statistics are meaningful indicators because China valid patent count is correlated with R&D input and financial output. Chen & Zhang (2019) studied China's patent surge and its driving forces on patent applications filed by Chinese firms and found that R&D investment, foreign direct investment, and patent subsidy have different effects on different types of patents. They found that R&D investment has a positive and significant impact on patenting activities for all types of patents; the stimulating effect of foreign direct investment on patent applications is only robust for utility model patents and design patents; the patent subsidy only has a positive impact on design patents.

He *et al.* (2016) found that it was difficult in integrating Chinese patent data with company data, so they constructed a China patent database of all China listed companies and their subsidiaries from 1990 to 2010. Chen *et al.* (2018, 2020) used the patent data and stock data of China listed companies of RMB common stocks (A-shares) in Shanghai main board (SH main board) from 2011 to 2017 and found the patent indicators have leading effect on A-share's stock price. Chiu *et al.* (2020a, 2020b) focused on the whole China A-shares without distinguishing the stock boards from 2016Q4 to 2018Q3. They found that the patent indicators also have leading effect on the financial indicators including the stock price, return-on-asset (ROA), return-on-equity (ROE), book-value-per-share (BPS), earnings-per-share (EPS), price-to-book (PB) and price-to-earnings (PE). The patent prediction equations for quantitatively giving the predictive values of the aforementioned financial indicators are proposed.

The China A-shares are listed on four stock boards including SH main board, Shenzhen main board (SZ main board), Growing-Enterprises board (GE board) and Small-and-Medium Enterprises board (SME board). Chiu *et al.* (2020c, 2020d, 2020e, 2021), Li *et al.* (2020a, 2020b, 2021) further studied the patent leading effect on each stock board, proposed each stock board's patent prediction equations on the stock price, ROA, ROE, BPS, EPS, PB and PE, finally proposed patent based stock selection criteria to have stock the performance surpassing the market trend.

COVID-19 is an impact to everything including technology and finance. The World Health Organization (WHO) on March 11, 2020, has declared COVID-19 outbreak a global pandemic. The stock markets around the world including China stock market fluctuated dramatically in 2020. Figure 1 shows the principal China stock indexes performance from Jan. 2019 to Dec. 2020, wherein, 300317 is the stock index consisting of all China A-shares, 000002 is the stock index consisting of all A-shares in SH main board, 399101 is the stock index consisting of all A-shares in SME board, 399102 is the stock index consisting of all A-shares in GE board. Apparently, stock indexes in 2020 are more volatile than those in 2019.

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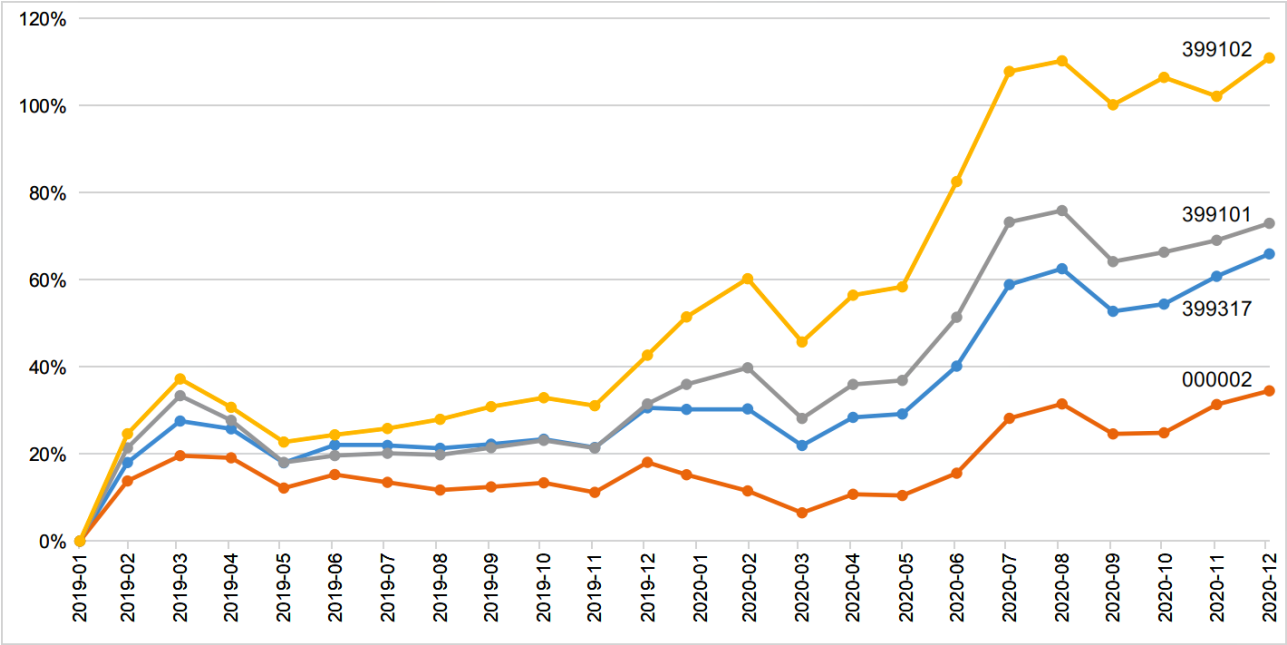

Figure 1: Performance of Principal China Stock Indexes from JAN 2019 to DEC 2020

The fluctuation modes of stock indexes are far beyond any patent indicator's varying trend. Tsai *et al.* (2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2022) discussed the relationship between China patents and A-shares' stock performance in recent years. The China A-shares with the higher innovation continuity showed the higher stock return rate mean (Tsai *et al.*, 2021a). The China A-shares with the higher patent count showed the higher stock price mean and the higher stock return rate mean (Tsai *et al.*, 2021b, 2021f). The China A-shares with the higher technology variety showed the higher stock return rate mean (Tsai *et al.*, 2021c). The China A-shares having patents of the longer examination duration showed the higher stock price mean and the higher stock return rate mean (Tsai *et al.*, 2021d). The China A-shares having patents of the higher backward citation count showed the higher stock price mean (Tsai *et al.*, 2021e). The A-shares having patents but receiving no forward citations were proved to show the highest stock price mean whereas the A-shares receiving forward citation counts above the average showed the lowest stock price mean (Tsai *et al.*, 2022).

The claim is usually regarded as the most important part of a patent because it forms the boundary of patent right. The claim of a patent is a list which consisting of a series of numbered statements, each of which comprising a subject matter and the corresponding patentable characteristics. A patent having higher claim counts usually has more stable and stronger patent right and is regarded more valuable when comparing with the patent having less claim counts.

Lai & Che (2009a, 2009b, 2009c) applied US patent claim count as one of indicators for quantitatively modeling patent legal values. Chiu *et al.* (2020a, 2020b, 2020c, 2021) and Li *et al.* (2020a, 2020b, 2021) applied China patent claim count as one of indicators to build the patent prediction equations for giving the predictive values of China A-share's financial indicators. However, the detailed impact of patent claim count on China A-share's stock return rate has not been discussed. It is therefore the objective of this research to solve, more particularly, to see the impact variance between different stock boards under the COVID-19 pandemic.

2. Methodology

2.1 Company Integrated Patent Database

It is a common phenomenon that a listed company has lots subsidiaries. When a subsidiary's revenue is merged to its parent company as shown in the formal financial report, the subsidiary's patents are inferred to contribute to parent company's financial performance. Therefore, a company integrated China patent database is built in this research, wherein, all subsidiaries' patents are merged together with parent company's patents. Furthermore, if a patent is co-owned by parent company and any of the subsidiaries, it is regarded as a single one patent of the parent company for avoiding duplicated calculation. However, if a patent is co-owned by two or more parent A-shares, it is inferred to contribute equivalently to each parent A-share's financial performance, so the patent is duplicately specified to each of the parent A-shares.

2.2 Patent Species and Claim Groups

There are three patent species regarding claim counts of published patents in China including the invention publication, the invention grant, and the utility model grant. The invention publication is an invention application which published by overcoming the preliminary examination. The invention grant is an invention application which granted by overcoming not only the preliminary examination but also the substantial examination. The utility model grant is a utility model application which granted by overcoming the preliminary examination. Since the attorney's

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service charge and official fees including filing and examination from high to low is the invention grant > the invention publication > the utility model grant, so the invention grant is usually regarded as the most valuable patent species with high level innovation while the utility model grant is usually regarded less valuable and the innovation level is low. In this research, the claim's impact of aforementioned patents of three species are all discussed and compared.

For each of four quarters of 2020, patents of three species are retrieved from the company integrated patent database by the patent publication date and the patent grant date. For 2020Q1, patents are retrieved by the publication date or the grant date from 2019/04/01 to 2020/03/31. For 2020Q2, patents are retrieved by the publication date or the grant date from 2019/07/01 to 2020/06/30. And so forth 2020Q3 and 2020Q4.

When patents are retrieved, the average claim count per patent of each A-share is calculated. By setting the stock return rate as the dependent variable and the average claim count as the independent variable, the R^2 of a modeled linear regression equation is less than 0.01. It is inappropriate to use linear modeling for the stock return rate and the average claim count because of the poor explanatory ability.

The discrete data analysis model is therefore applied. The average claim count per patent of all effective samples of A-shares are ranked by percentile. The effective samples are divided into five claim groups by claim count percentile rank (PR) as below:

Claim group 1: PR 0~20, the lowest claim count;
Claim group 2: PR 20~40;
Claim group 3: PR 40~60;
Claim group 2: PR 60~80;
Claim group 5: PR 80~100, the highest claim count.

2.3 Population and Sample

The population comprises all China A-shares listed in SH main board, SZ main board, GE board and SME board. SH main board and SZ main board comprise mostly the state-owned companies and big size companies. GE board and SME board comprise mostly medium and small size companies. An effective sample for each quarter of 2020 must be an A-share listed in 2019 and 2020 so as to have a definite annual stock return rate and have at least one new patent published or granted in the patent retrieval interval as described in sub-section above.

Table 1 shows the effective samples statistics of the whole stock market and four stock boards in four quarters of 2020, wherein, the whole market consists of all effective samples of four stock boards. The sampling rate of the effective samples to all A-shares is more than 50%. Table 2 shows the number of effective samples of each claim group for discussing the stock return rate. With regard to the patent species, the number of invention publication's effective samples is close to the number of utility model grant's effective samples; the invention grant is of the least number of effective samples due to the rejection of substantial examination. The numbers of effective samples in different claim groups are not the same but quite close, while the numbers of effective samples in different quarters of 2020 are also close. The analysis in this research should be of no survivorship bias.

Table 1: Effective Samples Statistics

Patent Species	Stock Board	Effective Samples				
		2020Q1	2020Q2	2020Q3	2020Q4	Total
Invention Publication	Whole Stock Market	2,610	2,660	2,644	2,643	10,557
	SH Main Board	976	1,004	1,001	1,004	3,985
	SZ Main Board	280	280	276	282	1,118
	GE Board	624	636	631	623	2,514
	SME Board	730	740	736	734	2,940
Invention Grant	Whole Stock Market	2,046	2,092	2,108	2,182	8,428
	SH Main Board	739	760	788	802	3,089
	SZ Main Board	220	218	221	236	895
	GE Board	500	531	515	528	2,074
	SME Board	587	583	584	616	2,370
Utility Model Grant	Whole Stock Market	2,459	2,541	2,553	2,565	10,118
	SH Main Board	934	961	974	992	3,861
	SZ Main Board	265	279	285	281	1,110
	GE Board	556	579	579	579	2,293
	SME Board	704	722	715	713	2,854

Source: This Research

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Table 2: Effective Samples Statistics for Claim Groups

Patent Species	Stock Board	Effective Samples					
		Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Invention Publication	Whole Stock Market	2,242	1,981	2,139	2,683	1,512	10,557
	SH Main Board	797	817	777	1,067	527	3,985
	SZ Main Board	224	223	226	221	224	1,118
	GE Board	509	501	498	537	469	2,514
	SME Board	588	642	534	763	413	2,940
Invention Grant	Whole Stock Market	1,699	1,872	1,486	1,685	1,686	8,428
	SH Main Board	636	605	673	557	618	3,089
	SZ Main Board	180	226	151	159	179	895
	GE Board	511	326	407	437	393	2,074
	SME Board	496	474	463	533	404	2,370
Utility Model Grant	Whole Stock Market	2,108	1,948	2,015	2,023	2,024	10,118
	SH Main Board	772	772	773	771	773	3,861
	SZ Main Board	224	220	222	222	222	1,110
	GE Board	475	442	462	491	423	2,293
	SME Board	571	571	577	564	571	2,854

Source: This Research

2.4 Analysis of Variance

Analysis of Variance (ANOVA) is applied for discovering:

(1) whether the claim counts are significantly different between different patent species;

(2) whether the claim counts are significantly different between different stock boards; and

(3) whether the claim count significantly impacts the stock return rate or not.

ANOVA is a statistical approach used to compare variances across the means of different data groups. The outcome of ANOVA is the "F-Ratio".

$$F = \frac{MST}{MSE} = \frac{\sum n_j (\overline{x_j} - \overline{x})^2 / (k-1)}{\sum\sum (x - \overline{x_j})^2 / (N-k)} \quad \text{.....(1)}$$

This ratio shows the difference between the within group variance and the between group variance, which ultimately produces a result which allowing a conclusion that the null hypothesis $H_0: \mu_1 = \mu_2 = ... = \mu_k$ is supported or rejected. If there is a significant difference between the groups, the null hypothesis is not supported, and the F-ratio will be larger and the corresponding p value should be smaller than 0.05.

3. Result and Finding

3.1 Patent Species of Invention Publication

Table 3 shows the claim count means of invention publication's claim groups. With regard to claim groups 1, 2 and 4, it seems that SZ main board has the lowest claim count means while GE board has the highest claim count means. With regard to claim group 3, it seems that SH main board has the lowest claim count means while GE board also has the highest claim count means. With regard to claim group 5, it seems that SZ main board has the lowest claim count means while SH board has the highest claim count means. In general, GE board seems to have the highest claim count means in most claim groups while SZ main board has the lowest claim count means in most claim groups.

Table 3: Claim Count Means of Invention Publication's Claim Groups

Stock Market	Claim Count Mean					
	Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Whole Stock Market	5.61	7.75	8.81	9.76	11.85	8.61
SH Main Board	5.36	7.49	8.59	9.66	12.11	8.47
SZ Main Board	5.30	7.46	8.59	9.47	10.90	8.35
GE Board	5.83	8.07	9.10	9.87	11.77	8.90
SME Board	5.63	7.90	8.93	9.78	11.57	8.64

Source: This Research

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Table 4 shows the results of ANOVA on invention publication's claim count between four stock boards. The claim count variances between different stock boards reach p***≤0.001 significance in all claim groups. Different stock boards have significantly different claim count means.

Table 4: Result of ANOVA on Invention Publication's Claim Count Between Stock Boards

Claim Group	Stock Board	Claim Count			
		Sum Square	Mean Square	F	p
1	Between Stock Boards	102.1	34.0	18.838	0.001***
	Within Stock Boards	3,785.6	1.8		
2	Between Stock Boards	144.3	48.1	326.727	0.001***
	Within Stock Boards	323.5	0.1		
3	Between Stock Boards	97.3	32.4	452.198	0.001***
	Within Stock Boards	145.1	0.1		
4	Between Stock Boards	20.3	6.8	94.402	0.001***
	Within Stock Boards	194.5	0.1		
5	Between Stock Boards	70.5	23.5	3.163	0.001***
	Within Stock Boards	11,201.4	7.4		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Tables 5 further shows the multiple comparisons of ANOVA on invention publication's claim count between every two stock boards, wherein, SH stands for SH main board, SZ stands for SZ main board, GE stands for GE board, SME stands for SME board. With regard to claim groups 1, 2, 3 and 4, the claim count variances between SH main board and SZ main board are free of significance; the other claim count variances are of significance. According to the significant mean differences, GE board is therefore confirmed to have the highest claim count means, SZ main board is therefore confirmed to have lowest claim count means. With regard to claim group 5, the claim count variance between SME board and SH main board is the only one of significance; the other claim count variances are free of significance. SH main board has the higher claim count mean than SME board. Though SH main board seems to have the highest claim count means than the other stock boards in Table 4, but it could not be confirmed because the mean differences between SH main board and other stock boards are free of significance except between SH main board and SME board. In general, GE board has the highest claim count means in most claim groups and SZ main board to has the lowest claim count means in most claim groups.

Table 5: Multiple Comparisons of ANOVA on Invention Publication's Claim Count between Stock Boards

Claim Group	Stock Board		Claim Count		
	Board (I)	Board (J)	Mean Difference (I-J)	Std. Error	p
1	SZ	SH	-0.196	0.105	0.062
	GE	SH	0.468	0.076	0.001***
	GE	SZ	0.664	0.111	0.001***
	SME	SH	0.273	0.073	0.001***
	SME	SZ	0.469	0.109	0.001***
	SME	GE	-0.195	0.081	0.017*
2	SZ	SH	-0.033	0.028	0.248
	GE	SH	0.586	0.022	0.001***
	GE	SZ	0.618	0.030	0.001***
	SME	SH	0.416	0.020	0.001***
	SME	SZ	0.448	0.029	0.001***
	SME	GE	-0.170	0.023	0.001***
3	SZ	SH	-0.002	0.021	0.935
	GE	SH	0.509	0.015	0.001***
	GE	SZ	0.510	0.022	0.001***
	SME	SH	0.339	0.015	0.001***
	SME	SZ	0.340	0.022	0.001***
	SME	GE	-0.170	0.017	0.001***
4	SZ	SH	-0.023	0.016	0.166

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	GE	SH	0.209	0.014	0.001***
	GE	SZ	0.232	0.018	0.001***
	SME	SH	0.116	0.013	0.001***
	SME	SZ	0.139	0.017	0.001***
	SME	GE	-0.093	0.015	0.001***
5	SZ	SH	-0.142	0.294	0.628
	GE	SH	-0.332	0.173	0.055
	GE	SZ	-0.190	0.297	0.523
	SME	SH	-0.534	0.179	0.003**
	SME	SZ	-0.392	0.300	0.192
	SME	GE	-0.202	0.184	0.273

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Table 6 shows the stock return rate means of each stock board's claim groups. With regard to the whole stock market, the stock return rate mean seems to increases as the claim count increases. With regard to SH main board, it seems that claim group 2 has the lowest stock return rate mean while claim group 5 has the highest stock return rate mean. With regard to SZ main board, it seems that claim group 1 has the lowest and the only negative stock return rate mean while claim group 4 has the highest stock return rate mean. With regard to GE board, it seems that claim group 1 has the lowest stock return rate mean while claim group 5 has the highest stock return rate mean. With regard to SME board, it seems that claim group 1 has the lowest stock return rate mean while claim group 5 has the highest stock return rate mean. With regard to claim groups 1, 3, 4 and 5, SZ main board has the lowest stock return rate means while GE board has the highest stock return rate means. With regard to claim group 2, SH main board has the lowest stock return rate mean while GE board also has the highest stock return rate mean. In general, it seems that GE board has the highest stock return rate means in all claim groups while SZ main board has lowest claim count means in most claim groups.

Table 6: Stock Return Rate Means of Invention Publication's Claim Groups

Stock Board	Stock Return Rate Mean (%)					
	Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Whole Stock Market	5.07	6.80	10.56	12.00	22.09	10.71
SH Main Board	5.32	3.15	5.52	9.52	15.29	7.36
SZ Main Board	-6.67	3.94	4.94	9.42	2.66	2.84
GE Board	11.16	14.49	19.82	14.61	34.21	18.58
SME Board	4.92	8.22	15.70	12.08	19.50	11.50

Source: This Research

Table 7 shows the results of ANOVA on the stock return rate between invention publication's claim groups. The stock return rate variances of the whole stock market and each of stock boards reach p***≤0.001 significance. Different invention publication's claim groups have significantly different stock return rate means in the whole stock market and each stock board.

Table 7: Result of ANOVA on Stock Return Rate Between Invention Publication's Claim Groups

Stock Board	Claim Group	Stock Return Rate (%)			
		Sum Square	Mean Square	F	p
Whole Stock Market	Between Groups	301,877.7	75,469.4	29.147	0.001***
	Within Groups	27,321,714.1	2,589.2		
SH Main Board	Between Groups	58,554.3	14,638.6	6.428	0.001***
	Within Groups	9,063,856.4	2,277.4		
SZ Main Board	Between Groups	31,109.1	7,777.3	5.315	0.001***
	Within Groups	1,628,697.6	1,463.3		
GE Board	Between Groups	160,160.0	40,040.0	12.537	0.001***
	Within Groups	8,013,049.9	3,193.7		
SME Board	Between Groups	68,456.6	17,114.1	6.031	0.001***
	Within Groups	8,328,305.6	2,837.6		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Table 8 shows the multiple comparisons of the stock return rate between every two claim groups. With regard to the whole stock market, the stock return rate variances between claim groups 2 and 1, between claim groups 4 and 3, are free of significance; the other stock return rate variances are of significance. According to the significant mean differences, claim group 5 is confirmed to have the highest stock return rate mean while claim group 1 is confirmed to have the lowest stock return rate mean. With regard to SH main board, the stock return rate variances between claim groups 4 and 2, between claim groups 5 and 1, between claim groups 5 and 2, between claim groups 5 and 3, between claim groups 5 and 4, are of significance; the other stock return rate variances are free of significance. According to the significant mean differences, claim group 5 is confirmed to have the highest stock return rate mean while claim group 2 is confirmed to have the lowest stock return rate mean. With regard to SZ main board, the stock return rate variances between claim groups 2 and 1, between claim groups 3 and 1, between claim groups 4 and 1, between claim groups 5 and 1, are of significance; the other stock return rate variances are free of significance. According to the significant mean differences, claim group 4 is confirmed to have the highest stock return rate mean while claim group 1 is confirmed to have the lowest stock return rate mean. With regard to GE board, the stock return rate variances between claim groups 3 and 1, between claim groups 5 and 1, between claim groups 5 and 2, between claim groups 5 and 3, between claim groups 5 and 4, are of significance; the other stock return rate variances are free of significance. According to the significant mean differences, claim group 5 is confirmed to have the highest stock return rate mean while claim group 1 is confirmed to have the lowest stock return rate mean. With regard to SME board, the stock return rate variances between claim groups 2 and 1, between claim groups 4 and 2, between claim groups 4 and 3, between claim groups 5 and 3, are free of significance; the other stock return rate variances are of significance. According to the significant mean differences, claim group 5 is confirmed to have the highest stock return rate mean while claim group 1 is confirmed to have the lowest stock return rate mean. In general, in the whole stock market and most stock boards except SZ main board, claim group 5 has the highest stock return rate means while claim group 1 has the lowest stock return rate means.

Table 8: Multiple Comparisons of ANOVA on Stock Return Rate for Invention Publication's Claim Groups

Stock Market	Claim Group		Stock Return Rate (%)		
	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	p
Whole Stock Market	2	1	1.730	1.569	0.270
	3	1	5.495	1.538	0.001***
	3	2	3.765	1.587	0.018*
	4	1	6.929	1.456	0.001***
	4	2	5.199	1.507	0.001***
	4	3	1.434	1.475	0.331
	5	1	17.019	1.693	0.001***
	5	2	15.289	1.738	0.001***
	5	3	11.524	1.710	0.001***
	5	4	10.090	1.636	0.001***
SH Main Board	2	1	-2.175	2.376	0.360
	3	1	0.196	2.406	0.935
	3	2	2.370	2.391	0.322
	4	1	4.194	2.234	0.061
	4	2	6.369	2.219	0.004**
	4	3	3.998	2.251	0.076
	5	1	9.969	2.679	0.001***
	5	2	12.144	2.666	0.001***
	5	3	9.773	2.693	0.001***
	5	4	5.775	2.541	0.023*
SZ Main Board	2	1	10.615	3.619	0.003**
	3	1	11.611	3.607	0.001***
	3	2	0.996	3.611	0.783
	4	1	16.092	3.627	0.001***
	4	2	5.477	3.631	0.132
	4	3	4.481	3.619	0.216
	5	1	9.331	3.615	0.010**

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	5	2	-1.284	3.619	0.723
	5	3	-2.280	3.607	0.527
	5	4	-6.761	3.627	0.063
GE Board	2	1	3.338	3.557	0.348
	3	1	8.658	3.562	0.015*
	3	2	5.321	3.576	0.137
	4	1	3.456	3.496	0.323
	4	2	0.119	3.510	0.973
	4	3	-5.202	3.516	0.139
	5	1	23.051	3.617	0.001***
	5	2	19.713	3.631	0.001***
	5	3	14.392	3.636	0.001***
	5	4	19.594	3.572	0.001***
SME Board	2	1	3.301	3.041	0.278
	3	1	10.778	3.184	0.001***
	3	2	7.477	3.120	0.017*
	4	1	7.168	2.923	0.014*
	4	2	3.867	2.853	0.175
	4	3	-3.610	3.005	0.230
	5	1	14.578	3.420	0.001***
	5	2	11.277	3.360	0.001***
	5	3	3.800	3.491	0.276
	5	4	7.410	3.254	0.023*

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

3.2 Patent Species of Invention Grant

Table 9 shows the claim count means of invention grant's claim groups. With regard to claim groups 1, 2, 3 and 5, it seems that SH main board has the lowest claim count means while GE board has the highest claim count means. With regard to claim group 4, SZ main board has the lowest claim count mean while GE board also has the highest claim count mean. In general, it seems that GE board has the highest claim count means in all claim groups while SH main board has the lowest claim count means in most claim groups.

Table 9: Claim Count Means of Invention Grant's Claim Groups

Stock Market	Claim Count Mean					
	Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Whole Stock Market	3.13	5.42	6.71	7.98	11.47	6.91
SH Main Board	3.02	5.15	6.47	7.81	11.20	6.69
SZ Main Board	3.24	5.44	6.65	7.72	12.09	6.94
GE Board	3.69	5.83	7.05	8.36	12.21	7.28
SME Board	3.16	5.47	6.76	8.21	11.40	6.87

Source: This Research

Table 10 shows the results of ANOVA on invention grant's claim counts between four stock boards. For each of claim count groups, the claim count variances between different stock boards reach p***≤0.001 significance. Different stock boards have significantly different claim count means for each of claim groups.

Table 10: Result of ANOVA on Invention Grant's Claim Count Between Stock Boards

Claim Group	Stock Board	Claim Count			
		Sum Square	Mean Square	F	p
1	Between Stock Boards	135.9	45.3	34.812	0.001***
	Within Stock Boards	2,366.4	1.3		
2	Between Stock Boards	101.0	33.7	202.855	0.001***
	Within Stock Boards	269.9	0.2		
3	Between Stock Boards	88.3	29.4	223.055	0.001***

	Within Stock Boards	223.1	0.1		
4	Between Stock Boards	104.2	34.7	173.992	0.001***
	Within Stock Boards	335.8	0.2		
5	Between Stock Boards	305.5	101.8	4.726	0.001***
	Within Stock Boards	34,263.8	21.6		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Tables 11 shows the multiple comparisons of ANOVA on invention grant's claim count between every two stock boards. With regard to claim groups 1 and 2, the claim count variance between SME board and SZ main board is free of significance; while the other claim count variances are of significance. According to the significant mean differences, GE board is therefore confirmed to have the highest claim count mean while SH main board is therefore confirmed to have lowest claim count mean. With regard to claim groups 3 and 4, the claim count variances between every two stock boards are of significance. GE board is confirmed to have the highest claim count mean while SZ main board is confirmed to have lowest claim count mean. With regard to claim group 5, the claim count variances between SZ main board and SH main board, between GE board and SH main board, between SME board and GE board, are of significance; while the other claim count variances are free of significance. GE board is therefore confirmed to have the highest claim count mean while SH main board is confirmed to have lowest claim count mean. In general, GE board has the highest claim count means in all claim groups; SH main board has the lowest claim count means in claim groups 1, 2, and 5 while SZ main board has the lowest claim count means in claim groups 3 and 4.

Table 11: Multiple Comparisons of ANOVA on Invention Grant's Claim Count between Stock Boards

Claim Group	Stock Board		Claim Count		
	Board (I)	Board (J)	Mean Difference (I-J)	Std. Error	p
1	SZ	SH	0.227	0.096	0.019*
	GE	SH	0.670	0.068	0.001***
	GE	SZ	0.443	0.099	0.001***
	SME	SH	0.140	0.068	0.040*
	SME	SZ	-0.086	0.099	0.384
	SME	GE	-0.530	0.072	0.001***
2	SZ	SH	0.293	0.032	0.001***
	GE	SH	0.681	0.028	0.001***
	GE	SZ	0.388	0.035	0.001***
	SME	SH	0.327	0.025	0.001***
	SME	SZ	0.033	0.033	0.310
	SME	GE	-0.355	0.029	0.001***
3	SZ	SH	0.189	0.033	0.001***
	GE	SH	0.583	0.023	0.001***
	GE	SZ	0.395	0.035	0.001***
	SME	SH	0.291	0.022	0.001***
	SME	SZ	0.102	0.034	0.003**
	SME	GE	-0.293	0.025	0.001***
4	SZ	SH	-0.089	0.040	0.027*
	GE	SH	0.550	0.029	0.001***
	GE	SZ	0.639	0.041	0.001***
	SME	SH	0.400	0.027	0.001***
	SME	SZ	0.489	0.040	0.001***
	SME	GE	-0.151	0.029	0.001***
5	SZ	SH	0.897	0.394	0.023*
	GE	SH	1.012	0.300	0.001***
	GE	SZ	0.115	0.419	0.783
	SME	SH	0.204	0.297	0.492
	SME	SZ	-0.692	0.417	0.097
	SME	GE	-0.808	0.329	0.014*

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Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Table 12 shows the stock return rate means of each stock board's claim groups. With regard to SH main board, it seems that claim group 2 has the lowest stock return rate mean while claim group 5 has the highest stock return rate mean. With regard to SZ main board, it seems that claim group 1 has the lowest stock return rate mean while claim group 4 has the highest stock return rate mean. With regard to GE board, it seems that claim group 3 has the lowest stock return rate mean while claim group 5 has the highest stock return rate mean. With regard to SME board, it seems that claim group 4 has the lowest stock return rate mean while claim group 5 has the highest stock return rate mean. Though different stock boards have different distribution types of stock return rates, however in the whole stock market, the stock return rate mean seems to have an increasing trend as the claim count increases. With regard to claim groups 1, 2, 3 and 5, SZ main board seems to have the lowest stock return rate means while GE board seems to have the highest stock return rate means. With regard to claim group 4, SH main board seems to have the lowest stock return rate mean while GE board also seems to have the highest stock return rate mean. In general, GE board seems to have the highest stock return rate means in all claim groups while SZ main board seems to have the lowest stock return rate means in most claim groups.

Table 12: Stock Return Rate Means of Invention Grant's Claim Groups

Stock Board	Stock Return Rate Mean (%)					
	Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Whole Stock Market	9.34	9.30	10.31	13.28	17.03	11.83
SH Main Board	7.05	2.58	6.75	9.74	11.70	7.52
SZ Main Board	-2.63	1.84	-1.21	17.23	8.09	4.41
GE Board	18.57	21.29	14.40	21.38	25.10	20.01
SME Board	11.09	13.34	12.26	10.78	19.14	13.07

Source: This Research

Table 13 shows the results of ANOVA on the stock return rate between invention grant's claim groups. The stock return rate variances between five claim groups of the whole stock market, SH main board, and SZ main board are of significance, wherein, the stock return rate variances of the whole stock market and SZ main board reach p*≤0.001 significance, the stock return rate variance of SH main board reaches p*<0.05 significance. The stock return rate variances of GE board and SME board are free of significance. Different claim groups have significantly different stock return rate means in the whole stock market, SH main board and SZ main board.

Table 13: Result of ANOVA on Stock Return Rate Between Invention Grant's Claim Groups

Stock Board	Claim Group	Stock Return Rate (%)			
		Sum Square	Mean Square	F	p
Whole Stock Market	Between Groups	75167.6	18791.9	7.078	0.001***
	Within Groups	22363469.0	2655.0		
SH Main Board	Between Groups	28799.1	7199.8	3.220	0.012*
	Within Groups	6896200.2	2236.1		
SZ Main Board	Between Groups	43743.8	10936.0	7.731	0.001***
	Within Groups	1258907.5	1414.5		
GE Board	Between Groups	25416.9	6354.2	1.909	0.106
	Within Groups	6885178.8	3327.8		
SME Board	Between Groups	19944.4	4986.1	1.677	0.153
	Within Groups	7031515.7	2973.2		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Different claim groups have significantly different stock return rate means only in the whole stock market, SH main board and SZ main board. Table 14 further shows the multiple comparisons of the stock return rate between every two claim groups in the whole stock market, SH main board and SZ main board. With regard to the whole stock market, the stock return rate variances between claim groups 2 and 1, between claim groups 3 and 1, between claim groups 3 and 2, between claim groups 4 and 3, are free of significance; the other stock return rate variances are of significance. According to the significant mean differences, claim group 5 is confirmed to have the highest stock return rate mean while claim group 2 is confirmed to have the lowest stock return rate mean. With regard to SH main board, the stock return rate variances between claim groups 4 and 2, between claim groups 5 and 2, are of significance; the other stock return rate variances are free of significance. According to the significant mean differences, claim group 5 is confirmed to have the higher stock return rate mean while claim group 2 is confirmed to have the lower stock return rate mean. With regard to SZ main board, the stock return rate variances between claim groups 2 and 1,

between claim groups 3 and 1, between claim groups 4 and 1, between claim groups 5 and 2, are free of significance; the other stock return rate variances are of significance. According to the significant mean differences, claim group 4 is confirmed to have the highest stock return rate mean while claim group 1 is confirmed to have the lowest stock return rate mean. In general, higher claim groups have higher stock return rate means while lower claim groups have lower stock return rate means. Claim group 5 has the highest stock return rate means and claim group 2 has the lowest stock return rate means in most stock boards.

Table 14: Multiple Comparisons of ANOVA on Stock Return Rate between Invention Grant's Claim Groups

Stock Board	Claim Group		Stock Return Rate (%)		
	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	p
Whole Stock Market	2	1	-0.040	1.727	0.981
	3	1	0.970	1.830	0.596
	3	2	1.010	1.790	0.573
	4	1	3.941	1.772	0.026*
	4	2	3.981	1.730	0.021*
	4	3	2.971	1.834	0.105
	5	1	7.694	1.771	0.001***
	5	2	7.735	1.730	0.001***
	5	3	6.725	1.833	0.001***
	5	4	3.753	1.775	0.034*
SH Main Board	2	1	-4.467	2.686	0.096
	3	1	-0.303	2.615	0.908
	3	2	4.164	2.649	0.116
	4	1	2.685	2.744	0.328
	4	2	7.152	2.777	0.010*
	4	3	2.988	2.709	0.270
	5	1	4.646	2.671	0.082
	5	2	9.113	2.705	0.001***
	5	3	4.949	2.635	0.060
	5	4	1.960	2.763	0.478
SZ Main Board	2	1	4.471	3.757	0.234
	3	1	1.418	4.150	0.733
	3	2	-3.053	3.953	0.440
	4	1	19.862	4.093	0.001***
	4	2	15.391	3.893	0.001***
	4	3	18.444	4.274	0.001***
	5	1	10.715	3.970	0.007**
	5	2	6.243	3.763	0.097
	5	3	9.297	4.156	0.026*
	5	4	-9.148	4.099	0.026*

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

3.3 Patent Species of Utility Model Grant

Table 15 shows the claim count means of utility model's claim groups. With regard to all claim groups, it seems that SZ main board has the lowest claim count means while GE board has the highest claim count means.

Table 15: Claim Count Means of Utility Model Grant's Claim Groups

Stock Board	Claim Count Mean					
	Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Whole Stock Market	6.78	8.23	7.36	8.43	16.44	9.44
SH Main Board	4.32	5.89	6.72	7.72	9.68	6.87
SZ Main Board	4.25	5.86	6.70	7.69	9.41	6.78
GE Board	4.54	6.21	7.21	8.40	10.17	7.26

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SME Board	4.44	6.01	6.91	8.08	9.85	7.05

Source: This Research

Table 16 shows the results of ANOVA on utility model grant's claim count between four stock boards. The claim count variances between four stock boards reach p***≤0.001 significance in all claim groups. For each of claim groups, different stock boards have significantly different claim count means.

Table 16: Result of ANOVA on Utility Model Grant's Claim Count Between Stock Boards

Claim Group	Stock Board	Claim Count			
		Sum Square	Mean Square	F	p
1	Between Stock Boards	20.2	6.747	6.898	0.001***
	Within Stock Boards	1993.4	0.978		
2	Between Stock Boards	32.9	10.959	159.671	0.001***
	Within Stock Boards	137.3	0.069		
3	Between Stock Boards	76.3	25.450	371.292	0.001***
	Within Stock Boards	139.1	0.069		
4	Between Stock Boards	161.3	53.770	389.405	0.001***
	Within Stock Boards	282.2	0.138		
5	Between Stock Boards	104.7	34.894	17.612	0.001***
	Within Stock Boards	4049.8	1.981		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Tables 17 shows the multiple comparisons of ANOVA on utility model grant's claim count between every two stock boards, wherein, SH, SZ, GE and SME stand for SH main board, SZ main board, GE board and SME board respectively. With regard to claim group 1, the claim count variances between SH main board and SZ main board, between SME board and GE board, are free of significance; while the other claim count variances are of significance. According to the significant mean differences, GE board is therefore confirmed to have the highest claim count mean while SZ main board is therefore confirmed to have lowest claim count mean. Claim groups 2, 3 and 4, the claim count variances between SH main board and SZ main board are free of significance; while the other claim count variances are of significance. GE board is confirmed to have the highest claim count means while SZ main board is confirmed to have lowest claim count means. With regard to claim group 5, the claim count variance between SME board and SH main board is free of significance; while the other claim count variances are of significance. GE board is confirmed to have the highest claim count mean while SZ main board is confirmed to have lowest claim count mean. In General, in the whole stock market and all stock boards, GE board has the highest claim count means while SZ main board has lowest claim count means.

Table 17: Multiple Comparisons of ANOVA on Utility Model Grant's Claim Count between Stock Boards

Claim Group	Stock Board		Claim Count		
	Board (I)	Board (J)	Mean Difference (I-J)	Std. Error	p
1	SZ	SH	-0.074	0.075	0.323
	GE	SH	0.221	0.058	0.001***
	GE	SZ	0.295	0.080	0.001***
	SME	SH	0.113	0.055	0.038*
	SME	SZ	0.187	0.078	0.016*
	SME	GE	-0.108	0.061	0.080
2	SZ	SH	-0.020	0.020	0.309
	GE	SH	0.321	0.016	0.001***
	GE	SZ	0.341	0.022	0.001***
	SME	SH	0.127	0.014	0.001***
	SME	SZ	0.147	0.021	0.001***
	SME	GE	-0.195	0.017	0.001***
3	SZ	SH	-0.021	0.020	0.288
	GE	SH	0.485	0.015	0.001***
	GE	SZ	0.506	0.021	0.001***
	SME	SH	0.189	0.014	0.001***

	SME	SZ	0.210	0.021	0.001***
	SME	GE	-0.296	0.016	0.001***
4	SZ	SH	-0.033	0.028	0.237
	GE	SH	0.676	0.021	0.001***
	GE	SZ	0.710	0.030	0.001***
	SME	SH	0.354	0.021	0.001***
	SME	SZ	0.387	0.029	0.001***
	SME	GE	-0.322	0.023	0.001***
5	SZ	SH	-0.273	0.107	0.011*
	GE	SH	0.481	0.085	0.001***
	GE	SZ	0.754	0.117	0.001***
	SME	SH	-0.002	0.076	0.977
	SME	SZ	0.270	0.110	0.014*
	SME	GE	-0.484	0.088	0.001***

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Table 18 shows the stock return rate means of utility model grant's claim groups. With regard to the whole stock market and all stock boards, it seems that claim group 1 has the lowest stock return rate means while claim group 5 has the highest stock return rate means. With regard to all claim groups, it seems that SZ main board has the lowest stock return rate means while GE board has the highest stock return rate means.

Table 18: Stock Return Rate Means of Utility Model Grant's Claim Groups

Stock Board	Stock Return Rate Mean (%)					
	Group 1	Group 2	Group 3	Group 4	Group 5	All Groups
Whole Stock Market	5.57	7.27	8.35	8.70	20.69	10.10
SH Main Board	2.89	4.14	5.13	3.91	16.02	6.42
SZ Main Board	-1.70	-0.28	1.89	3.68	7.95	2.31
GE Board	15.51	16.43	15.76	18.71	30.72	19.23
SME Board	5.30	7.67	10.82	8.94	21.13	10.78

Source: This Research

Table 19 shows the results of ANOVA on the stock return rate between utility model grant's claim groups. The stock return rate variances between five claim groups of the whole stock market and most stock boards are of significance except SZ main board. Different claim groups have significantly different stock return rate means in the whole stock market, SH main board, GE board and SME board.

Table 19: Result of ANOVA on Stock Return Rate Between Utility Model Grant's Claim Groups

Stock Board	Claim Group	Stock Return Rate (%)			
		Sum Square	Mean Square	F	p
Whole Stock Market	Between Groups	296164.5	74041.1	26.704	0.001***
	Within Groups	28039887.4	2772.7		
SH Main Board	Between Groups	91035.6	22758.9	10.163	0.001***
	Within Groups	8634968.9	2239.4		
SZ Main Board	Between Groups	12600.7	3150.2	2.086	0.081
	Within Groups	1669093.1	1510.5		
GE Board	Between Groups	71516.2	17879.0	4.310	0.002**
	Within Groups	9490672.6	4148.0		
SME Board	Between Groups	85756.7	21439.2	7.665	0.001***
	Within Groups	7968276.9	2796.9		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Since different claim groups have significantly different stock return rate means in the whole stock market and most stock boards except SZ main board, Table 20 shows the multiple comparisons of the stock return rate between every two claim groups. The stock return rate variances between claim groups 5 and 1, between claim groups 5 and 2,

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between claim groups 5 and 3, between claim groups 5 and 4, are all of significance; the other stock return rate variances are free of significance. According to the significant mean differences, claim group 5 is confirmed to have the highest stock return rate means while claim group 1 is confirmed to have the lowest stock return rate means in the whole stock market, SH main board, GE board and SME board.

Table 20: Multiple Comparisons of ANOVA on Stock Return Rate between Utility Model Grant's Claim Groups

Stock Board	Claim Group		Stock Return Rate (%)		
	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	p
Whole Stock Market	2	1	1.700	1.655	0.304
	3	1	2.775	1.641	0.091
	3	2	1.075	1.673	0.521
	4	1	3.129	1.639	0.056
	4	2	1.428	1.671	0.393
	4	3	0.354	1.657	0.831
	5	1	15.123	1.639	0.001***
	5	2	13.423	1.671	0.001***
	5	3	12.348	1.657	0.001***
	5	4	11.995	1.655	0.001***
SH Main Board	2	1	1.253	2.409	0.603
	3	1	2.244	2.408	0.351
	3	2	0.991	2.408	0.681
	4	1	1.024	2.409	0.671
	4	2	-0.229	2.409	0.924
	4	3	-1.220	2.409	0.612
	5	1	13.134	2.408	0.001***
	5	2	11.880	2.408	0.001***
	5	3	10.889	2.407	0.001***
	5	4	12.110	2.409	0.001***
GE Board	2	1	0.918	4.256	0.829
	3	1	0.245	4.208	0.954
	3	2	-0.673	4.285	0.875
	4	1	3.201	4.145	0.440
	4	2	2.283	4.223	0.589
	4	3	2.956	4.175	0.479
	5	1	15.201	4.306	0.001***
	5	2	14.284	4.381	0.001***
	5	3	14.956	4.334	0.001***
	5	4	12.001	4.273	0.005**
SME Board	2	1	2.369	3.130	0.449
	3	1	5.519	3.122	0.077
	3	2	3.150	3.122	0.313
	4	1	3.639	3.140	0.247
	4	2	1.270	3.140	0.686
	4	3	-1.880	3.131	0.548
	5	1	15.830	3.130	0.001***
	5	2	13.461	3.130	0.001***
	5	3	10.311	3.122	0.001***
	5	4	12.191	3.140	0.001***

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

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3.4 Cross Analysis of Patent Species

With regard to the whole stock market, Table 21 shows the results of ANOVA on the stock return rate between three patent species. The stock return rate variances between different patent species in claim groups 1, 4 and 5 are of significance; the stock return rate variances in claim groups 2 and 3 are not. Different patent species have significantly different stock return rate means only in claim groups 1, 4 and 5.

Table 21: Result of ANOVA on Stock Return Rate Between Patent Species in Whole Stock Market

Claim Group	Patent Species	Stock Return Rate (%)			
		Sum Square	Mean Square	F	p
1	Between Patent Species	27765.2	13882.6	5.442	0.004**
	Within Patent Species	15208479.4	2550.9		
2	Between Patent Species	5234.6	2617.3	1.144	0.319
	Within Patent Species	13351204.9	2288.5		
3	Between Patent Species	8776.6	4388.3	1.917	0.147
	Within Patent Species	13167804.4	2289.3		
4	Between Patent Species	23206.9	11603.4	4.839	0.008**
	Within Patent Species	15460852.7	2397.8		
5	Between Patent Species	24684.7	12342.4	3.047	0.048*
	Within Patent Species	20623286.9	4050.1		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Since different patent species have significantly different stock return rate means in claim groups 1, 4 and 5, Table 22 shows the multiple comparisons of ANOVA on the stock return rate between every two patent species in aforementioned claim groups. With regard to claim groups 1 and 4, the stock return rate variances between invention publications and invention grants, between invention grants and utility model grants, are of significance; the other stock return rate variance is not. According to the significant mean differences, invention grants have the highest stock return rate means while invention publications have the lowest stock return rate mean in claim group 1 and utility model grants have the lowest stock return rate mean in claim group 4. With regard to claim group 5, the stock return rate variance between invention publications and invention grants is of significance; the other stock return rate variances are not. According to the significant mean difference, invention publications have the higher stock return rate mean than the other two patent species.

Table 22: Multiple Comparisons of ANOVA on Stock Return Rate between Patent Species in Whole Stock Market

Claim Group	Patent Species		Stock Return Rate (%)		
	Species (I)	Species (J)	Mean Difference (I-J)	Std. Error	p
1	Invention Publication	Invention Grant	-4.895	1.617	0.002**
	Invention Publication	Utility Model Grant	-0.468	1.570	0.765
	Invention Grant	Utility Model Grant	4.427	1.627	0.007**
4	Invention Publication	Invention Grant	-3.198	1.518	0.035*
	Invention Publication	Utility Model Grant	1.773	1.433	0.216
	Invention Grant	Utility Model Grant	4.972	1.610	0.002**
5	Invention Publication	Invention Grant	5.605	2.285	0.014*
	Invention Publication	Utility Model Grant	2.374	2.171	0.274
	Invention Grant	Utility Model Grant	-3.231	2.139	0.131

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

With regard to SH main board, Table 23 shows the results of ANOVA on the stock return rate between three patent species. The stock return rate variance between different patent species is of significance only in claim group 4; the stock return rate variances in the other claim groups are free of significance. Different patent species have significantly different stock return rate means only in claim group 4 of SH main board.

Table 23: Result of ANOVA on Stock Return Rate Between Patent Species in SH Main Board

Claim Group	Patent Species	Stock Return Rate (%)			
		Sum Square	Mean Square	F	p

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1	Between Patent Species	6,204.4	3,102.2	1.329	0.265
	Within Patent Species	5,140,351.8	2,334.4		
2	Between Patent Species	869.6	434.8	0.229	0.795
	Within Patent Species	4,152,684.2	1,895.3		
3	Between Patent Species	1,007.8	503.9	0.267	0.766
	Within Patent Species	4,192,890.9	1,888.7		
4	Between Patent Species	16,899.4	8,449.7	3.952	0.019*
	Within Patent Species	5,114,875.3	2,138.3		
5	Between Patent Species	6,964.9	3,482.5	1.113	0.329
	Within Patent Species	5,994,223.4	3,130.1		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Table 24 further shows the multiple comparisons of ANOVA on the stock return rate between every two patent species in claim group 4. The stock return rate variances between invention publications and utility model grants, between invention grants and utility model grants, are of significance; the other stock return rate variance is not. According to the significant mean differences, invention grants have the highest stock return rate mean while utility model grants have the lowest stock return rate mean.

Table 24: Multiple Comparisons of ANOVA on Stock Return Rate between Patent Species in SH Main Board

Claim Group	Patent Species		Stock Return Rate (%)		
	Species (I)	Species (J)	Mean Difference (I-J)	Std. Error	p
4	Invention Publication	Invention Grant	-0.218	2.417	0.928
	Invention Publication	Utility Model Grant	5.608	2.186	0.010**
	Invention Grant	Utility Model Grant	5.826	2.571	0.024*

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

With regard to SZ main board, Table 25 shows the results of ANOVA on the stock return rate between three patent species. The stock return rate variance between different patent species is of significance only in claim group 4; the stock return rate variances in the other claim groups are free of significance. Different patent species have significantly different stock return rate means only in claim group 4 of SZ main board.

Table 25: Result of ANOVA on Stock Return Rate Between Patent Species in SZ Main Board

Claim Group	Patent Species	Stock Return Rate (%)			
		Sum Square	Mean Square	F	p
1	Between Patent Species	1,984.5	992.2	1.013	0.364
	Within Patent Species	594,387.7	979.2		
2	Between Patent Species	923.1	461.6	0.349	0.705
	Within Patent Species	904,233.9	1,322.0		
3	Between Patent Species	2,969.7	1,484.8	1.010	0.365
	Within Patent Species	864,107.1	1,469.6		
4	Between Patent Species	21,373.2	10,686.6	6.304	0.002**
	Within Patent Species	1,234,012.9	1,695.1		
5	Between Patent Species	1,343.2	671.6	0.349	0.706
	Within Patent Species	965,194.4	1,926.5		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

Table 26 further shows the multiple comparisons of ANOVA on the stock return rate between every two patent species in claim group 4. The stock return rate variances between invention publications and invention grants, between invention grants and utility model grants, are of significance; the other stock return rate variance is not. According to the significant mean differences, invention grants have the highest stock return rate mean while utility model grants have the lowest stock return rate mean.

Table 26: Multiple Comparisons of ANOVA on Stock Return Rate between Patent Species in SZ Main Board

Claim Group	Patent Species		Stock Return Rate (%)		
	Species (I)	Species (J)	Mean Difference (I-J)	Std. Error	p
4	Invention Publication	Invention Grant	-12.781	3.937	0.001**
	Invention Publication	Utility Model Grant	0.776	3.532	0.826
	Invention Grant	Utility Model Grant	13.5561	4.277	0.002**

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

With regard to GE board and SME board, Table 27 shows the results of ANOVA on the stock return rate between three patent species. The stock return rate variances between different patent species is free of significance in all claim groups. Different patent species do not have significantly different stock return rate means in GE board and SME board.

Table 27: Result of ANOVA on Stock Return Rate Between Patent Species in GE Board

			Stock Return Rate (%)			
Stock Board	Claim Group	Patent Species	Sum Square	Mean Square	F	p
GE Board	1	Between Patent Species	14,154.4	7,077.2	2.120	0.120
		Within Patent Species	4,981,579.0	3,338.9		
	2	Between Patent Species	9,271.2	4,635.6	1.610	0.200
		Within Patent Species	3,645,849.0	2,879.8		
	3	Between Patent Species	7,373.6	3,686.8	1.327	0.266
		Within Patent Species	3,789,820.1	2,778.5		
	4	Between Patent Species	11,400.8	5,700.4	2.123	0.120
		Within Patent Species	3,925,164.1	2,684.8		
	5	Between Patent Species	17,847.1	8,923.5	1.422	0.242
		Within Patent Species	8,046,489.1	6,276.5		
SME Board	1	Between Patent Species	12,474.9	6,237.4	2.389	0.092
		Within Patent Species	4,313,067.4	2,610.8		
	2	Between Patent Species	9,936.8	4,968.4	1.880	0.153
		Within Patent Species	4,450,557.9	2,642.8		
	3	Between Patent Species	6,852.7	3,426.3	1.295	0.274
		Within Patent Species	4,157,433.4	2,646.4		
	4	Between Patent Species	3,203.0	1,601.5	0.589	0.555
		Within Patent Species	5,048,436.5	2,718.6		
	5	Between Patent Species	1,133.8	566.9	0.147	0.864
		Within Patent Species	5,358,603.0	3,869.0		

Source: This Research; p*<0.05, p**≤0.01, p***≤0.001

4. Conclusion and Recommendations

Based on the company integrated China patent database and the stock information revealed by Shanghai stock exchange and Shenzhen stock exchange in China, the impact of patent claim counts on the stock return rates under COVID-19 pandemic was thoroughly analyzed via ANOVA. The annual stock return rates of China A-shares in four quarters of 2020 were calculated. An effective sample A-share for each quarter of 2020 was listed in 2019 and 2020 so as to have a definite annual stock return rate, and must have at least one new China patent published or granted in the patent retrieval interval of one year. The China company listed overseas were excluded. Any patents other than China patents were also regardless.

The average claim count of A-share's China patents which published or granted over previous one years by the end of each quarter of 2020 was calculated. Thousands of effective sample A-shares listed in the whole China stock market and four stock boards including SH main board, SZ main board, GE board and SME board, were divided into five claim groups according to their average claim count percentile rake from low to high. The following conclusions were arrived:

(1) In general, the average claim count per patent had a significant impact on A-share's stock return rate. Though the stock market fluctuated seriously under COVID-19 pandemic, the average claim count of any patent species was still a good indicator for classifying A-share's stock return rate. The A-shares in the higher claim groups showed the significantly higher stock return rate means while the A-shares in the lower claim groups showed the significantly lower stock return rate means.

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(2) With regard to patent species of the invention publication, the claim count variances between four stock boards were of significance. GE board had the highest claim count means in most claim groups while SZ main board had the lowest stock price return rate means in most claim groups. The stock return rate variances between five claim groups in the whole stock market and all four stock boards were of significance. Claim groups 5 had the highest stock return rate means in the whole stock market, SH main board, GE board and SME board; claim group 4 had the highest stock return rate mean in SZ main board. Claim groups 1 had the lowest stock return rate means in the whole stock market, SZ main board, GE board and SME board; claim group 2 had the lowest stock return rate mean in SH main board.

(3) With regard to patent species of the invention grant, the claim count variances between four stock boards were of significance. GE board also had the highest claim count means in all claim groups while SH main board had the lowest stock price return rate means in most claim groups. The stock return rate variances between five claim groups in the whole stock market, SH main board and SZ main board were of significance. Claim groups 5 had the highest stock return rate means in the whole stock market and SH main board; claim group 4 had the highest stock return rate mean in SZ main board. Claim groups 2 had the lowest stock return rate means in the whole stock market and SH main board; claim group 1 had the lowest stock return rate mean in SZ main board. However, the stock return rate variances between five claim groups in GE board and SME board were free of significance.

(4) With regard to patent species of the utility model grant, the claim count variances between four stock boards were of significance. GE board also had the highest claim count means in all claim groups while SZ main board had the lowest stock price return rate means in all claim groups. The stock return rate variances between five claim groups in the whole stock market, SH main board, GE board and SME board were of significance. Claim groups 5 had the highest stock return rate means and claim groups 1 had the lowest stock return rate means in aforementioned stock boards. However, the stock return rate variance between five claim groups in SZ main board was free of significance.

(5) With regard to the stock return rate variance between three patent species, not the variances in all claim groups are of significance. The variances between patent species in all claim groups of GE board and SME board were free of significance; the variances in claim groups 4 of SH main board and SZ main board were of significance while the variances in the other claim groups were free of significance; the variances in claim groups 1, 4 and 5 of the whole stock market were of significance while the other variances were free of significance. Different patent species' claim count did not show significantly different stock return rates in most claim groups. However, in claim groups 4 of the whole stock market, SH main board and SZ main board, invention grants had higher stock return rate means while utility model grants had lower stock return rate means; in claim group 5 of the whole stock market, invention publications had the higher stock return rate while utility model grants had the lower stock return rate.

(6) When considering the patent claim count as a indicator, the invention publication was a more appropriate patent species than the invention grant and the utility model grant, because the claim count of the invention publication could be applied in the whole stock market and each stock board for significantly classifying the stock return rate. The claim count of the utility model grant was not a significant indicator in SZ main board; while The claim count of the invention grant was not a significant indicator in GE board and SME board. However, since the utility model grants usually had shorter examination duration and earlier grant dates than the invention publications and the invention grants, it might be more convenient to apply the utility model grant's claim count for classifying stock return rates and finding valuable stocks of the potential of the higher stock return rate.

The finding of this research would improve the understanding of China patents and the innovation outcome of China A-shares. It would also contribute the art of the patent valuation and the listed company evaluation. Based on the results, there might be some issues for future research. For example, the independent claims are usually regarded as more important than the dependent claims, does the independent claim count play more significance than the dependent claim count in classifying China A-share's stock return rate? In addition, does the results come out from this research also applicable for other patent systems? It is because the claim count of a patent is strongly affected by the law and rules of the patent systems. For China patent system, the extra official fee will be charged when a patent has more than ten claims. For US patent system, the extra official fee will be charged when a patent has more than twenty claims. For European patent system, the extra official fee will be charged when a patent has more than fifteen claims. A company's patent policy and innovation behavior might also be affected by different patent systems.

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Impact of Exchange Rate Volatility on International Trade: Case of USA and Canada

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ABSTRACT

Purpose:
The aim of this study is to investigate the impact that exchange rate volatility has on international trade flows including here exports and imports.
Design/methodology/approach:
This study is based on quarterly data from 2000-2018 making 224 observations in total. To measure the relationship between the chosen variables, it was used VAR-Vector Autoregressive Model. One of the main advantages of this model is traced back at the fact that it allows for dynamic relationship specification. Given that we are dealing with financial and macroeconomic variables, the role of each variable cannot be expected to be immediately monitored. On the contrary, it could be expected that it takes time for the interrelationships to be obvious and manifested. All this justifies the use of VAR. In total, two equations each with three independent variables are used to answer to the research question. Regressors are selected after a deliberate literature review and they are: price level, GDP, exchange rate and its volatility.
Findings:
The results suggest that there exists indeed an impact of exchange rate volatility on international trade among the US and Canada. This relationship seems to be changing among months and at different levels of significance. The final findings indicate a positive long-run relationship between exchange rate volatility and exports. These results are in line with the findings that other researchers have concluded in their studies. Regarding the imports, there exists a long-run relationship, but its impact differs in different periods.
Research limitations/implications:
One of the limitations and also a recommendation for improvement, is the number of explanatory variables. This came as a result of some lack of data for the included period.
Originality/value:
This topic is not only of great importance to policy maker, but it is also an added value to the current literature on the matter as it provides a thorough up-to-date analysis. It also draws on a sample of considerable size, thus providing consistency.

1. INTRODUCTION

1.1 A Brief Historical Background on the Matter

For a country operating under the fixed exchange rate regime, the term volatility would be either unfamiliar or quite irrelevant. In contrast, being under a free-floating exchange rate regime exposes all parties involved and the country as a whole to the risk of unexpected exchange rate fluctuations which in turn affect the outcomes to trade. This is a phenomenon that countries all over the world are facing on a regular basis and have learnt to cope with.

From the end of World War 2nd until the collapse of Bretton Woods System, international trade worldwide took place under a fixed exchange rate regime. After 1973, countries turned to free-floating exchange rates, fully determined by market forces, thus raising the risks of unpredictable exchange rate volatility. As globalization started to spread across the globe, the importance of international trade flows (e.g. exports, imports) increased, as more and more countries shifted from closed economies to open ones. At the same time, the exposure to foreign exchange rate

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risk increased. They needed to minimize the risk, while still benefiting from the international cooperation and collaboration which brought economic benefits and others alike. As the saying goes, the risk and return go hand in hand in finance world; yet the idea is to undertake investments which are characterized by reasonable levels of risk so as to incur minimal financial losses.

The impact of exchange rate is noticed in the trade surplus or deficit. If we are dealing with a weak domestic currency, exports are encouraged while imports get more expensive, and vice versa happens with a strong domestic currency. Trade surplus and deficit play an important role also in the economic growth. Trade surplus has the good impact on the economic growth, when exports are higher than imports. In this case, it means that the country has a higher output from its factories and more employed people. Higher exports mean a high flow of fund in the country and this raises the consumer spending leading to a positive impact on the economic growth. In any case, for a healthier economy it is better when there are high imports and exports which leads to a stronger economy.

As the phenomena spread together with the concern of investors and other involved parties, so did the term Foreign Exchange Rate Risk (FER). Such term emerged so as to show the likelihood that a certain individual can incur financial losses due to unexpected appreciation or depreciation in the value of a currency during a certain period of time, which is used as the main medium of conducting the said trade transaction. If we turn to some simple math logic, for sure we expect that the "quantity of money at stake" depends on a variety of factors where two are quite straightforward:

-The amount of change in the value of one currency against another

-The total amount of exposure (said transaction)

The larger these two elements, the greater the risk is in times of massive instability and uncertainty.

However, it must be emphasized that here even behavioral science does play a huge role. Even though sometimes the underlying economic factors do not lead to a certain phenomenon, if there exists a wide-spread belief about a matter of financial nature then due to the behavior of the involved parties, the expected outcome will emerge. As said earlier this will not be the result of the existing circumstances that were before, but simply a result of investors' expectations and their consequent behavior (Rodriguez, 1974).

1.1.1 A time Evolution of International Trade – USA Case

Starting with the ruling of Theodore Roosevelt, United Stated became a significant player in international trade, particularly with its neighboring regions. Trade policy in United States has developed significantly in the long time since the entry of milestone 1934 Reciprocal Trade Agreements Act (RTAA). At the start of this time, the US and its partners had set up high import taxes. At that time, there were no international agreements that would settle some ground rules for trade among countries. The existing ones were mostly on bilateral basis and more in manufacturing goods and trying to lower or eliminate import taxes. Starting from then, many obstacles have been lowered or eliminated between US and its trading countries. Its first Free Trade Agreement was in 1985 with Israel. After that, US made another agreement with Canada which was Canada – United States Free Trade Agreement in 1988 which later was superseded by the NAFTA (North American Free Trade Agreement). NAFTA was established in 1994 and it was between US – Mexico – Canada. Nowadays, United States is one of the leading countries in the free trade movement, being part of large groups such as General Agreement on Tariffs and Trade (GATT).

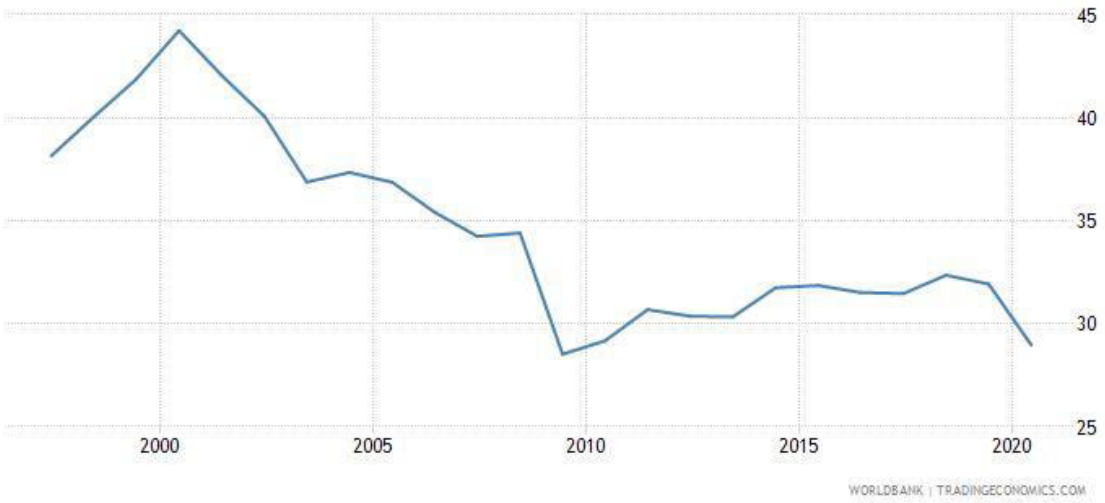

Figure 1.1 Canada – Exports of Goods and Services as share of GDP

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1.1.2 A time Evolution of International Trade – Canada Case

International trade seems to be considered the soul of the Canadian economy (see Figure 1.1 and Figure 1.2). The country, through years, relies in its exports and imports, especially during the huge development of worldwide trade, the decades following the Second World War, to help their rising standards of life. With the new findings in different areas, improvement of technology, information, the country was led to new ways of development of new goods and services and trading them. The lowering of trade barriers, definitely has had huge effects in the economy of the country, prompting in efficiency, furthermore expectations for life standards. The country's exports have had a fast increase after the adoption of NAFTA. Being such an important factor to the economy, the country has made many bilateral and multilateral trade agreements with many countries. Some of the countries that the Canada has Free Trade Agreements (FTAs) are: Chile, Costa Rica, Colombia, Honduras, Israel, Korea, Jordan, Panama and Peru. Other FTAs the country has are: European Free Trade Association (EFTA) and Comprehensive Economic and Trade Agreement (CETA). Lately the country has suffered some decrease in exports, but the Bank of Canada is taking the proper measures in gaining the desired results. In a speech held by the Deputy Governor of the Bank of Canada, Timothy Lane, it was said that the bank is building new proportions that better catch the competitiveness of the country, relative to their export market as well as compared to third nations (Lane, 2017).

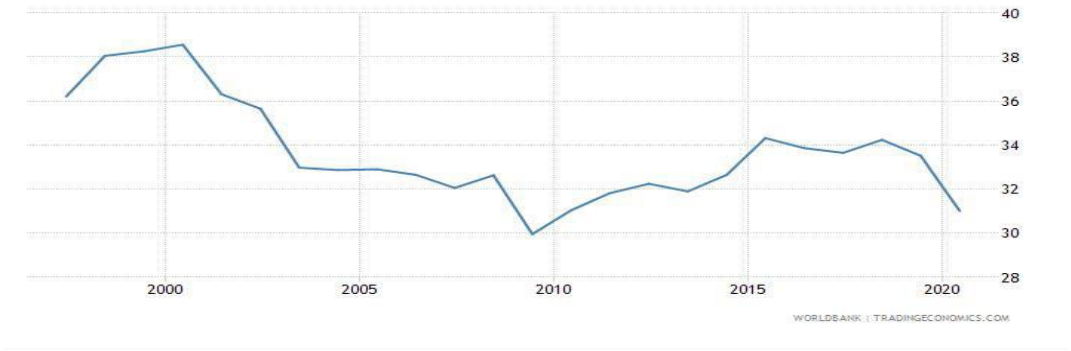

Figure 1.2 Canada – Imports of Goods and Services as share of GDP

1.2 Main Components of International Trade flows

International trade incorporates many elements, yet an important term tightly connected to it is International Trade Balance. The latter is explained by the difference of imports and exports. Import means foreign goods coming in the country while export means domestic products traded outside the country. These variables are also included in the four components of GDP as a difference between each other (X=E-I). They are the primary indicators for the country's international trade which is important for the growth of the economy. Higher exports are better than higher imports and, in this way; a positive net export can be achieved.

Nevertheless, the pool of factors affecting international trade flows is not restricted to exchange rate risk and FDI. Researchers have found that there are plenty political, macroeconomic and financial variables that do impact the trade flows in international level. Among such authors are: Boateng et al. (2015), Uddin et al.(2019), Kayalvizhi & Thenmozhi (2018), Slaveski & Nedanovski (2000).

1.3 Research Questions and Motivation

Studying the role of risk and its exposure on various investment decisions it is really important in the world of finance. In this thesis we go further. The thesis tends to examine, critically analyze and measure how the volatility of exchange rate between US and Canadian Dollar affects the respective trade flows between two of the largest economies in the world.

In short, driven also by my personal interest on the matter I will try to answer the following:

-Which is (if any) the role of Exchange Rate Volatility on imports and exports between the selected countries.

1.4 Scope of the Study

This study focuses only on the case of USA and Canada. It investigates the international trade flows between these two countries since they are among the strongest and largest economies in the economic arena in a global level. Checking the pattern and the results of the analysis for these two countries can be really informative and useful to the practitioners, academicians, investors and policy makers worldwide.

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2. LITERATURE REVIEW

2.1 Some International Evidence on the Matter

Based on a qualitative method, an analysis was done with the purpose to find out the possible positive effect that the volatility has on national productivity and labor demand which lead to an impact in exports too. It is said that while the RER volatility goes up, at the same time are increased also the export opportunities to the world market (Broll & Averlant, 2010). In this study, it was said that volatility does impact the international trade, but there are a lot of studies that concluded the opposite.

A study by Crowley & Lee (2003) suggests by their findings that the relationship between exchange rate volatility and investment is very weak in case that the volatility would be low, but stronger if the opposite happens with the volatility of exchange rate.

Like the previous study, in a sample of twelve African countries, it was found that indeed exchange rate volatility has an impact on trade flows in many of the countries. But this impact changes when it comes to short-run and long-run. In short-run, the impact was on many of the countries, while on long-run the impact was only on export in five countries and only on import for one country. At the same moment, the study states that economic activity level in the world and at home, are major determinant of exports and imports (Oskooee & Gelan, 2018). In another study conducted by Senadza & Diaba (2017) for Sub-Saharan Africa, were found almost the same results. It was found no significant impact of volatility on import, while in short-run and long-run was found a negative and positive impact of volatility on exports respectively. The study was conducted over the period 1993 to 2014.

Two researchers, Calderon & Kubota (2018), conducted a study to find whether the composition of international trade facilitates the impact that shocks have on real exchange rate for 82 countries. Indeed, their study found an impact proving that it is important for real exchange rate stability. It was shown that trade done in manufacturing can decrease RER volatility and the opposite happens with trade in non-manufacturing.

Another study, done on the bilateral trade between Korea and Japan, analysis the short-run and long-run effects on trade flows coming as cause of the changes in exchange rate. With the usage of ARDL approach, findings indicate that in short-run, there is indeed an impact on the exports and imports of Korea by the bilateral exchange rate, but not that sensitive in long-run (Baek, 2013). Continuing with Japan, a study by Oskooee et al. (2016) is conducted to observe the commodity trade with Pakistan (2016). Taking in consideration 44 Pakistani export industries to Japan and 60 Pakistani import industries from Japan, was found that not many of these industries, short-run nor long-run, were impacted by the volatility of exchange rate. Also, in Nigeria, a study (Osinubi & Amaghionyeodiwe, 2009) showed that foreign investors need not to worry about the volatility of exchange rate.

In 2013, a study was conducted on the effects of exchange rate volatility in the RMB-JPY rate on the trade between Japan and China. The study was based on data between January 2002 and December 2011, but focusing more on the period after January 2005 which consists with the time when a new reform was done on the exchange rate regime. This reform came after more than a decade carefully pegging the renminbi to (RMB) to the U.S. dollar at a swapping scale of 8.28 and it reevaluated the currency and a change of the conversion scale system. The revaluation sets the renminbi at 8.11 against the dollar, which adds up to a valuation for 2.1%. Under this reform, instead of referring only to one currency, the People's Bank of China will create a pool of currencies while picking its target for their currency. In the paper were used two methods to measure the volatility: AR-EGARCH model and the other one is standard deviation of daily changes of exchange rate. For defining the short run and long run impacts of different variables in exports of these two countries, was used the ARDL approach. Based on the findings, it seems that the volatility has no impact on the Japan's exports to China, but a negative one was found on the China's exports to Japan which seems to be during the reform. China seem to be more sensitive toward the exchange rate risk. High volatility is more likely to affect China's exports to Japan (Nishimura & Hirayama, 2013).

In 2014, a study was constructed taking in consideration bilateral trade between Czech Republic and its major trading partners. By using Johansen cointegration test, with quarterly data, it was found that volatility does not have any clear effect on trade flows (Šimáková, 2014).

Another study examines the possible impact that the exchange rate uncertainty has on the exports in the Southeast Asia, more precisely for the ASEAN-5 group (Thailand, Malaysia, Singapore, Indonesia and Philippines). The model used includes world output, domestic output, terms of trade and volatility. To estimate volatility, is used the GARCH model while for the relationship is used the Johansen-Fisher panel cointegration test. Findings say that a change in both, world and domestic output, leads to a positive impact on the amount of exports, whereas a depreciation in exchange term has a negative impact on exports. Lastly, it was found that the volatility of exchange rate has indeed a negative effect on the exports of ASEAN-5 group. The study suggests that despite of the fact that getting rid of volatility is not conceivable, there can be found other ways of keeping it in control in order to minimize the fluctuations through the government and the central banks (Upadhyaya et al., 2020).

An analysis by Oskoee & Kovyryalova (2008) implemented on the trade between UK and USA, uses annual data for the period 1971-2003 with 177 product exchange. This study tends to find the effect that the volatility of exchange rate has on the trade based on disaggregate exchange data in order to avoid the aggregation bias problem. The results have shown that in short-run, the volatility of exchange rate (GBP/USD) is a huge impact on imports of 109 businesses and 99 exports. Most of the time this impact is negative. But in the study is noticed that during the long-

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run, for a huge part of the cases, these effects are somehow lowered. In long-run, the imports of 62 businesses and exports of 86 are affected. Yet, when considered in the overall findings, in most of the cases the impact seems to be negative.

2.2 Research on USA and Canada

A study conducted by Belanger et al. (1992), focused on the trade between Canada and US in five sectors, concluded that there is no significant relationship between the exchange rate volatility and the trade between the two countries. Exchange rate volatility did not decrease the volume of trade significantly.

In contrast, Choudry (2005) found that there is indeed a significant impact of the exchange rate volatility on exports and this impact seems to be negative. Continuing with the Canadian exports to US, the results of the study by Lee (2003) do not show a long-run relationship between export, foreign income, relative price and exchange rate volatility while ARDL models used in the study estimate that in short-run there is indeed an adverse effect on exports.

Opposite from the study of Choudry (2005), McKenzie & Brooks (1997) in their analysis conducted with focus on the impact exchange rate volatility on Germany-US bilateral trade flows, found a positive relationship between exchange rate volatility and trade flow by using ARCH derived measure for volatility.

Recent years many studies have been done using industry levels data to many countries in order to find out which commodities trade are more sensitive to the volatility of exchange rate. This model is used also in a paper conducted on the USA-Chile trade by Oskooee et al. (2014). The study brings new insights in the aggregate trade and 49 individual industries. By using the ARDL cointegration method, it was found that 10 out of 40 interacted enterprises have encountered with an improvement on their trade in the long-run, after the deterioration of dollar. Then by the J curve, was found that only nine industries pursue such an example.

Another study by using disaggregated data for the time spam from 1989-2002, monthly based, tries to bring a new insight in the impact that the exchange rate volatility in each component has on the trade of USA with Canada, Germany and Hong Kong, employing a technique that enables decomposition of movements within the rate of exchange to changes within the basic and impermanent elements and measure of the corresponding volatility. Findings show that the effect of the volatility coming from the basic components of the bilateral trade, differs through the product types. Meaning that a higher volatility caused by the basic components causes an increase in the amount of trade for some products and a decrease in the amount of trade for some other. This can be as a result of the fact that traders find different ways to cooperate with the volatility that they face, and these ways are different for different products. While, regarding the impermanent or transitory elements, the volatility being caused by this fact, seem to have a negative on trade for both aggregate and disaggregate product levels. Study found that if uncertainty and volatility is high, this leads to a decrease in the amount of trade (Tadesse, 2009).

Continuing with the usage of disaggregated data, this study analysis the impact that the volatility of exchange rate has on the trade between USA and Korea for ten industries. Taking in consideration the role of volatility and the third country, the ARDL method is generated for imports and exports apart with the purpose to have more accurate results. It was revealed that Korea's larger export manufactures like machinery and transportation articles were very sensitive to the bilateral exchange rate, volatility and third country in short and long-run. While its imports were unresponsive to all the mentioned variables in short and long-run. All in together leads to the conclusion that the devaluation of the Korea currency can have a positive impact in short and long-run on the Korea's amount of exports. Also, the economic growth is considered to be very important and has a key role in influencing the trade between these two countries (Baek, 2014).

2.3 The Identified Literature Gap

Analyzing the literature review on US-Canada, is noticed a lack of studies. Not many studies are conducted on the bilateral trade between these two countries and the possible relationship between exchange rate volatility and international trade in terms of exports and imports. This study will be an addition to the literature review and also it will be an up-to-date analysis.

3. METHODOLOGY

3.1 Data Selection

In this paper, dependent variables will be exports and imports as they are the main components of international trade. As independent variables, for the analysis are chosen: GDP, CPI, exchange rate and volatility. Exchange rate is used only to find the volatility and not included in the model.

Below a brief explanation of the independent variables is given, and what their plausible effect can be.

Firstly, let's start with Growth Domestic Product (GDP). GDP is an indicator that shows the total value of goods and services of a country within one year. All researched use GDP as an indicator for the economic growth of one country as it better explains the economy of one country from one year to another. Being hard to find monthly data for GDP, researchers try to use a proxy to explain it. As some researchers do, the Index of Industrial Production (IIP) is chosen as a proxy for GDP. IIP is a monthly measure of the trend of Gross Domestic Product.

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Another explanatory variable is Consumer Price Index. It is a measure of the average changes in the price level of market basket of consumer goods and services purchased by households. The goods sold in daily basis to an average consumer, is where CPI has its focus. If there occurs an increase in CPI, it is considered as an indicator for inflation and vice versa, a decrease in CPI shows deflation. It is closely related to interest rates which can impact exchange rates. A very high inflation can have a direct influence on input costs, which can affect exports. These increasing expenses may lead to a significant impact on export competitiveness in the international market place.

Our next variable is exchange rate. It is the rate at which one currency will be exchanged for another one. Also, it is explained as the value of one country's currency to another country's currency. Its effect is very important since both countries chosen for this research, operate in a free-floating exchange rate. Based on the data found, the exchange rate volatility is generated.

These all are important components of calculating the GDP of a country: GDP= C+I+G+ (X-M),where C is consumers spending, I are investment spending, G are government spending, X are exports and M are imports.

And the last variable is volatility. Operating in a free-floating exchange rate regime, volatility is always expected to be there. It represents the degree to which a variable change over time. The more it changes, or the quicker it changes over time, the higher will be the volatility. High volatility might make decisions harder for international trade and investments.

3.2 Sample

This paper takes as case study the countries USA and Canada. Data are retrieved from reliable sources which consist of official websites of the countries and they belong to the period 2000-2018. Total number of observations is 224 since data are taken monthly based. They are retrieved from official websites such as World Bank and also the official pages of the countries such as: U.S. Bureau of Economic Analysis and Bank of Canada. Cross checking was done on different sources in order to make sure about the reliability of the data selected for the model.

3.3 Research Method

The method used for the study is quantitative research. This research draws a linear regression with the aim to explain international trade regarding exchange rate volatility by using three independent variables. The variables that are included in the model (mentioned above) were chosen based on the literature review McKenzie & Brooks (1997) and the availability of the data. Unlike other studies that focused on one variable, here all the variables are gathered in one model to have a clearer idea of the impact that volatility has.

Regarding the method used, many researchers use different ways to find the relationship between the variables. Mainly in the studies, the ARDL method approach is noticed to have been used to analyze the relationship. Baek (2014), Oskooee et al. (2014), Lee (2013), Nishimura & Hirayama, (2013) and other researchers use the ARDL method in their studies. Other researchers such as: Upadhyaya et al. (2020), use Johansen-Fisher panel cointegration test, while Renani & Mirfatah (2012), use Johansen and Juselius's cointegration approach. Different from the methods mentioned above, this research will be using the abovementioned variable in order to explain all the bidirectional relationships that might exist between each variable and lags of itself as well as lags of other variables by using a VAR model.

Vector Autoregression (VAR) Model is a model used to show the linear interdependencies among multiple time series. It is used to determine whether a long run relationship exists among variables. At the end, there are given individual equations for each one of them, but our focus will be only in the ones that explain the dependent variables used in this paper.

Regarding the volatility, again there are different methods that can be used. One of the mostly used in the studies above, were the ARCH and GARCH methods (ex.: McKenzie & Brooks (1997) used ARCH method, Upadhyaya et al. (2020) used GARCH method, etc.). Nishimura & Hirayama (2013) used two methods for volatility: 1. AR-EGARCH model and 2. Standard deviation of each daily changes of exchange rate. Based on the literature review, it was decided to use the standard deviation method to measure the volatility of exchange rate for each month.

3.4 Robustness Test

In order to be able to use VAR model and for the model to work, all variables have to be stationary. In the first test, the results showed that GDP was not stationary. For this problem to be fixed, all data were generated again at first difference to ensure that all variables are stationary. It was conducted the unit root test of Philips Perron and it seems that at first differences the problem of spurious regression is not present. Said that, all the variables are integrated of order I (1); hence were included all explanatory variables and the explained variables in this form. Lastly, the relevant assumption of stationary is satisfied as well (see Table 3.1). This means that there exists enough evidence to reject the null hypothesis.

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Table 3.1 Unit Root Test (Philips Perron Test)

Null hypothesis: *The Variable is Non-Stationary (It has a unit root)*			
		Adj. t-Stat	Prob.*
cpicanada	Phillips-Perron test statistic	-13.587	0.0000
		Adj. t-Stat	Prob.*
cpiusa	Phillips-Perron test statistic	-9.4382	0.0000
		Adj. t-Stat	Prob.*
Exchange rate volatility	Phillips-Perron test statistic	-178.55	0.0001
		Adj. t-Stat	Prob.*
exports	Phillips-Perron test statistic	-108.05	0.0001
		Adj. t-Stat	Prob.*
gdpcan	Phillips-Perron test statistic	-88.685	0.0001
		Adj. t-Stat	Prob.*
gdpusa	Phillips-Perron test statistic	-42.659	0.0001
		Adj. t-Stat	Prob.*
imports	Phillips-Perron test statistic	-116.54	0.0001

After making sure all variables are stationary, next step is to decide the lag length criteria for the VAR model. AIC is widely used in the length specification criteria and is said that the lag with the lower AIC, is better. By checking the results (see Table 3.2), it is noticed that the lowest AIC is at lag length 8. This means that our optimal Lag Length based on AIC is 8.

Table 3.2 VAR Lag Length Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3681.425	NA	2204743.	34.47126	34.58136	34.51575
1	-3215.493	897.0269	44793.10	30.57470	31.45552*	30.93063
2	-3132.179	154.9496	32548.28	30.25401	31.90554	30.92137*
3	-3101.416	55.20043	38731.65	30.42445	32.84669	31.40325
4	-3025.050	132.0350	30190.85*	30.16869	33.36165	31.45893
5	-2995.636	48.93147	36651.16	30.35174	34.31541	31.95342
6	-2946.763	78.10558	37294.04	30.35292	35.08731	32.26604
7	-2890.348	86.46831	35597.62	30.28362	35.78872	32.50818
8	-2826.175	94.15962*	31850.98	30.14182*	36.41764	32.67782
9	-2787.084	54.80049	36361.89	30.23443	37.28096	33.08186

Prior the generation of the VAR model, LM test was computed to check whether there exists serial correlation in the residuals. Based on the obtained results, the null hypothesis (No serial correlation at lag h) was rejected.

In the Table 3.3, found below, as the final results suggest, there is not enough evidence to reject the null hypothesis meaning that no serial correlation exists at lag 8.

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Table 3.3 Serial Correlation LM Test

VAR Residual Serial Correlation LM Tests

Included observations: 222

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	149.6618	49	0.0000	3.209498	(49, 1024.9)	0.0000
2	70.71382	49	0.0228	1.459458	(49, 1024.9)	0.0229
3	82.87022	49	0.0018	1.720420	(49, 1024.9)	0.0018
4	80.15747	49	0.0033	1.661923	(49, 1024.9)	0.0033
5	63.18139	49	0.0838	1.299271	(49, 1024.9)	0.0840
6	87.37251	49	0.0006	1.817841	(49, 1024.9)	0.0006
7	63.08152	49	0.0852	1.297155	(49, 1024.9)	0.0853
8	61.58545	49	0.1070	1.265479	(49, 1024.9)	0.1072

The results gained after conducting the serial correlation LM test, show that at a lag length VAR Model of order 8, the problem of serial correlation in residuals is fully mitigated. That said, we are able to satisfy the respective Gauss Markov Assumption.

With respect to assumptions related to Random Sampling and Normality in residuals, it can be said that both of them are automatically satisfied.

4. DISCUSSION AND RESULTS

4.1 VAR Model Specification

To achieve the results, as mentioned above, the analysis will be based on two models as specified below:

- $E_t^{US} = f\{G_t^{US}, G_t^{Can}, P_t^{US}, P_t^{Can}, X_t V_t\}$
- $I_t^{US} = f\{G_t^{US}, G_t^{Can}, P_t^{US}, P_t^{Can}, X_t V_t\}$

Where, E_t^{U} are exports of US with Canada and I_t^{US} imports of US with Canada. G_t stands for Gross Domestic Product, P_t for Consumer Price Index, $X_t V_t$ for exchange rate volatility and for this, the exchange rate of USD/CAD is used.

Based on this model, the sequent analysis will be conducted to check the relationship between exchange rate volatility and the other variables. For our analysis, we used dynamic specification, a VAR model of order 8 decided based on the lowest value of Akaike Information Criterion. Prior running the main model, we ran a simple regression analysis, just for testing, using as dependent variables imports and exports and as independent variable only exchange rate volatility.

4.2 Empirical Findings & Discussions

To provide an analysis on the impact of exchange rate volatility to international trade, the VAR model is used, which gives us the chance to interpret the bidirectional relationship between variables and their lags. Also, as mentioned above, the results gained from the simple regression, showed that there is no significant relationship between exchange rate and imports/exports. This means that there is no impact of exchange rate on the imports and exports.

As mentioned above (Table 3.2), using Akaike Information Criterion was decided that the optimal lag length to estimate our VAR model is of order 8. After deciding the lag length and all the tests explained above, the model was generated to provide us dynamic results due to lag length. All obtained results are explained below.

Main focus of the research are the models that explain and give the answer to the research question mentioned in the beginning. Further to the obtained results (see Appendix A), it is noticed that the first significant model is Exports of US to Canada as a dependent variable. As results indicate, there is a relationship between exports of US to Canada with the following variables: price level of US, GDP of Canada, GDP of US, imports, its own lags and exchange rate

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volatility. Considering all variables one by one, it can be seen that CPI of US has a significant impact at lag (-7) and (-8). Since for t-statistics the absolute value of a result higher than 1.645 the significance level is 10%, based on these results, it can be said the same for CPI in both periods. This means that an increase on the CPI, will show a positive impact on exports after seventh month, but it will be changed to a negative one after eighth month. Continuing with the GDP of Canada, there is a significant relationship with the exports at lag (-5) with a negative impact and later a positive one after the eighth month, at a significance level of 10%.

Also, an increase in the current GDP of US, has a positive impact in after second, third and fourth month, but no relationship or impact after that. At second month, the significance level is 10%, but it changes for the third and fourth month. Since the t-statistic value at that period is higher than 1.95, there is a significance level of 5%. These results are also supported by the research conducted by Baek (2014) where the results state the economic growth has a significant role on trade. Also imports seem to have a significant impact on exports after the fourth month at a significance level of 10% and at fifth month at a significance level of 10%. After fifth month, the results show no significant impact on exports. Coming to the final independent variable included in the model which is exchange rate volatility. As seen in the results, volatility of exchange rate has a significant impact on exports at lag (-1) at 5% significance. This means that an increase in the current exchange rate volatility, will have a positive effect after the first month. A significant positive impact is also noticed after the seventh month but based on the value of t-statistics the impact is at significance level of 10%. Based on the results, exchange rate volatility has a positive impact on exports which complies with the findings of Senadza & Diaba (2017). Also Baek (2014) and McKenzie & Brooks (1997) suggest a positive impact of exchange rate volatility on exports after the devaluation of exchange rate.

The analysis continues with the next model where imports are the dependent variable. Based on the results gained by VAR model, it can be noticed that there exists a significant relationship with the independent variables: price level of USA, exports, GDP of USA, with its own lags and exchange rate volatility. At significance level 5%, there is a positive impact of price level on exports after first month which later after the second month it is converted into a negative one. After second month, results show no significant impact anymore. After price level, also exports show a negative and positive significant impact on imports after fourth and seventh month respectively (based on t-statistics at 5% significance level). The results indicate no impact of GDP of Canada on exports at all periods, while the USA GDP shows an impact after the first month at significance level 5% and an impact after fourth month, but at significance level 10%. This means that an increase on GDP will cause a positive impact at both periods. After the fourth month, there is no impact anymore. Coming to the last variable, it can be seen that the results indicate firstly a positive effect of exchange rate volatility on exports at the lag (-1). This means that an increase on the exchange rate volatility, will give a positive impact after the first month at a significance level 5%. While after the fourth month, there exists a negative relationship between these two variables, meaning that an increase on the exchange rate volatility will lead to a negative effect on imports and after that no significant impact is noticed in the model. Also Oskoee & Kovyryalova (2008) in their research support these findings based on their analysis. They also indicated a negative impact of volatility on imports.

Looking at the overall results, it is noticed that for some variables, the relationship among variables changes among different months. Taking a look at exchange rate volatility as an independent variable, we can notice that it has an impact on other models too. For the price level of Canada there is no significant relationship at all, meaning no impact while on the other hand, on the price level of USA, there is a significant positive impact after first month and sixth one. Regarding the GDP of each country, the results indicate a negative impact on the GDP of Canada after fourth month and later no impact at all. At that same period, a negative impact is noticed also on the GDP of USA later to be followed by a positive one after sixth period.

5. CONCLUSIONS

5.1 Final Findings

International trade flows have always been considered the cornerstone of innovation, economic growth and progress. Their influence can be spread in various aspects and fields, yet various hazards and risks exist. Knowing that currently currencies around the world are subject to free forces of the market (i.e. demand and supply), the fluctuations in the rates of exchange and cross rates can be huge. This gives rise to what is known as Foreign exchange risk.

This thesis builds on secondary data collected over a 19-year period, so as to answer the research question on how the above-mentioned exchange rate risk affects the trade flows in international level and more specifically between US and Canada. VAR model is used so as to check in a dynamic way the direction, strength and statistical significance of the interrelationships between on one hand: GDP, CPI, exchange rate and volatility and on the other: exports and imports between the two studied countries.

The results suggest that there exists indeed an impact of exchange rate volatility on international trade among the US and Canada. This relationship seems to be changing among months and at different levels of significance. The final findings indicate a positive relationship in long-run between exchange rate volatility and exports. These results are in line with the findings that other researchers have concluded in their studies. Regarding the imports, there exists a long-run relationship, but its impact differs in different periods. Also, other researchers indicate in their studies that

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the gained results are not that consistent, and change based on data, countries and industries involved. There exist periods when a change in exchange rate volatility brings no impact on exports nor imports. A potential clarification for such results can be the increase of subsidiary instruments such as option and future which make it possible for investors to be preventive to the riskiness of possible profits that arise by the fluctuations of prices and exchange rates. Also, another implication can be the fact that there are multinational companies, corporations that operate worldwide and the losses that can be suffered by the volatility of a currency can be recuperated with the profits coming from the fluctuations of another currency. All these fluctuations caused by the volatility of exchange rate suffered an increase after the Bretton Woods collapse. Due to the fact that the market sharers are risk averse, this brought an increase in the future market. The more they grow, more inconsistent impact there will be. Also, as can be seen in the literature review, there were cases when there was no impact on trade or significant impact but weak. Another key point to be mentioned is the fact that developing countries would be more impacted by these fluctuations than the developed ones due to the fact that their markets are not yet that strong.

All in all, it seems that all authors have found different results of exchange rate volatility impact that come as a result of the countries with different economies that are studied in different periods. This makes it difficult to generalize the significance of the impact of exchange rate volatility. However, our study focuses on the existence of this relationship between two trading partners USA and Canada. For the imports, results suggested different impact after different periods but after the fourth month no relationship at all. While for exports we have a positive long-run relationship between them. The chosen countries are both developed economies and have already developed ways to prevent and absorb the possible risks that might encounter from these fluctuations.

Variables (lags)	Exports
CPI_USA (-7)	+
GDP_CAN (-5)	-
GDP_CAN (-8)	+
GDP_US (-2) (-3) (-4)	+
IMPORTS (-4) (-8)	-
IMPORTS (-5)	+
ERV (-1) (-7)	+

Variables (lags)	Imports
CPI_USA (-1)	+
GDP_USA(-2)	-
EXPORTS (-7)	+
GDP_US (-1) (-4)	+
ERV (-1)	+
ERV (-4)	-

Note: + positive impact, - negative impact, ERV Exchange Rate Volatility

Figure 5.1 Summary of the Final Findings

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The Effects of Protectionism on the Exports of the Trade Partners: A Composite Index

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ABSTRACT

Purpose:
This study constructs a quantitative tool that can interpret the effects of trade protectionism on trading partners.

Design/methodology/approach:
Trade protectionist policies are a crucial phenomenon of international political economy. The existing literature has analyzed the consequences, causes, and effects of trade protectionist policies. A principal aspect of the present study is the diverse consequences of the operation of protectionism on trading partners. The central question is this: exactly in what way are the exports of trading partners influenced by a trade "war"? The methodology utilized is the composition of a Composite Index (CI).

Findings:
The analysis of this paper showed that the country's participation in international trade flows, economic and commercial strength and symmetrical or asymmetric interdependence with the countries involved on trade protectionism are the important aspects that determine the significance of the protectionist effects.

Research limitations/implications:
The composite index signifies the amount of the impact and not the kind. Actually, a state can have an unimportant influence on the trade protectionist policies of two of its trading partners, but this consequence could have an undesirable connotation. The reason is that the index does not examine the entire exports of a country, but the proportion of trade interconnections.

Originality/value:
The composite index is crucial for interpreting the effects of a phenomenon of global political economy.

1. Introduction

Trade protectionist policies are a critical phenomenon of global economic relations. The phenomenon of protectionism has a simultaneous effect as that of the phenomenon of international trade. According to Shafaeddin (1998) many developed countries have managed to develop through protective measures. There are many reasons for implementing protective measures (Abboushi, 2010). According to Melgar et al. (2012) a large increase in the unemployment rate or inflation may increase protectionist attitudes. Kutlina-Dimitrova & Lakatos (2017) described the potential (negative) effects of the application of protective measures worldwide and reported that, while protective measures have an attractive connotation, especially for the short term, the increase in global protectionism is likely to have wide-ranging negative consequences for the whole economy, for consumers, for producers (businesses), for governments, investments, and trade flows. Note that protectionist policies form the basis of the "strategic trade policy"[2] argument, which has as its central point the ability of government policy (which has the means) to change the competition to favor domestic companies as opposed to foreign companies (Coughlin et al., 1988).

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2. Krugman (1987) mentions this argument.

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In the current period, the world community has witnessed a trade quarrel between the US and China that has reached the dimensions of a trade "war." Studies have argued that the reason for this "war" may be China's "mercantilist" economic policy (Beeson (2009); Hawkins (2005); Yu (2019); Atkinson et al. (2017)). Essentially, the causes of the trade war are firstly, the high bilateral trade deficit of the US. Moreover, China charges an upper tariff on imports from the US (non-reciprocal trade policies). Furthermore, the US accusation through American multinational companies of transferring the technology of American companies legally and illegally within China, and another cause is the dynamics of threatening the position of the dollar as a reserve currency from the Chinese currency. The main reason that explains the intensity of the trade war is the technological leadership in several areas that are considered critical to national security for both countries (Feenstra & Sasahara (2018); Vani (2020); Kalsie & Arora (2019); Edwards (2018); Gros (2019)).

The commercial confrontation among US-China is a multifaceted economic phenomenon. That is, there are several important aspects of the trade war between these two countries that do not only belong to the field of trade rivalry. Otherwise, it can be said that the trade war is the "tip of the iceberg" in a series of broader economic rivalries. In other words, the reasons that have led to the declaration of this war should be mentioned as thoroughly as possible. The US's main impeachment of China is the accusation of "unfair" trade practiced by China. It should not be forgotten that the US has lost five million jobs in the industrial sector since 2000, particularly in the manufacturing sector (low-wage labour force (Feenstra & Sasahara, 2018)). Such decline has been exacerbated by China's admission to the WTO (Bartash, 2018). Because of this economic situation, it is reasonable for the US to reproach China. Of course, the US accusations about China's "unfair" trade relate to the rising trade deficit, intellectual property theft and the compulsory allocation of US know-how to China (Vani, 2020). It is interesting to present the causes of the war (Kalsie & Arora, 2019). In particular, the first cause is the high bilateral trade deficit with the US. The second reason is that China charges an elevated tariff on imports from the US - non-reciprocal trade policies. The third cause is the accusation by the USA - through us multinational companies - of transferring the technology of American companies by legal and illegal means to China. Later, China's industrial (protectionist) policies are another rebuke of the US accusing China of an increased role for the government in upgrading Chinese industry - economy. Still, the U.S. believes that China can evolve more technologically advanced in a range of industries that can be a heavy cost to the U.S. Next, another cause is the dynamics of the rivalry and competition of multinational companies of an emerging economy (such as China) with multinational companies based in advanced economies. Finally, another cause is the dynamics of the threat of the dollar's position as a reserve currency by the Chinese currency. In essence, China has acquired the criteria by which it can compete with America (Edwards, 2018). Although the reasons given have an economic background, they do not explain the intensity of this trade war. The main reason for these is technological leadership in several areas considered critical to national security for both countries (Gros, 2019).

Trump's trade wars show two aspects of the international system (Liu & Wing, 2018). The first aspect is the increased concern for national security. The second aspect must do with the reluctance of the US to continue to promote economic globalization. The economic differences expressed in trade wars are a systematic feature of the current situation. The current situation is an uncoordinated multipolar political-economic international order. The causes of the trade war include macroeconomic issues such as unemployment and the trade deficit, to geo-strategy and international policy issues such as national security. Any trade war can have winners and losers. What is certain is that the consequences of this war are significant because of the position occupied by the countries concerned in the international economic system.

To find out the outcomes of the US-China commercial conflict, it will be necessary to examine whether there have been and to what extent-negative or positive effects on the other countries of the international economic system. The degree of influence of the trade war and the type of effect is the measure by which the consequences of the trade war can be controlled. The imposition of U.S. protectionist measures has created an indirect impact on Thailand's trading partners through the global slowdown in the economy (declining global demand), for example China (Nidhiprabha, 2019). The U.S. trade war with China is hurting Japanese multinational corporations (Sun et al., 2019). Since more than 40% of China's exports were made by foreign multinational companies, the tariffs of the U.S. leadership Trump, fall on products coming from China, the subsidiaries of Japanese multinationals may take the burden of protective measures. India has a trade surplus with the US. The trade war with the US could damage India. If the war continues and worsens, then it says that the trade deficit and India's current account deficit will widen. Both the domestic market and industries, mainly pharmaceuticals, clothing, and textiles, will be affected (Mandal, 2018). The U.S. trade war with China may lead in the long term to rising inflation, a shortage of resources, environmental damage to the lack of work in Vietnam (Lam & Nguyen, 2019). The high liberalization of Vietnam's trade and the fact that both China and the United States are its main trading partners are the reasons for the great fall. Indonesia's exports continue to be affected by a rate of -0.24 from the trade war (Taufikurahman & Firdaus, 2019). Since the US trade war with China, the European Union and its Member States have been affected by a very small percentage. That is, there is a slight decline in GDP, (a decrease of 0.1 percentage points from the current state of the US-China trade dispute) (Breuss & Christen, 2019). The U.S.-China trade war may be beneficial for Latin American countries (Laborde & Piñeiro, 2019). In particular, in the short term, as the escalation of tariffs and retaliation between the countries will increase, this affects making Latin American countries' exports more attractive. The real effect of the China-US trade quarrel on Hong Kong's economy is indirect (Lau, 2019). The sector that will be affected first is national consumption. Then, because tourists from mainland China to Hong Kong make up almost 80% of the total

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number tourists of 65 million per year, the slowdown in the mainland Chinese economy will affect Hong Kong's tourism industry. The consequence of the U.S.-China trade conflict on Canada's trade is estimated to be significant, and the degree of impact depends on Canada's access to the U.S. market (Charbonneau, 2019).

As far as emerging economies are concerned, the two countries' trade war could have benefits instead of losses (Carvalho et al., 2019). In particular, for developing countries that were not directly affected by the actions of the commercial confrontation, their exports could be profitable, especially in sectors where these countries are competitive. For countries - other Asian economies - there may be benefits from the trade war through trade diversion in competing export sectors with China, but they may be damaged in sectors linked through supply chain networks to China (Gentile et al., 2020). The following can be mentioned the effect of the trade war between the US-China on most countries and their industries. In the agricultural sector, Brazil and Argentina are likely to export to a lesser extent, in the manufacturing sector, the largest market share losses are expected to be experienced by Japan and Germany, in the energy sector, Saudi Arabia, Australia, Russia and Korea as well as Angola, Indonesia, Mongolia, Turkmenistan, Singapore and Malaysia face a possible jeopardy of loss (Freund et al., 2020).

U.S. - China trade confrontation began in 2018. From July to December 2018, the trade - tariff war escalated[3]. The trade war between the two countries is a zero-sum game. There is no winner or loser from the clash of these two powers. Both countries do not profit from their trade conflict. The U.S. has no sound reason to exercise trade protectionist means. China has nothing to lose from the imposition of trade tariffs against it. The question that arises is what is the effect of the trade conflict. The effects of this trade combat must be properly and mostly quantitatively investigated. The way of studying the outcomes can be a composite index. The idea of this research paper is that the consequences of trade dispute on the exports of trading partners are formed by the combination of three pillars. A collective investigation of the size of trade in value added, productivity and interdependence verify whether the consequences on a state are noteworthy or not. With the U.S. - China trade war as a case study, this analysis[4] shall develop a quantitative tool appropriate for calculating the effects of trade protectionism on the exports of trading partners. The quantitative tool is the *Composite Index of the Intensity Effect of Trade Protectionism.*

The rest of this study is organized as follows: next, the theoretical basis of the pillars for the indicator is quoted. Next the methodology is cited. In the end the demonstration of the composite index is quoted. The present study was based on the construction of a composite indicator (CI) (quantitative procedure of assessment).

2. The theoretical frame of the Composite Index

The indicator is constructed by three pillars. Firstly, the *trade in value added*, secondly, *productivity*, and thirdly, *interdependence.* These pillars have the ability to describe the impact of the trade protection procedures of two countries on the exports of their trading associates. It is essential to describe the pillars distinctly to apprehend their selection.

First, the choice of trade in value added[5] was made because Global Value Chains (GVCs) and trade in intermediate goods are an undeniable reality of the modern global economic system[6]. Today, two fundamental characteristics should be mentioned, firstly, intermediate inputs could influence the development in trade and secondly, the GVCs affect not only the intensity but also the structure of global trade (Kelly & La Cava, 2013). Many studies have proved that the productivity of a company is related to imported inputs[7]. Studies such as Kasahara and Rodrigue (2008), Halpern et al. (2009), Castellani & Fassio (2019), Smeets and Warzynski (2010), and Bas and Strauss-Kahn (2011) are examples. Still, studies have proved that the decrease in charges on imported inputs assists the productivity of many businesses (Amiti and Konings (2009), Goldberg, et al. (2010), Feng et al. (2012), Lileeva and Trefler (2010) and, Yu (2011)). Imported intermediates have a boosting result on the productivity of companies. Notable is what Zaclicever (2019) states. Especially, the variety of the geographical origin and the diverse categories of intermediate imported products make possible positive results on the export activity of the industries. The changes in trade obstacles in the intermediate imported goods habitually have an important effect on export operation in the final product sector (Navas et al., 2014). A significant argument is made by Grossman and Helpman (2021). That is, they state that great tariffs are impracticable for the reason that they compel businesses to acquire from fewer competent traders. A central component of intermediate merchandises is that the country's consumers do not directly address the domestic price of the intermediate good (Batra & Naqvi, 1989). Furthermore, Jamil and Arif (2019) mention that the decrease in tariffs on intermediate inflows may have advantages for states. Especially, imported intermediate inputs can advance both the export price and the size. However, the price of the intermediate good causes disturbances in the productive activities of the country. In fact, when a country is very dependent on intermediate inflows from another country, it is not in the interest of that country to impose tariffs on its trading partner. That is to argue, the assumption on the basis of which the first pillar option is based is that countries that

3. See: Bown (2021).
4. A similar procedure has been carried out by Karakostas (2021, 2022a, 2022b).
5. Concerning the determining factors of trade in value added see: Choi, (2013), Yücer et al. (2014), Nakazawa et al. (2014), Guilhoto et al. (2015) and concerning the measurement of value-added trade see: Johnson and Noguera (2009) and Daudin et al. (2009).
6. As Choi (2020) states the GVCs have become the base for the national development strategies.
7. See: Romer, (1987), Rivera-Batiz & Romer, (1991), Backus et al. (1992).

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have a high proportion of exports of intermediate goods are not harmed as much as countries that have a small proportion of exports of intermediate goods. So, it is very important the share in the exports of intermediate goods.

The second pillar is productivity. The choice of productivity was made for the reason that it contributes to the exports of a country. Productivity is positively linked to the performance of exports and can be considered a critical factor in the survival of a country's exports to the foreign market. Examples of this supposition are Yasar et al., (2003); Wagner, (2002); van Biesebroeck, (2003); Mengistae and Pattillo, (2004); Liu et al., (1999); Hallward-Driemeier, et al., (2002); Greenaway & Kneller, (2003); Greenaway and Kneller, (2004a); Sjöholm, (1999); Greenaway and Kneller, (2004b); Greenaway and Yu, (2004); Castellani, (2002); Bernard et al., (2003); Clerides et al., (1998); Bernard et al., (1999); Bernard and Jensen, (2004a); Bernard and Jensen, (2004b); Baldwin and Gu, (2003); Aw and Hwang, (1995); Kraay, (2002); Arnold and Hussinger, (2004); Aw et al., (2000); Melitz, (2003) and, Ghironi and Melitz, (2005). Ayadi and Mattoussi (2014) report the link between productivity and commercial performance. Essentially, this bond is innovation. Innovation plays a significant role because the technological nature of the product makes the product a monopolistic product, due to its innovation (Fare et al., 2012). The choice of the productivity pillar was made for the main reason that when a country has high productivity its exports can face any challenge. Even if challenges are of a commercial and protective nature. That is, productivity determines the "quality" of goods and thus renders protective measures ineffective. As reported by Akcigit et al. (2018)[8], differences in productivity lead to the definition of trade flows. They also state that the productivity (quality) of intermediate goods determines the choice of the producers of the final products whether to choose domestic or foreign intermediate goods. Essentially, the choice of productivity proves that the potential of an economy - expressed in productivity - can be the key to weakening the effects of protectionist measures imposed directly on a country or indirectly.

The third pillar chosen is interdependence. The choice of interdependence is because the more a nation is interdependent with a trading partner, the stronger the effects of the protectionist tensions it can create with other countries will be. The kind of interdependence is great. That is, the existence of, for example, Foreign Direct Investments[9] (FDIs) achieves the reduction of protective measures. This is partly true. As Blonigen and Feenstra (1997) mention, the deterrent outcomes of foreign direct investment apply according to the type of FDI and according to the type of protection. It is therefore appropriate to define the trade interconnection of countries as the appropriate measure of interdependence. Trade barriers vary greatly between countries and industries (Wang, 2001). Studies such as Frankel and Rose (1997), (1998); Clark and van Wincoop (2001); Fatas (1997) argue that when two countries have a high trade bond then they have highly correlated business cycles. Choe (2001) studying the effects of commercial interdependence and business cycles found that there is a correlation. Studies such as Rana (2007) and, Allegret and Essaadi (2011) found the same synchronization. In other words, they found that the intense bilateral trade between countries is exacerbating synchronization. Baxter and Kouparitsas (2005) found that there is a strong correlation. Juvenal and Monteiro (2017) and, Surugiu and Surugiu (2015) have reported the relationship between trade and business circles. Ning and Ye (2012) found that there is a synchronization between bilateral trade and economic performance. He and Liao (2012) and Lee and Azali (2010) report that trade fostered the business cycle co-movement. Rana et al. (2012) state that intra-industry trade development was the key force rather than the inter-industry trade. Wang (2010) and, Zhang and Akgmetova (2018) argue that bilateral trade is a factor that creates this concurrence (the other factor is FDI). The main reason why interdependence has been chosen as the third pillar is because trade[10] interconnection is essentially the channel through which any fluctuations can be more easily transferred. For example, Wu and Pan (2014) (by researching bilateral economic relations between Japan and China) have shown that this correlation must exist. Figure 1. presents the Composite Indicator.

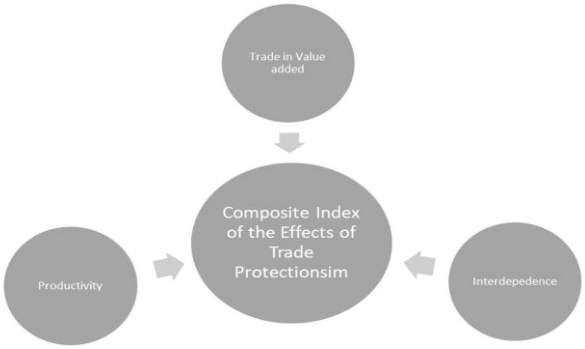

Figure 1. The pillars of the indicator

Source: Author's conceptual framework

8. They mention: "… failing to incentivize U.S. firms to accelerate technological improvement, the protectionist policy cannot compensate for the loss of high-quality imports and leads to substantial welfare losses in the medium to long run …" (p. 55).
9. See: Bhagwati et al. (1987); Dinopoulos (1989); Dinopoulos and Wong (1991); Dinopoulos (1992); and Bhagwati, et al. (1992).
10. There are studies such as Kumakura (2006) and Shin and Wang (2003) that report that there is no significant correlation.

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The abovementioned pillars can describe the diverse consequences that the two countries' trade protectionist policies have on their trading partners. The first pillar suggests a state's participation in international trade flows, the second pillar has the ability to articulate the economic and trade potency of a country and the third pillar implies the balanced or asymmetric dependence of a country with the countries concerned in trade protectionist policies. The following unit portrays the methodology to be followed.

3. Methodology

The principal idea of this research is to create an Index that determines the consequences of the trade protectionist policies on the exports of the trade partners quantitatively. The methodology is a calculable approach. The index to be constructed is a composite indicator. Nardo et al. (2005, p. 7) indicated what a composite index is. Actually, they quote:

"... a composite indicator is the mathematical combination of individual indicators representing different dimensions of a concept, the description of which is the objective of the analysis ..."

The OECD Handbook on Constructing Composite Indicators (OECD, 2008) is the guide for the formation of the index. The Min-Max Normalization Method is the method of normalization. Freudenberg (2003) states that composite indicators are a gradually operated means for evaluating countries' performances at particular scientific subjects. Examples are competitiveness, innovation, etc. In accordance with the OECD (2008, p. 28):

"Min-Max normalizes the indicators so that they have the same range [0,1] by subtracting the minimum value and dividing by the range of the index values …"

The Min-Max Normalization equation is the following:

$$C = (Value - Min) / (Max - Min) \quad (1)$$

The normalization procedure followed by the World Economic Forum is as follows, in proportion to Schwab (2019: 614), each sub-index is developed in accordance with the following:

$$Score_{i,c} = (Value_{i,c} - wp_i / frontier_i - wp_i) * 100 \quad (2)$$

where $Value_{i,c}$ is the value of sub-index i of country c, the worst performance (wp_i) is the lowest acceptable value for sub-index i and $frontier_i$ corresponds to the highest value (at best possible result) for sub-index i.

Both the normalization and concentration method utilized by the World Economic Forum to structure the Global Competitiveness Report is operated. The World Economic Forum utilizes the Min-Max method (ranging from 0 to 100) for the normalization of each sub-index.

As stated by Ochel & Rohn (2006), the Min-Max Normalization process is followed by the Fraser institute: Economic Freedom of the World (EFW index) and World Economic Forum (WEF) Growth Competitiveness Index (GCI). This method of normalization was selected because keeps the relationship among the original data (Aksu et al. 2019). The reported method normalizes the data by comparing and determining the best value as the largest and the worst value as the smallest.

With regard the concentration stage, the method utilized by the World Economic Forum is followed. The procedure of obtaining the average is followed. The process is stated in the Global Competitiveness Report. As Petkovová et al. (2020) describe, the mostly used approaches for aggregation are arithmetic and geometric averages. They refer that both simplicity and general awareness of their calculation are the main advantages.

Talukder et al. (2017, p. 8) quote:

"Commonly applied aggregation options include additive aggregation (arithmetic mean), […] The arithmetic mean is a linear function. The normalized […] indicators are summed to compute the arithmetic mean ..."

The method for assessing the arithmetic mean is:

$$x = \sum_{i=1}^{n} x / N \quad (3)$$

As stated by Mazziotta & Pareto (2013) there is no common technique to create an indicator, but then again, they state four stages to develop an indicator. The first stage is the description of the phenomenon. Second the assembly of individual indicators. Third the normalization of the individual sub-indicators and lastly the aggregation of the normalized indicators. The indicator consists of three (3) pillars. The criteria for each pillar were based on the literature analysis. Figure 2. shows the function of the Index.

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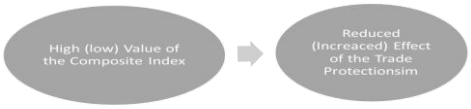

Figure 2. Schematic Display of the Function of the Index

Source: Theoretical approach of the author

The indicators of the first pillar are the percentage (%) Intermediate Product Exports, because it can explain the country's participation in Global Value Chains (international trade flows)[11] and the Revealed Comparative Advantage (RCA)[12] of the Intermediate Product Exports. The best value is the highest. The worst value is the lowest. The indicators of the second pillar are the Total Factor Productivity (index - level at current purchasing power parities) because to the fact that can clarify the economic strength of a country[13]. The best value is the highest. The worst value is the lowest. The indicators of the third pillar are the Trade Intensity Index[14] with US and China distinctly because this indicator is efficient of explaining the trade connection of two trading partners[15]. The best value is the lowest. The worst value is the highest. This indicator is estimated for both countries distinctly. The database for this study is World Integrated Trade Solution (WITS), Federal Reserve Economic Data (FRED) and The World Bank.

The countries chosen are four (4) and are: *Switzerland, India, Japan, and Brazil.* The states were chosen indicatively on the basis of a principal standard. The standard is that it should be of a diverse economic level. Actually, developed countries and developing (UN, 2021). The selection of countries was based on the availability of data.

The year chosen is *2019* and was selected for the reason that it is the time directly afterwards the operation of protective actions by both states and previously the pandemic. The year presents a more actual examination of the matter at issue. A specific period cannot be investigated because there cannot be an adequate time range of analysis. The reason is that the trade protection policies between the countries concerned do not cover a long-time range.

The meaning of the index is the following*: the higher the value of the composite index, the smaller the effect of trade competition on the exports of the countries concerned.* The indicator reveals an inversely proportional association. The composite index estimates the strength of the consequences of trade protectionism on the exports of trading partners and not the kind since the consequences may differ, i.e., be negative or positive[16]. The following unit will display the outcomes and show the composite index.

4. Calculation and Demonstration of the Index

This unit presents the indicator. To assess the consequences of trade protectionism, the following stages will be taken. First, the normalization of the data will follow. Table 1. shows the values of the selected indicators[17] of Switzerland, India, Japan, and Brazil for 2019.

11. See: OECD (2015).

12. The Revealed Comparative Advantage (RCA) is calculated by the formula:

$$RCA_{ij} X_{ij} / X_{Tj} / X_{iw} / X_{Tw} \quad (4)$$

where X_{ij} is the exports of country j of product i; X_{Tj}, is the sum of exports of country j; X_{iW} is the world exports of product i; X_{TW} is the World Total Exports. The RCA ranges between zero and unity in case a country is not intense in exports and from one to infinity if it is intense (Balassa, 1965).

13. See: Truong (2016) and Isaksson (2007).

14. The Trade Intensity Index (TII) is calculated by the formula:

$$TII_{ij} = (X_{ij}/ X_{it}) / (X_{wj}/ X_{wt}) \quad (5)$$

where X_{ij} is the values of country i's exports to country j, X_{wj} is the values of world exports to country j, X_{it} is the country i's total exports and X_{wt} is the total world exports. The Trade Intensity Index is used to determine whether the value of trade between two countries is greater or smaller than would be expected on the basis of their importance in world trade. An index of $T_{ij} > 1$ indicates a bilateral trade flow that is larger than expected, given the partner country's importance in world trade while $T_{ij} < 1$ indicates a bilateral trade flow that is smaller than expected, given the partner country's importance in world trade (Maryam et al, 2018).

15. See: Wolfgang (1978).

16. See: Sun et al. (2019); Mandal, (2018); Taufikurahman & Firdaus, (2019); Breuss & Christen, (2019); Laborde & Piñeiro, (2019); Carvalho et al. (2019); Robinson & Thierfelder, (2019).

17. For the Trade Intensity Index, see Appendix.

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Table 1. The Values of the selected indicators for Switzerland, Brazil, United Kingdom, India, for the year 2019.

Country	*Product Share of Intermediate Exports to the USA* (%)*	*Product Share of Intermediate Exports with China* (%)*	*RCA of Intermediate Exports to the USA* (Index 2009=100)*	*RCA of Intermediate Exports with China* (Index 2009=100)*	*Total Factor Productivity at Constant National Prices** (Index 2017=1, Not Seasonally Adjusted)*	*Trade Intensity Index*** (with USA)*	*Trade Intensity Index*** (with China)*
Switzerland	33.7	52.9	1.36	3.24	1.02	0.94	0.66
India	27.0	44.9	1.81	2.63	1.02	1.07	0.48
Japan	11.3	24.5	0.81	1.15	1.00	1.64	2.24
Brazil	33.9	10.0	2.12	0.49	0.97	1.15	3.57

To finish the formation of the indicator, the normalization of the values and calculation of the average follow. Table 2. presents the normalized values. Table 3. shows the average. The average of the values is basically the values of the composite index.

Table 2. The normalized values for the selected countries.

Country	*Product Share of Intermediate Exports to the USA (%)*	*Product Share of Intermediate Exports with China (%)*	*RCA of Intermediate Exports to the USA (Index 2009=100)*	*RCA of Intermediate Exports with China (Index 2009=100)*	*Total Factor Productivity at Constant National Prices (Index 2017=1, Not Seasonally Adjusted)*	*Trade Intensity Index (With USA)*	*Trade Intensity Index (With China)*
Switzerland	99.12	100.00	41.98	100.00	100.00	100.00	100.00
India	69.47	81.35	76.34	77.82	100.00	81.43	106.19
Japan	0.00	33.80	0.00	24.00	60.00	0.00	45.70
Brazil	100.00	0.00	100.00	0.00	0.00	70.00	0.00

Source: Author's calculation.

Table 3 displays the values of the index.

Table 3. The Index

Country	*Values of the Composite Index*
Switzerland	91.59
India	84.66
Japan	23.36
Brazil	38.57

Source: Author's calculation.

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It is not easy to have a complete validation of the index. Due to the fact that there is no suitable time frame of more than a decade concerning the trade conflict (trade protectionist policies) of the US-China. Yet, to gain an adequate authentication of the index, a comparison of the prices of the index with the standard deviation[18] of the percentage change[19] in the exports of goods and services of the concerned countries can be made for the years 2017-2020. Table 4. shows the exports of the countries Switzerland, India, Japan, and Brazil.

Table 4. Exports of Goods and Services (% change from year ago - seasonally adjusted - annual, average) of the selected countries, for the years 2017-2020.

Year	*Switzerland*	*India*	*Japan*	*Brazil*
2017	*0.51*	*9.71*	*11.33*	*5.48*
2018	*5.34*	*15.63*	*4.82*	*24.33*
2019	*0.18*	*4.90*	*-4.36*	*1.80*
2020	*-7.95*	*-6.37*	*-14.12*	*20.18*

Table *5.* displays the values and the Standard Deviation of percentage change in Switzerland, India, Japan, and Brazil.

Table *5.* Assessment of the values of the Index with the Standard Deviation of the Percentage Change in Exports of Goods and Services for Switzerland, India, Japan, and Brazil for the years 2017-2020

Switzerland	Value of the Index: *91.59* - Standard Deviation of the percentage change in Exports of goods and services: *4.77*
India	Value of the Index: *84.66* - Standard Deviation of the percentage change in Exports of goods and services: *8.07*
Japan	Value of the Index: *23.36* - Standard Deviation of the percentage change in Exports of goods and services: *9.60*
Brazil	Value of the Index: *38.57* - Standard Deviation of the percentage change in Exports of goods and services: *9.51*

Source: Author's calculation.

The outcomes of this comparative examination are that Switzerland with the highest value has the smallest effect from the trade protectionist policies of the US-China. In contrast, Japan has the highest effect with the lowest price of the composite index. Concerning developing countries, it is observed that India has less effect than Brazil. It is certain that the outcomes of the trade protectionist measures among the US-China are not separated from the causes of a country's economic performance but from the structural and commercial features of each country.

5. Conclusion

The effectiveness of the trade protectionism is influenced by two factors: The first is that a country to develop competitive products, the import tax that adds value (taxes on the intermediate goods) to the country's exports should be low. Additionally, the country's export tax should be just as low for its trading partners (taxes on the final goods of trading partners on imports of the country). Concurrently, the second factor should also apply, namely the tax on imports of final products from trading partners to be as high as possible. Thus, that the state can export the final goods at a competitive price. Fundamentally, the consequences of trade protectionist policies are exacerbated or mitigated for a trading partner according to the pillars of the index built in the present analysis.

This paper created an index. The index is the *Composite Index of the Effects of Trade Protectionism*. This analysis is an effort to measure a basic fact in global economic affairs. The indicator can determine the scale of the influence of two countries' trade protectionist policies on trade partners' exports.

18.Standard deviation is a statistical measure used by researchers to calculate the amount of change or dispersion of a set of data value s. The greater the standard deviation, the more the values are distributed. The smaller the standard deviation, the less the sample values are distributed. Variance is the square of the standard deviation and measures the variability of observations around the mean value. Basically, the standard deviation describes the standard distance of an observation from the distribution center or mean value. The formula for standard deviation is as follows (Hassani et al., 2010): $SD = \sqrt{\frac{\sum_{i=1}^{N}(x_i - x)^2}{N-1}}$

19. See: Andersen (2019).

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The indicator can determine the scale of the consequences of trade protectionism for the next reasons. The participation in intermediate goods makes a country a strong trading partner and excludes as far as possible any trade confrontations. This makes its exports indispensable. Moreover, a country's productivity indicates how competitive it can become. The upper the productivity can be, the greater competitively it turns out to be. This formulates its exports strong. Furthermore, trade interconnection could reveal interdependence with trading partners. The bigger the trade interconnection, the bigger the interdependence. How commercially interconnected the country is, also shows how symmetrically or asymmetrically it is reliant. The usage of the indicator can be utilized to any trade dispute between states and to clarify the consequences for any trading partner. The outcome of the study makes the index an efficient and suitable means for understanding the consequence of trade protectionism on trade partners' exports.

To come to the point, the reasons for the valuableness of this index are its overall use, since the explanation of the consequences is not restricted to particular states but to the whole global economic system and, secondly, to the wide-ranging frame of explanation, because the selection of pillars includes - as far as possible - the range of global economic affairs. This study offers a primary examination on the consequences of trade protectionism on the exports of the trade partners. The theoretical basis and the outcomes of the index are robust conditions for the consistency and functionality of the index created in this research.

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Appendix

2019		***Bn ($)***	
Country	Exports to USA	Exports to China	Total Exports of the country
Switzerland	43	21	479
India	54	17	529
Japan	140	134	894
Brazil	29	63	264
World	2,364	1,655	24,780

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Effects of Directors and Officers Insurance on Earnings Management Strategies: Moderating Role of Restatement Announcements

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ABSTRACT

Purpose: The purpose of this study investigates the role of directors and officers (D&O) insurance and restatement announcements in earnings management strategies.

Design/methodology/approach:
Using data on Taiwan's capital market, we implement two-stage method regression to examine the effects of D&O insurance on the earnings management strategies of firms and the role of restatement announcements.

Findings:
The results reveal that managers prefer to adopt accrual earnings management when firms have purchased D&O insurance. Moreover, the results reveal that restatement announcements cause managers to switch their earnings management strategies from accrual to real earnings management when firms have purchased D&O insurance.

Research limitations/implications:
This study has following research limitations. (1) the Taiwanese government requires listed firms to purchase D&O insurance; thus, the results of our analysis cannot be generalized to the period following the imposition of this requirement. (2) In contrast to the United States or other countries with high levels of investor protection, Taiwan's capital market is still an emerging capital market.

Originality/value:
Our study support the moderating role of D&O insurance, which constrains managers from manipulating earnings through accrual earnings management; they also highlight the risk-taking role of D&O insurance when firms make restatement announcements.

1. Introduction

The present study investigates the association between directors and officers (D&O) insurance and relative earnings management strategies; it also examines the moderating effects of restatement announcements on this association. Restatement announcements are regarded as an indicator of poor financial reporting quality, and such announcements have become a concern among stakeholders and regulators. D&O insurance provides board members with protection from claims of misconduct related to their decisions or actions. In addition, it promotes talent retention and enhances the ability of directors and officers to implement appropriate decisions that benefit shareholders. A study indicates that D&O insurance covers defense costs and potential damages, and that it can effectively reduce shareholder litigation costs (Baker and Griffith, 2010) and increase information risk (Chen et al., 2016). Nevertheless, when insurers have direct financial involvement in paying for claims, they are incentivized to assess firm status and to price financial reporting risk, particularly in situations in which firm directors and officers are involved in surface lawsuits (Boyer and Stern, 2012; Cao and Narayanamoorthy, 2014) or restatement announcements (Cao and Narayanamoorthy, 2014).

Accounting studies focus on the trade-offs among earnings management strategies or the choice of behaviors related to earnings management strategies (Cohen et al., 2008; Cohen and Zarowin, 2010; Badertscher, 2011; Zang, 2012; Braam et al., 2015; Zhu et al., 2015; Kothari et al., 2016). These studies indicate that real earnings management is more difficult to assess than accrual earnings management. The manipulation of real activities does not involve roles related to compliance with Generally Accepted Accounting Principles (GAAP; Kothari et al., 2016), resulting in less scrutiny from external stakeholders. Although research indicates that firms with D&O insurance coverage implement accrual earnings management to a high degree (Khan and Wald, 2015; Chen et al., 2016), the relevant

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studies neglect the role of negative events. Jarrell and Peltzman (1985) report that capital markets penalize firms when these firms make announcements involving negative information. Dechow et al. (2010) assert that manager/director layoffs, capital market penalties, and litigation lawsuits are the three major consequences faced by firms making restatement announcements. A study indicates that when they make restatement announcements, firms have negative abnormal returns (Palmrose et al., 2004), higher litigation risk (Palmrose and Scholz, 2004), and higher equity capital cost (Hribar and Jenkins, 2004). Cao and Narayanamoorthy (2014) stated that insurers charge higher insurance premiums when firms have lower earnings quality or make restatement announcements. The aforementioned studies provide evidence that restatement announcements attract the attention of stakeholders (e.g., D&O insurers) and are costly for firms.

Cao and Narayanamoorthy (2014) argue that insurers can price potential litigation risks when firms make negative event announcements *ex ante*, and they are charged higher D&O insurance risk premiums after making such announcements. Insurance risk premiums represent a type of agency cost. If a firm has a higher risk premium than its peer, the firm is driven to reduce its potential litigation risk. Thus, when firms do not make negative event announcements, we predict that D&O insurance plays a risk-taking role that induces managers to manipulate earnings through accrual earnings manipulation. By contrast, when firms make negative event announcements, we predict that D&O insurance plays a monitoring role that may constrain managers from manipulating earnings by switching from accrual earnings manipulation to real earnings manipulation. However, this switch results in insurers absorbing the risk related to real earnings management.

We collect data from the Market Observation Post System (MOPS) and the Taiwan Economic Journal (TEJ) database. The results reveal that purchasing D&O insurance is positively associated with accrual earnings management but negatively associated with real earnings management. We also obtain evidence that managers prefer not to implement accrual or real earnings management after their firms make restatement announcements. In addition, we reveal that firms that have purchased D&O insurance switch their earnings management strategy from accrual to real earnings management when they make restatement announcements. This finding is robust after controlling for earnings management selection bias, use of D&O insurance premium as a measure, and use of change in earnings management regression. Finally, the present study compares various real earnings manipulation strategies and reveals that, when firms have purchased D&O insurance, managers are more committed to increasing earnings through price discounts or generous credit terms after their firms make restatement announcements.

The present study makes several contributions to the D&O insurance and accounting literature. (1) It is the first study to examine the role of D&O insurance purchase on earnings management strategies and to demonstrate that D&O insurance plays a risk-taking role that induces managers to prefer the implementation of accrual earnings manipulation. This finding is similar to that of Chen et al. (2016). However, in contrast to their research, we discover that managers switch their earnings management strategies from accrual to real earnings management when their firms make restatement announcements; this finding supports the monitoring role of D&O insurance in accrual earnings management. Kothari et al. (2016) state that, relative to real earnings management, accrual earnings management requires compliance with rules and can be more easily scrutinized by external stakeholders. High scrutiny from external stakeholders results in managers switching their earnings management strategies from accrual to real earnings management.

(2) Based on D&O insurance and restatements research, we provide evidence that managers switch earnings management strategies when they are scrutinized by D&O insurers after their firms make restatement announcements. Our study differs from other earnings management studies that examine capital market incentives in relation to earnings management strategies.

(3) The present study also contributes to accounting research. We reveal that managers are willing to manipulate earnings through real earnings manipulation when firms are scrutinized by D&O insurers after these firms make restatement announcements. The rest of the paper is organized into four sections. Section 2 provides a literature review, Section 3 describes the research methodology and sample selection process, Section 4 provides a description of the research results and findings, and Section 5 provides the conclusion and implications of the present study.

2. Literature Review and Hypothesis Development

2.1 D&O Insurance and Earnings Management

Increasing D&O insurance research has been recently conducted. Two competing hypotheses exist in D&O insurance research, namely the monitoring and opportunism hypotheses. According to the monitoring hypothesis, insurers can scrutinize the insured and provide limited coverage (Holderness, 1990; O'Sullivan, 1997). Researchers report that D&O insurance involves the payment of claims arising from matters pertaining to directors and officers; therefore, insurers must develop appropriate technologies for converting the observable characteristics of policyholders into risk

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measurements, such that reasonable insurance coverage can be achieved (Boyer and Stern, 2012; 2014). Cao and Narayanamoorthy (2014) also contend that insurers are incentivized to price financial reporting risks to compensate for potential litigation related to financial reporting. Yuan et al. (2016) investigate the relationship between D&O insurance and stock-price-crash risk, and they indicate that purchasing D&O insurance can reduce stock-price-crash risk; notably, their analyses reveal that the effect of D&O insurance on crash risk is more pronounced in firms with a weaker corporate governance environment (e.g., low board independence, engagement of non-Big Four auditors [i.e., Deloitte, Ernst & Young, KPMG, and PwC], reduced institutional shareholdings, and reduced investor protection). Liao et al. (2022) examine the effect of D&O insurance on the pricing of seasoned equity offerings, and their results reveal that SEO firms with D&O insurance coverage or higher levels of insurance coverage experience less negative announcement-related effects, indicating the monitoring role of D&O insurance.

According to the opportunism hypothesis, D&O insurance partially covers the litigation risk related to directors and officers; consequently, directors and officers do not act in a manner that promotes stakeholders' interests. Studies argue that low levels of information transparency and risk-taking (among managers) are evidence of opportunism (Chung and Wynn, 2008; Wynn, 2008; Lin et al., 2011; Lin et al., 2013; Li and Liao, 2014; Khan and Wald, 2015; Chen et al., 2016). For example, Chen et al. (2016) report that D&O insurance reduces the disciplining effect of shareholder litigation, which increases the cost of equity. Similarly, Weng et al. (2017) demonstrate that firms are more likely to restate their financial reports when managers are covered by higher levels of D&O insurance.

The literature on extensive earnings management focuses on the trade-offs or management choice behaviors pertaining to accrual and real earnings management (Cohen et al., 2008; Cohen and Zarowin, 2010; Badertscher, 2011; Zang, 2012; Shen et al., 2015; Braam et al., 2015; Enomoto et al., 2015; Kothari et al., 2016). Cohen et al. (2008) are the first researchers to examine this change in earnings management strategy, and they discover that firms switched from accrual to real earnings management after the Sarbanes–Oxley Act was passed. Zang (2012) report alternate evidence regarding the earnings management choices of firms; she verifies that managers evaluate the trade-offs between real and accrual earnings management on the basis of their relative manipulation costs. Braam et al. (2015) also point out that a switch from accrual to real earnings management occurs because of not only relative manipulation costs but also political connections.

Therefore, D&O insurance can be regarded as a mechanism for mitigating the litigation risk of directors and officers, and this mechanism increases the tendency to overinvest and reduces financial reporting quality. Studies also state that managers tend to engage in accrual earnings manipulation, which reduces conservatism (Chung and Wynn, 2008; Chen et al., 2016). Therefore, we infer that firms with D&O insurance prefer to manipulate earnings through an accrual earnings management strategy and propose the following hypothesis:

H1: Managers prefer to manipulate earnings through accrual earnings management than through real earnings management when their firms have purchased D&O insurance.

2.2 Reporting Restatements and Earnings Management

Research demonstrates that after announcing financial reporting restatements, firms may encounter adverse consequences, including deceases in the stock price (Palmrose et al., 2004), increases in equity capital costs (Hribar and Jenkins, 2004), and increases in debt capital costs (Graham et al., 2008; Park and Wu, 2009). Furthermore, outside directors face labor market penalties (Srinivasan, 2005; Desai et al., 2006) and shareholder lawsuits (Palmrose and Scholz, 2004). Hribar and Jenkins (2004) reveal that restatement announcements increase the average cost of equity capital by 7% to 19%. Kravet and Shevlin (2010) assert that firms that announce restatements are exposed to higher discretionary information risk relative to firms that do not make restatement announcements.

Jarrell and Peltzman (1985) note that capital markets penalize firms with that make negative information announcements; thus, after their firm make restatement announcements, managers must quickly restore investor confidence (Wilson, 2008). Studies also indicate that firm managers become more conservative, become less inclined to issue earnings forecasts, and exhibit risk-adverse behavior after their firms make restatement announcements (Ettredge et al., 2012; Ettredge et al., 2013). Wiedman and Hendricks (2013) propose the compliance[1] and signaling views[2] to demonstrate the effect of restatement announcements on financial reporting quality. These aforementioned results reveal that firm managers can improve financial reporting quality and adopt the signaling view. Therefore, we infer that managers prefer to not manipulate earnings through accrual or real earnings management after their firms make restatement announcements.

H2: Managers prefer to not manipulate earnings through accrual or real earnings management when firms make restatement announcements.

[1] The compliance view posits that restatement announcements compel managers to correct errors to comply with regulatory requirements.
[2] The signaling view posits that that restatement announcements induce managers to improve financial reporting quality, which reduces information uncertainty.

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2.3 D&O Insurance and Earnings Management: Moderating Role of Restatement Announcements

Kothari et al. (2016) note that accrual earnings management involves managers exercising their discretion and judgment to misreport underlying operating performance under GAAP. By contrast, real earnings management involves managers acting with the intention of misleading stakeholders by manipulating earnings to deviate from normal business practices (Roychowdhury, 2006). For decision-making, managers have an information and processing capacity that is superior to those of external stakeholders; thus, external stakeholders are willing to delegate the responsibility of making investment and operating decisions to managers. Thus, real earnings management is more difficult to assess than accrual earnings management (Cohen et al., 2008; Zang, 2012; Braam et al., 2015).

When corporations announce financial reporting restatements, they receive considerable scrutiny from external stakeholders, and their managers immediately attempt to restore investor confidence (Wilson, 2008). On the basis of the aforementioned findings, we infer that when D&O insurance plays a monitoring role, restatement announcements induce D&O insurers to constrain managers from manipulating earnings through accrual earnings management. We also predict that restatement announcements induce managers to seek opportunities to manipulate earnings through real earnings management (Wiedman and Hendricks, 2013). Lin et al. (2019) also indicate that managers' opportunistic behavior and the monitoring role of D&O insurance are dependent on the negative event announcements of firms; notably, their study reveals that purchasing D&O insurance is positively associated with idiosyncratic risk, and that negative event announcements moderate the correlation between D&O insurance and idiosyncratic risk. Thus, D&O insurers absorb risk from the manipulation of real activities. On the basis of the aforementioned inference, we proposed the following hypothesis:

H3: Managers prefer to manipulate earnings through real earnings management than through accrual earnings management when their firms have purchased D&O insurance after making restatement announcements.

3. Research Design and Sample Selection

3.1 Data and Sample Selection

For sample collection, we first manually collect D&O insurance data from 2008 to 2014 from the MOPS. We then collect data from the TEJ database, a source of financial and corporate governance data, excluding the data of financial and insurance institutions; the test variables are constructed using the collected data. An earnings management variable is constructed that requires eight complete observations for each industry and for each year before data merging is performed. After the earnings management data are obtained, they are merged with the manually collected financial and corporate governance data. Table 1 presents the sample selection process. The final sample used in the analysis comprises 8,483 firm–year observations that cover the years from 2009 to 2014[3]. To mitigate the potential problems caused by extreme outliers, the financial variable data at the top and bottom 1% of the observations are winsorized.

Table 1 Sample Selection and Sample Character

Panel A: Sample Selection	
Initial data with earnings management, financial, corporate governance, and directors and officers	9,741
Exclude firm with missing corporate governance and financial data	(273)
Exclude firm with missing corporate governance and financial data at $t-1$	(985)
Use of sample in analysis	8,483

3.2 Model Specification

The present study mainly examines the effect of D&O insurance on the earnings management strategy and investigates the moderating role of restatement announcements. Studies report that the disclosure of D&O insurance is voluntary, and that purchase decisions are made on the basis of firm characteristics (Core, 1997; Chung and Wynn, 2008). To address the problem of endogeneity, we use the two-stage method in the present study (Chung and Wynn, 2008). In the first stage, a probit model is employed to examine D&O insurance purchase decisions. The dependent variable is the purchase decision of a firm. The independent variables are the determinants of the firm's decision to purchase D&O insurance, which include the board director's ownership, board size, the ratio of independent directors on the board, the blockholders' ownership, whether the firm has a net loss, financial leverage, firm size, firm performance, firm growth, and whether the firm is in a high-tech industry (Core, 1997; 2000; Chung and Wynn, 2008). The first stage regression is expressed through the following equation:

[3] The research period is 2008–2014, but the analysis period is set as 2009–2014 to obtain the testable variable at $t-1$.

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$$P(Purchase_{it} = 1) = \alpha_0 + \beta_1 BH_{it} + \beta_2 BSIZE_{it} + \beta_3 INDR_{it} + \beta_4 BLKH_{it} + \beta_5 LOSS_{it} + \beta_6 LEV_{it} + \beta_7 SIZE_{it} + \beta_8 ROA_{it} + \beta_9 MTB_{it} + \beta_{10} HTECH_{it} + \varepsilon_t \quad (1)$$

where BH_{it} is the ownership of the board director of firm i at the beginning of the fiscal year t; $BSIZE_{it}$ is the number of board directors that firm i has at the beginning of the fiscal year t; $INDR_{it}$ is the ratio of independent directors on the board of directors of firm i at the beginning of the fiscal year t; $BLKH_{it}$ is the ownership of the blockholders of firm i at the beginning of the fiscal year t; $LOSS_{it}$ is assigned a value of 1 if firm i reported a net loss in the previous year; LEV_{it} is the debt ratio of firm i at the beginning of the fiscal year t; $SIZE_{it}$ is the natural log of the market value of firm i at the beginning of the fiscal year t; ROA_{it} is the return on assets of firm i at the beginning of the fiscal year t; MTB_{it} is the market to book ratio of firm i at the beginning of the fiscal year t. *HITECH* is assigned a value of 1 if the firm is in the electronics industry.

In the second stage, probit regression is applied (including an inverse Mills ratio obtained from the first stage of estimation) to examine the effects of D&O insurance and restatement announcements on the earnings management strategy. The dependent variable in Model (2) is the relative earnings management strategy (REMS), which is dependent on the relative strength of accrual or real earnings management. Therefore, the present study uses two diametric combinations of high/low levels of accrual or real earnings management strategies (AEM_HRM_L and AEM_LRM_H; Braam et al., 2015)[4]. We use a dummy variable to proxy this preference measurement. The main independent variables are D&O insurance, restatement announcement, and the interaction term of restatement and D&O insurance purchase. We control for the factors that incentivize managers to adopt earnings management; these factors include financial leverage (Chen and Huang, 2013; Braam et al., 2015), firm size (Badertscher, 2011; Braam et al., 2015), whether a firm has a net loss (Ali and Zhang 2015), ownership of institutional holdings (Cornett et al., 2008; Huang et al., 2013), the ownership of the board director (Leuz et al., 2003; Haw, 2004), board size (Xie et al., 2003), the ratio of independent directors on the board (Peasnell et al., 2005; Cornett et al., 2008; Hazarika et al., 2012; Huang et al., 2013), and the presence of Big Four auditors (Huang et al., 2013; Zhu et al., 2015).

On the basis of H1, the present study predicts the direction of coefficient β_9 to be positive when the dependent variable is measured and determined to exhibit high levels of accrual-based earnings management but low levels of real earnings management in the empirical model. However, on the basis of H2, the present study does not predict the direction of coefficient β_{10}. Finally, on the basis of H3, we predict the direction of coefficient β_{11} to be positive when the dependent variable is measured and determined to exhibit high levels of real earnings management but low levels of accrual-based earnings management. The equation for measuring REMS is as follows:

$$P(REMS = 1) = \alpha_0 + \beta_1 LEV_{it} + \beta_2 SIZE_{it} + \beta_3 LOSS_{it} + \beta_4 INST_{it} + \beta_5 BH_{it} + \beta_6 BSIZE_{it} + \beta_7 INDR_{it} + \beta_8 BIG4_{it} + \beta_9 REST_{it} + \beta_{10} D\&O_{it} + \beta_{11} RD\&O_{it} + IMR + IND + YEAR + \varepsilon_{it} \quad (2)$$

where LEV_{it} is the debt ratio of firm i at the end of the fiscal year t; $SIZE_{it}$ is the natural log of the total assets of firm i at the end of the fiscal year t; $LOSS_{it}$ is assigned a value of 1 if firm i reported a net loss in the previous year; $INST_{it}$ is the institutional holdings of firm i at the end of the fiscal year t; BH_{it} is the ownership of the board director of firm i at the end of the fiscal year t; $BSIZE_{it}$ is the number of board directors that firm i has at the beginning of the fiscal year t; $INDR_{it}$ is the ratio of independent directors on the board of directors of firm i at the end of the fiscal year t; $BIG4_{it}$ is assigned a value of 1 if firm i is audited by a Big Four auditor for the fiscal year t; $D\&O_{it}$ is assigned a value of 1 if firm i purchased D&O insurance for the fiscal year t; $REST_{it-1}$ is assigned a value of 1 if firm i made a restatement announcement or multiple restatement announcements in the previous year. *RD&O* is the interaction term of restatement and D&O insurance purchase.

3.3 Earnings Management Measurement

3.3.1 Accrual Earnings Management

This study adopts the modified Jones model developed by Kothari et al. (2005) and includes additional control for return on assets to calculate discretionary accruals (the cross-section for each year and for each industry is estimated on the basis of at least eight firm–year observations). The residual from the modified Jones model is the proxy of accrual earnings management; the modified Jones model is expressed through the equation as follows:

$$TA_{it}/A_{it-1} = a_0 + \beta_1 \left(1/A_{it-1}\right) + \beta_2 (\Delta SALE_{it} - \Delta AR_{it})/A_{it-1} + \beta_3 PPE_{it}/A_{it-1} + \beta_4 ROA_{it-1} + \varepsilon_{it} \quad (3)$$

[4] For the construction of earnings management strategy preference, the accrual earnings management strategy preference (AEMP) is the dummy variable if accrual earnings management is greater than the industry–year median by a value of 1. A similar method is used for real earnings management preference (REMP). We use combinations of high/low levels of real and accrual earnings management strategies and divide them into two earnings management preference categories.

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where TA_{it} is the total accrual of firm i at the end of the fiscal year t (i.e., the difference between the earnings before extraordinary items and discontinued operations and operating cash flow); A_{it-1} is the total assets at the beginning of the fiscal year t; $\Delta SALE_{it}$ is the change in revenue from year $t-1$ to t; ΔAR_{it} is the change in accounting receivables from year $t-1$ to t; PPE_{it} is the gross value of the property, plant, and equipment of firm i at the end of the fiscal year t; ROA_{it-1} is the return on assets of firm i for the previous year; and the residuals ε_{it} are the proxy of accrual earnings management[5].

3.3.2 Real Earnings Management

In the present study, real earnings management is measured using the framework provided by other studies (Roychowdhury, 2006; Cohen et al., 2008; Cohen and Zarowin, 2010; Zang, 2012; Chang et al., 2015; Kothari et al., 2016). Roychowdhury (2006) indicates that managers avoid losses by establishing a preference for managing earnings through three types of real activity manipulation: (1) sales manipulation (RM_CFO)[6], (2) overproduction (RM_PROD)[7], and (3) reduction of discretionary expenditure (RM_DISX)[8]. In accordance with the model proposed by Roychowdhury (2006), we use three metrics to proxy sales manipulation (RM_CFO), overproduction (RM_PROD), and reduction of discretionary expenditure (RM_DISX). The relevant equations are as follows:

$$CFO_{it}/A_{it\text{-}1} = \alpha_0+\alpha_1(1/\mathrm{A}_{\mathrm{it\text{-}1}})+\beta_1\,(\mathrm{Sale}_{\mathrm{it}}/\mathrm{A}_{\mathrm{it\text{-}1}})+\beta_2\,(\Delta\mathrm{Sale}_{\mathrm{it}}/\mathrm{A}_{\mathrm{it\text{-}1}})+\varepsilon_t \quad (4)$$

$$PROD_{it}/A_{it\text{-}1} = \alpha_0+\alpha_1(1/\mathrm{A}_{\mathrm{it\text{-}1}})+\beta_1\,(\mathrm{Sale}_{\mathrm{it}}/\mathrm{A}_{\mathrm{it\text{-}1}})+\beta_2\,(\Delta\mathrm{Sale}_{\mathrm{it}}/\mathrm{A}_{\mathrm{it\text{-}1}})+\beta_3\,(\Delta\mathrm{Sale}_{\mathrm{it\text{-}1}}/\mathrm{A}_{\mathrm{it\text{-}1}})+\varepsilon_t \quad (5)$$

$$DISEXP_{it}/A_{it\text{-}1} = \alpha_0+\alpha_1(1/\mathrm{A}_{\mathrm{it\text{-}1}})+\beta_1\,(\Delta\mathrm{Sale}_{\mathrm{it\text{-}1}}/\mathrm{A}_{\mathrm{it\text{-}1}})+\varepsilon_t \quad (6)$$

where CFO_{it} is the operating cash flow of firm i at the end of the fiscal year t; $SALE_{it}$ is the sales revenue of firm i at the end of the fiscal year t; $\Delta\mathrm{SALE}_{\mathrm{it}}$ is the change in the revenue of firm i from the year $t-1$ to t at the end of the fiscal year t; A_{it-1} is the total assets at the beginning of the fiscal year t; $PROD$ is the production cost measure as the sum of COGS and the change in the inventory of firm i from the year $t-1$ to t at the end of the fiscal year t; $\Delta SALE_{it-1}$ is the change in revenue of firm i from the year $t-1$ to t at the end of the fiscal year $t-1$; $DISEXP_{it}$ is discretionary expense, which is defined as the sum of the advertising expenses, research and development expenses, and selling, general, and administrative expenses of firm i at the end of the fiscal year t. Sales manipulation (RM_CFO), overproduction (RM_PROD), and reduction of discretionary expenditure (RM_DISX) are computed as the residuals (ε_{it}) from Eq. (4), (5), and (6).

To determine the aggregate effects of real earnings management, we utilize the method developed by Cohen and Zarowin (2010), which combines three variables to acquire two comprehensive metrics of real earnings management. The first measure is RM1, which is defined as expense reduction pertaining to real activity manipulation[9]. The second measure is RM2, which is defined as operation cash flow generation pertaining to real activity manipulation[10]. We also adopt the model proposed by Braam et al. (2015), which aggregates these three measures of real earnings management into a comprehensive measurement (RM)[11].

4. Empirical Results

4.1 Descriptive Statistics and Correlations

Tables 2 and 3 present the descriptive statistics and Pearson correlation results. Table 2 provides a summary of the examined statistics; it reveals that the mean and median values of accrual earnings management are −0.008 and −0.010, respectively. The mean and median values of the comprehensive indicator of real earnings management are

[5] To establish a consistent measurement standard for real earnings management, we use a standardized variable of accrual earnings management when we construct the high/low levels of real and accrual earnings management strategies.

[6] Sales manipulation (RM_CFO) is defined as the efforts of a manager to increase sales volume temporarily through price discounts or generous credit terms that accelerate the timing of sales.

[7] Overproduction (RM_PROD) is defined the efforts of a manager to reduce their fixed cost per unit sold through the overproduction of inventory; provided the fixed cost per unit sold is not compensated by an increase in marginal cost per unit, such efforts lead to a reduction in the cost of goods sold.

[8] Reduction of discretionary expenditure (RM_DISX) results from reductions in discretionary expenditure (e.g., research and development expense and selling, general, and administrative expenses).

[9] RM1 is calculated by multiplying the standardized variable of abnormal discretionary expenses by −1 and adding the result to the standardized variable of abnormal production costs.

[10] RM2 is calculated by multiplying the standardized variable of abnormal cash flow from operations and the standardized variable of abnormal discretionary expenses by −1 and aggregating them into one measurement.

[11] RM is calculated by multiplying the standardized variable of abnormal cash flow from operations and the standardized variable of abnormal discretionary expenses by −1 and adding them to the standardized variable of abnormal production costs

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0.140 and 0.289, respectively. Furthermore, the mean value of the debt ratio is 35% (i.e., in our analysis sample, debt financing accounts for 35% of external financing, whereas the remaining 65% is obtained through equity financing). We also reveal that the mean values of institutional holdings and the board size are 0.355 and 6.8, respectively (i.e., institutions hold almost 36% of external stock on average, and the board of directors have an average of seven board directors). Finally, the mean values of BIG4, D&O purchases, and restatement announcements are 0.857, 0.563, and 0.019, indicating that approximately 85.7% of our sample are audited by Big Four auditors, approximately half of our sample have purchased D&O insurance, and 1.9% of our sample have made restatement announcements, respectively.

Table 2 Descriptive Statistics of Sample Firms

	Mean	S.D	P25	P50	P75
DA	-0.008	0.839	-0.451	-0.010	0.394
RM	0.140	1.776	-0.774	0.289	1.239
RM1	0.080	0.844	-0.212	0.201	0.589
RM2	0.103	1.151	-0.492	0.204	0.804
LEV	0.356	0.172	0.222	0.341	0.466
SIZE	15.146	1.338	14.231	14.963	15.896
LOSS	0.238	0.426	0.000	0.000	0.000
INST	0.355	0.221	0.175	0.318	0.513
BH	0.201	0.133	0.106	0.161	0.257
BSIZE	6.845	2.042	5.000	7.000	7.000
INDR	0.178	0.174	0.000	0.222	0.333
BIG4	0.857	0.350	1.000	1.000	1.000
REST	0.019	0.135	0.000	0.000	0.000
D&O	0.563	0.496	0.000	1.000	1.000
Obs.	8483				

Note: Variable definition: DA, accrual earnings management; RM, real earnings management (computed by multiplying standardized variable of abnormal cash flow from operations and standardized variable of abnormal discretionary expenses by −1 and adding them to standardized variable of abnormal production costs); RM1, real earnings management (computed by multiplying standardized variable of abnormal discretionary expenses by −1 and adding it to standardized variable of abnormal production costs; RM2, real earnings management (calculating by multiplying standardized variable of abnormal cash flow from operations and standardized variable of abnormal discretionary expenses by −1 and aggregating them into one measurement; LEV_{it}, debt ratio of firm i at end of fiscal year t; $SIZE_{it}$, natural log of total assets of firm i at end of fiscal year t; $LOSS_{it}$ is assigned a value of 1 if firm i had a net loss in previous year; $INST_{it}$, institutional holdings of firm i at end of fiscal year t; BH_{it}, ownership of board director of firm i at end of fiscal year t; $BSIZE_{it}$, number of board directors that firm i has at beginning of fiscal year t; $INDR_{it}$, ratio of independent directors on board of directors of firm i at end of fiscal year t; $BIG4_{it}$ is assigned a value of 1 if firm i is audited by Big Four auditor for fiscal year t; $D\&O_{it}$ is assigned a value of 1 if firm i has purchased D&O insurance for fiscal year t; $REST_{it-1}$ is assigned a value of 1 if firm i made a restatement announcement or multiple restatement announcements in previous year.

Table 3 presents the Pearson correlation results, which reveal that the original value of earnings management (both accrual and real) is negatively and significantly associated with D&O insurance purchases. This finding suggests that firms implement downward earnings management when they have purchased D&O insurance. We also find that the ratio of independent directors on a board is negatively and significantly associated with accrual and real earnings management, suggesting that firms with higher proportions of independent directors on their board of directors can constrain the implementation of upward earnings management by managers. Finally, the results also reveal that the restatement announcement proxy is positively and significantly associated with real earnings management. Therefore, managers prefer to implement upward earnings management through real earnings management.

Table 3 Pearson Correlation

	DA	RM	RM1	RM2	LEV	SIZE	LOSS	INST	BH	BSIZE	INDR	BIG4	REST	D&O
LEV	0.022*	0.234***	0.105***	0.203***	1.000									
	(0.043)	(0.000)	(0.000)	(0.000)										
SIZE	0.025*	0.126***	0.302***	0.104***	0.183***	1.000								

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	(0.020)	(0.000)	(0.000)	(0.000)	(0.000)								
LOSS	-0.207***	0.206***	0.001	0.190***	0.134***	-0.224***	1.000						
	(0.000)	(0.000)	(0.938)	(0.000)	(0.000)	(0.000)							
INST	0.015	-0.028**	0.079***	-0.042***	0.057***	0.444***	-0.173***	1.000					
	(0.159)	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
BH	0.022*	-0.013	-0.026*	-0.016	0.013	-0.130***	-0.034**	0.392***	1.000				
	(0.039)	(0.218)	(0.015)	(0.146)	(0.215)	(0.000)	(0.002)	(0.000)					
BSIZE	-0.025*	-0.007	0.042***	-0.021*	-0.023*	0.326***	-0.076***	0.213***	0.114***	1.000			
	(0.021)	(0.517)	(0.000)	(0.050)	(0.033)	(0.000)	(0.000)	(0.000)	(0.000)				
INDR	-0.028*	-0.075***	-0.079***	-0.081***	-0.079***	-0.134***	0.022*	-0.039***	-0.001	-0.006	1.000		
	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.043)	(0.000)	(0.915)	(0.589)			
BIG4	-0.019	-0.053***	0.006	-0.055***	-0.061***	0.152***	-0.072***	0.135***	0.019	0.081***	0.092***	1.000	
	(0.074)	(0.000)	(0.584)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.074)	(0.000)	(0.000)		
REST	0.004	0.041***	0.031**	0.042***	0.040***	0.026*	0.024*	0.004	-0.017	-0.001	-0.039***	-0.029**	1.000
	(0.727)	(0.000)	(0.004)	(0.000)	(0.000)	(0.017)	(0.028)	(0.708)	(0.113)	(0.917)	(0.000)	(0.008)	
D&O	-0.022*	-0.034**	-0.056***	-0.046***	-0.047***	0.110***	0.005	0.059***	-0.048***	0.075***	0.329***	0.167***	-0.020	1.000
	(0.047)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.664)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.063)	

a. Variable definitions are provided in Table 2.

b. *p*-values in parentheses. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

4.2 Regression Results

In this subsection, regression analysis is conducted to examine the effect of D&O insurance combined with restatement announcements on earnings management strategies. We use Heckman's (1979) two-stage regression to mitigate the problem of endogeneity. The results are presented in Table 4[12], which reveal that the ratio of independent directors on a board (INDR), firm size (SIZE), and being a firm in the high-tech industry (HITECH) are positively and significantly associated with D&O insurance purchases. By contrast, blockholders' ownership (BLKH), firm performance (ROA), and firm growth (MTB) are negatively associated with D&O insurance purchases. Our results are consistent with those of Chung and Wynn (2008), who demonstrate that larger firms and those in the high-tech industry tend to purchase D&O insurance, whereas growth firms are not willing to do so.

12 For the marginal effect of Table 4 please refer to Table A1 in the Appendix.

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Table 4 Probit Analysis of Determinants of Directors and Officers Insurance Purchase

	Coef.	P-Value
BH	-0.244	0.355
BSIZE	0.020	0.257
INDR	2.241***	0.000
BLKH	-0.898***	0.001
LOSS	0.077	0.263
LEV	-0.306	0.120
SIZE	0.199***	0.000
ROA	-0.631*	0.073
MTB	-0.188***	0.000
HITECH	0.574***	0.000
Constant	-3.149***	0.000
Obs.	8483	
Chi^2	288.821	
Pse. R^2	0.146	

a. Variable definition: BH_{it}, ownership of board director of firm i at beginning of fiscal year t; $BSIZE_{it}$, number of board directors that firm i has at beginning of fiscal year t; $INDR_{it}$, ratio of independent directors on board of directors of firm i at beginning of fiscal year t; $BLKH_{it}$, ownership of blockholders of firm i at beginning of fiscal year t; $LOSS_{it}$ is assigned a value of 1 if firm i had a net loss in previous year; LEV_{it}, debt ratio of firm i at beginning of fiscal year t; $SIZE_{it}$, natural log of market value of firm i at beginning of fiscal year t; ROA_{it}, return on assets of firm i at beginning of fiscal year t; MTB_{it}, market to book ratio of firm i at beginning of fiscal year t; HITECH is assigned a value of 1 if firm is in electronic industry.
b. p-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5 presents the regression results obtained through Eq. (2)[13]. Panel A of Table 5 presents the results of the effect of D&O insurance purchases on earnings management strategies. The results of Model A presented in Panel A reveal significant and positive coefficients for firms that have purchased D&O insurance. The marginal effect of D&O insurance purchases on accrual earnings management strategy is 0.023. Moreover, the results of Models B–D in Panel A indicate that relative to firms that have not purchased D&O insurance, those that have purchased D&O insurance are significantly less likely to use a combination of high-level real earnings management and low-level accrual earnings management strategies. The marginal effects of D&O insurance purchases on real earnings management strategy are −0.020, −0.041, and −0.022. This finding suggests that firms that have purchased D&O insurance prefer to implement an accrual earnings management strategy over a real earnings management strategy. This evidence supports H1.

Table 5 Probit Analysis of Directors and Officers (D&O) Insurance and Relative Earnings Management Strategies

Panel A. Effect of D&O insurance on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-0.798***	0.000	0.483***	0.000	-0.127	0.347	0.377***	0.005
SIZE	-0.171***	0.000	0.211***	0.000	0.292***	0.000	0.202***	0.000
LOSS	-0.927***	0.000	1.104***	0.000	0.655***	0.000	1.105***	0.000
INST	0.255*	0.056	-0.476***	0.000	-0.289**	0.032	-0.461***	0.000
BH	-0.003	0.989	0.425**	0.021	0.412**	0.034	0.400**	0.035
BSIZE	-0.004	0.778	0.005	0.664	-0.005	0.644	0.002	0.841
INDR	-0.311	0.224	0.217	0.351	0.465*	0.051	0.413*	0.075
BIG4	-0.044	0.530	-0.055	0.417	-0.037	0.578	-0.052	0.453
D&O	**0.097***	**0.059**	**-0.090***	**0.066**	**-0.145*****	**0.004**	**-0.102****	**0.040**
IMR	-0.346*	0.054	0.305*	0.076	0.391**	0.023	0.466***	0.007
Cons	2.486***	0.000	-4.712***	0.000	-5.538***	0.000	-4.655***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	8483		8483		8483		8483	
Chi^2	385.876		750.856		343.213		708.716	
Pse. R^2	0.073		0.132		0.061		0.131	
Panel B. Effect of restatement announcements on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	

13 For the marginal effect of Table 5 please refer to Table A2 in the Appendix.

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	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-0.798***	0.000	0.479***	0.000	-0.133	0.326	0.370***	0.006
SIZE	-0.171***	0.000	0.210***	0.000	0.290***	0.000	0.201***	0.000
LOSS	-0.926***	0.000	1.102***	0.000	0.652***	0.000	1.101***	0.000
INST	0.272**	0.042	-0.489***	0.000	-0.307**	0.024	-0.478***	0.000
BH	-0.020	0.919	0.438**	0.018	0.433**	0.028	0.417**	0.029
BSIZE	-0.003	0.813	0.004	0.680	-0.006	0.606	0.002	0.856
INDR	-0.295	0.249	0.191	0.412	0.429*	0.071	0.387*	0.095
BIG4	-0.029	0.673	-0.065	0.334	-0.054	0.410	-0.061	0.371
REST	0.120	0.673	-0.032	0.787	-0.061	0.597	0.070	0.533
IMR	-0.387**	0.030	0.336**	0.049	0.445***	0.009	0.504***	0.003
Cons	2.552***	0.030	-4.738***	0.000	-5.594***	0.000	-4.694***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	8483		8483		8483		8483	
Chi^2	388.813		746.366		335.267		706.118	
Pse. R^2	0.072		0.131		0.059		0.130	

Panel C. Effects of D&O insurance combined with restatements on earnings management strategy

	A(AEM_HRM_L)		B(AEM_LRM_H)		C(AEM_LRM1_H)		D(AEM_LRM2_H)	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-0.802***	0.000	0.491***	0.000	-0.123	0.365	0.382***	0.004
SIZE	-0.171***	0.000	0.211***	0.000	0.292***	0.000	0.202***	0.000
LOSS	-0.929***	0.000	1.105***	0.000	0.656***	0.000	1.104***	0.000
INST	0.254*	0.057	-0.473***	0.000	-0.287**	0.033	-0.460***	0.000
BH	-0.002	0.994	0.419**	0.023	0.410**	0.035	0.396**	0.037
BSIZE	-0.004	0.782	0.005	0.643	-0.005	0.655	0.003	0.824
INDR	-0.313	0.221	0.229	0.326	0.474**	0.047	0.427*	0.065
BIG4	-0.043	0.536	-0.051	0.445	-0.035	0.595	-0.047	0.492
REST	0.235	0.201	**-0.389****	**0.029**	-0.295	0.110	-0.243	0.179
D&O	0.102*	0.050	**-0.102****	**0.036**	**-0.153*****	**0.002**	**-0.114****	**0.022**
RD&O	-0.237	0.367	**0.662*****	**0.004**	**0.452****	**0.050**	**0.594*****	**0.009**
IMR	-0.349*	0.051	0.313*	0.068	0.397**	0.021	0.475***	0.006
Cons	2.492***	0.000	-4.721***	0.000	-5.546***	0.000	-4.666***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	8483		8483		8483		8483	
Chi^2	390.311		752.279		347.886		710.292	
Pse. R^2	0.073		0.133		0.061		0.132	

a. Variable definitions are provided in Table 2.

b. *p*-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Panel B of Table 5 presents the effects of restatement announcements on earnings management strategies. The results indicates that restatement announcements can have positive or negative effects on earnings management strategies; however, these effects are nonsignificant. The marginal effect of restatement announcements (REST) on accrual earnings management strategy is 0.029. Similarly, the marginal effects of restatement announcements (REST) on real earnings management strategy are −0.007, −0.017, and 0.015. This result is consistent with our inference that managers prefer not to manipulate earnings through accrual or real earnings management when their firms make restatement announcements (Ettredge et al., 2012; Ettredge et al., 2013). Therefore, H2 is supported.

Panel C of Table 5 presents the regression results obtained by using the interaction term to determine the effects of restatement announcements combined with D&O insurance on earnings management strategies. The results of Model A presented in Panel C reveal significant and positive coefficients and margins[14] for the firms that have purchased D&O insurance (D&O). However, these significant and positive coefficients and margins[15] become nonsignificant and negative after adjustment for restatement announcements. Further, the results of Models B–D indicate that firms that have purchased D&O insurance are less likely to implement real earnings management strategies[16]; however, these results are reversed after adjustment for restatement announcements[17].

[14] The marginal effect of purchasing D&O insurance is 0.024.

[15] The marginal effect of the interaction terms is −0.057.

[16] The marginal effects of purchasing D&O insurance are −0.023, −0.044, and −0.024.

[17] The marginal effects of the interaction term are 0.147, 0.129, and 0.127.

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The aforementioned result reveal that after restatement announcements are made, D&O insurers play a monitoring role to constrain managers from manipulating earnings through accrual earnings management. Furthermore, because of the risk-taking role of D&O insurance, restatement announcements also induce managers to adopt real activity manipulation as their earnings management strategy. This result supports H3.

4.3 Additional Tests

4.3.1 D&O coverage measure

Researchers assert that a dummy variable is a coarse measure (Lin et al., 2011; Lin et al., 2013); therefore, we use D&O insurance coverage to measure the level of D&O insurance, which is then used as a variable for verifying our inference. D&O insurance coverage is defined as the natural logarithm of the D&O insurance coverage of a firm in a fiscal year[18]. Table 6 presents the analysis results[19]; Panel A presents the D&O insurance premium and the corresponding earnings management strategy; the marginal effect of the D&O insurance premium on accrual earnings management strategy is 0.002 and significant. However, we also discover that the marginal effect on real earnings management strategy is negative and significant. The marginal effects of the D&O insurance premium on real earnings management strategy are −0.002, −0.003, and −0.002. Panel B presents the results of the effects of the D&O insurance premium combined with restatement announcements on earnings management strategy; the results reveal that the marginal effects of the D&O insurance premium and the interaction term on accrual earnings management strategy are 0.002 and −0.005. Furthermore, we discover an association between D&O insurance coverage and REMS; this finding is similar to that presented in Table 5. The marginal effects of the D&O insurance premium on real earnings management strategy are −0.002, −0.003, and −0.002. However, based on the marginal effects, the interaction term of the D&O insurance premium and restatement announcements is positively and significantly associated with the real earnings management strategy[20].

Table 6 Probit Analysis of Directors and Officers (D&O) Insurance Premium and Relative Earnings Management Strategies

Panel A. Effect of D&O insurance premium on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-0.797***	0.000	0.482***	0.000	-0.129	0.341	0.376***	0.005
SIZE	-0.173***	0.000	0.213***	0.000	0.295***	0.000	0.204***	0.000
LOSS	-0.928***	0.000	1.104***	0.000	0.656***	0.000	1.105***	0.000
INST	0.256*	0.055	-0.477***	0.000	-0.290**	0.032	-0.462***	0.000
BH	-0.004	0.982	0.427**	0.021	0.417**	0.033	0.402**	0.034
BSIZE	-0.004	0.773	0.005	0.663	-0.005	0.646	0.002	0.839
INDR	-0.31	0.224	0.215	0.357	0.463*	0.052	0.411*	0.076
BIG4	-0.044	0.531	-0.055	0.413	-0.038	0.571	-0.052	0.450
D&OA	**0.008***	**0.070**	**-0.007***	**0.093**	**-0.011*****	**0.007**	**-0.008***	**0.055**
IMR	-0.350*	0.051	0.309*	0.072	0.398**	0.021	0.470***	0.007
Cons	2.523***	0.000	-4.743***	0.000	-5.592***	0.000	-4.691***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	8483		8483		8483		8483	
Chi^2	386.846		750.523		341.311		709.642	
Pse. R^2	0.073		0.132		0.060		0.131	
Panel B. Effect of D&O insurance premium on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-0.802***	0.000	0.490***	0.000	-0.124	0.360	0.381***	0.005
SIZE	-0.173***	0.000	0.213***	0.000	0.295***	0.000	0.204***	0.000
LOSS	-0.930***	0.000	1.105***	0.000	0.657***	0.000	1.105***	0.000
INST	0.254*	0.057	-0.474***	0.000	-0.289**	0.033	-0.461***	0.000
BH	-0.003	0.987	0.422**	0.022	0.414**	0.034	0.399**	0.036
BSIZE	-0.004	0.776	0.005	0.639	-0.005	0.658	0.003	0.820
INDR	-0.313	0.220	0.227	0.330	0.471**	0.048	0.426*	0.066
BIG4	-0.043	0.536	-0.052	0.441	-0.036	0.588	-0.048	0.489

[18] For firms without D&O insurance, we set this variable to zero.

[19] For the marginal effect of Table 6 please refer to Table A3 in the Appendix.

[20] The margin effects of the interaction term of D&O insurance amount and restatement announcement are 0.012, 0.010, and 0.010.

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REST	0.244	0.181	**-0.385****	**0.030**	-0.283	0.123	-0.233	0.193
D&OA	**0.008***	**0.058**	**-0.008***	**0.053**	**-0.012*****	**0.005**	**-0.009****	**0.032**
RD&OA	-0.021	0.324	**0.054*****	**0.004**	**0.036***	**0.061**	**0.048****	**0.010**
IMR	-0.353**	0.049	0.317*	0.065	0.403**	0.019	0.479***	0.006
Cons	2.531***	0.000	-4.754***	0.000	-5.601***	0.000	-4.704***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	8483		8483		8483		8483	
Chi^2	391.525		751.917		345.5		711.253	
Pse. R^2	0.073		0.133		0.061		0.132	

a. Variable definitions are provided in Table 2.

b. *p*-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

4.3.2 Self-selection problem in earnings management

Self-selection is a major problem that affects firms' decisions regarding earnings management (Cohen and Zarowin, 2010; Zang, 2012). Therefore, the present study uses a selection model to control the self-selection problem. In the first stage, a firm's decision to engage in earnings management is modeled as a function of capital market incentives (Cohen and Zarowin, 2010); the relevant factors include the degree of analyst coverage (ANALYST; Cohen and Zarowin, 2010), the frequency with which the earnings forecasts of analysts are met or exceeded (HAB_BEAT; Kasznik and McNichols, 2002; Koh et al., 2008), and the number of outstanding shares (SHARES; Zang, 2012). We control for several factors that affect the earnings management strategy; these factors include firm size (SIZE), performance (ROA), leverage (LEV), and growth opportunities (MTB; Healy and Wahlen, 1999; Cohen and Zarowin, 2010).

Table 7 Probit Analysis of Earnings Management Selection Bias

Panel A. First stage of Heckman's two-stage regression

	Coef.	P-Value
Analyst	-0.016**	0.043
Hab_Beatr	-0.118*	0.055
Share	0.157***	0.003
SIZE	0.073	0.117
ROA	0.269	0.290
LEV	0.946***	0.000
MTB	0.618***	0.000
Constant	-2.888***	0.000
Year	included	
Ind	included	
Obs.	8434	
Chi^2	277.851	
Pse. R^2	0.061	

Panel B. Second stage of Heckman's two-stage regression

	A(AEM_HRM_L)		B(AEM_LRM_H)		C(AEM_LRM1_H)		D(AEM_LRM2_H)	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-0.311**	0.034	0.1	0.477	-0.516***	0.000	-0.046	0.742
SIZE	0.02	0.610	-0.001	0.979	0.101***	0.001	-0.003	0.919
LOSS	-0.797***	0.000	0.985***	0.000	0.519***	0.000	0.969***	0.000
INST	-0.082	0.551	-0.046	0.742	0.11	0.424	-0.103	0.461
BH	0.149	0.445	0.233	0.217	0.215	0.276	0.278	0.154
BSIZE	-0.002	0.856	0.001	0.926	-0.009	0.459	-0.003	0.803
INDR	-0.305	0.218	0.046	0.840	0.379	0.101	0.297	0.193
BIG4	-0.061	0.383	-0.049	0.472	-0.031	0.634	-0.044	0.509
REST	0.215	0.242	**-0.412****	**0.031**	**-0.312***	**0.094**	-0.263	0.150
D&O	**0.108****	**0.036**	**-0.116****	**0.017**	**-0.154*****	**0.002**	**-0.121****	**0.014**
RD&O	-0.185	0.488	**0.612****	**0.010**	**0.450***	**0.054**	**0.584****	**0.011**
DOIMR	-0.124	0.474	-0.02	0.904	0.092	0.584	0.142	0.404
EMIMR	1.965***	0.000	-2.122***	0.000	-1.885***	0.000	-2.177***	0.000
Constant	-1.621**	0.042	-0.186	0.786	-1.436**	0.030	-0.207	0.767
Year	included		included		included		included	
Ind	included		included		included		included	

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Obs.	8434	8434	8434	8434
Chi^2	456.755	859.864	420.307	807.362
Pse. R^2	0.094	0.155	0.077	0.152

a. Variable definitions are provided in Table 2. Additional variable definitions: Analyst, degree of analyst coverage; Hab_Beat, frequency with which earnings forecasts of analysts are met or exceeded; Share, natural logarithm of number of shares outstanding; Size, firm size; ROA, return on assets; LEV, firm leverage; MTB, market to book ratio.

b. *p*-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Panel A of Table 7 presents the results of the selection model[21]. Other than firm size and performance, the coefficient estimates for all the other factors are significant. Cohen and Zarowin (2010) assert that the coverage of financial analysts (ANALYST) involves scrutinizing and monitoring the activities of firms; thus, their managers are less incentivized to implement earnings management; this finding is consistent with our inference. However, the frequency with which the earnings forecasts of analysts are met or exceeded (HAB_BEAT) is negatively and significantly associated with firms' decisions to engage in earnings management. Koh et al. (2008) argue that after the occurrence of a scandal, meeting or exceeding analyst expectations is more positively correlated with future cash flow. Finally, we discover that the number of outstanding shares (SHARE) is positively and significantly associated with firms' decisions to engage in earnings management. Zang (2012) indicates that a higher number of outstanding shares provides managers with more incentives to actively engage in earnings management to achieve per-earnings targets, and our results correspond with Zang's inference.

Panel B of Table 7 presents the results of the effects of D&O insurance purchases and restatement announcements on REMS after controlling for the selection bias pertaining to D&O insurance purchases and earnings management strategies. The interaction term has a positive and significant coefficient and margin value[22] when real earnings management is implemented as the earnings management strategy. This finding suggests that managers prefer to apply the real activity manipulation method to manipulate earnings when their firms make restatement announcements, which supports H3.

4.3.3 Three types of real earnings management preferences

The present study further investigates the types of real earnings management strategies that managers are more likely to adopt when their firms have purchased D&O insurance after making restatement announcements. We use three diametric combinations of high/low levels of real earnings management strategies to detect one of three types of real earnings management preferences. This method is based on the low-level accrual earnings management strategy (REM_{1H}, REM_{2H}, and REM_{3H})[23]. Table 8 presents the results of the effect of D&O insurance purchases on the selection of earnings management strategies after firms have made restatement announcements[24]. We discover that the interaction term is positive and significant in the sales manipulation model (Model A) and reduction-of-discretionary-expenditure-manipulation model (Model C) but insignificant in the overproduction model (Models B)[25]. This finding suggests that in firms with D&O insurance, top managers prefer to manipulate earnings through the following real earnings management strategies after their firm have made earnings restatements: (1) implementation of price discounts or generous credit terms that accelerate the timing of sales and (2) reduction of discretionary expenditure.

Few studies explore the aforementioned three types of real earnings management manipulation, particularly those that examine D&O insurance. Although Chen et al. (2016) use accrual earnings management to investigate the relationship between D&O insurance purchases and reporting quality, they neglect the effect of real earnings management. By contrast, our study is the first to demonstrate that managers are more committed to increasing earnings through price discounts or generous credit terms and the reduction of discretionary expenditure when their firms have purchased D&O insurance and made restatement announcements.

[21] For the marginal effect of Table 7 please refer to Table A4 in the Appendix.

[22] The margin values for interaction terms are 0.135, 0.118 and 0.164.

[23] REM_{1H} is defined as having lower discretionary accruals, and the sales manipulation (RM_CFO) is high, but overproduction (RM_PROD) and the reduction of discretionary expenditures (RM_DISX) are low. REM_{2H} is defined as having lower discretionary accrual, high overproduction (RM_PROD), and low sales manipulation (RM_CFO) and reduction of discretionary expenditures (RM_DISX). REM_{3H} is defined as having lower discretionary accrual, high reduction of discretionary expenditures (RM_DISX), but low overproduction (RM_PROD) and sales manipulation (RM_CFO).

[24] For the marginal effect of Table 8 please refer to Table A5 in the Appendix.

[25] The margin values for interaction terms are 0.158, 0.093, and 0.120.

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Table 8 Probit Analysis of Directors and Officers Insurance (D&O) and Relative Real Earnings Management Strategy

	$REM1_H$	$REM2_H$	$REM3_H$
LEV	0.484***	0.653***	-0.256*
	(0.000)	(0.000)	(0.061)
SIZE	-0.077***	0.195***	0.283***
	(0.005)	(0.000)	(0.000)
LOSS	1.350***	0.961***	0.594***
	(0.000)	(0.000)	(0.000)
INST	-0.220*	-0.290**	-0.201
	(0.088)	(0.017)	(0.129)
BH	-0.305	0.376**	0.334*
	(0.137)	(0.039)	(0.082)
BSIZE	0.015	0.008	-0.007
	(0.245)	(0.489)	(0.542)
INDR	-0.256	0.303	0.437*
	(0.312)	(0.179)	(0.057)
BIG4	0.039	-0.108*	-0.039
	(0.551)	(0.084)	(0.552)
REST	-0.665***	-0.239	-0.239
	(0.001)	(0.170)	(0.169)
D&O	0.002	-0.048	-0.151***
	(0.962)	(0.292)	(0.003)
RD&O	0.892***	0.364	0.408*
	(0.001)	(0.116)	(0.064)
DOIMR	-0.164	0.379**	0.323*
	(0.374)	(0.020)	(0.055)
Constant	-0.192	-4.575***	-5.271***
	(0.748)	(0.000)	(0.000)
Year	included	included	included
Ind	included	included	included
Obs.	8483	8483	8483
Chi^2	0.213	0.105	0.054
Pse. R^2	1247.519	694.579	305.026

a. Variable definitions are provided in Table 2.
b. *p*-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

4.3.4 Effects of D&O insurance and restatement announcements on changes in earnings management

Based on the aforementioned results, we can verify how D&O insurance purchases and restatement announcements affect the preferences of managers for specific earnings management strategies. However, an unaddressed question is how D&O insurance purchases and restatement announcements affect the adoption of earnings management. Therefore, we perform multiple regressions to examine the effect of purchasing D&O insurance and making restatement announcements on the adoption of earnings management. The dependent variable in Model (7) is the change in earnings management (ΔEM); using this variable for period t+1 enables the examination of the effects of either restatements or D&O insurance on increments pertaining to earnings management. The independent variable in Model (7) is a dummy variable, which serves to acquire the effects of both D&O insurance purchases and restatement announcements. The regressions are performed using the following equation:

$$\Delta EM_{it+1} = \alpha_0 + \beta_1 REST_{it} + \beta_2 D\&O_{it} + \beta_3 RD\&O_{it} + \beta_4 CFO_{it} + \beta_5 SIZE_{it} + \beta_6 LEV_{it} + \beta_7 INST_{it} + \beta_8 INDR_{it} + \beta_9 BH_{it} + \beta_{10} BIG4_{it} + IMR + Ind + Year + \varepsilon_{it} \quad (7)$$

where ΔEM is the change of earnings management of firm i at the end of fiscal year t+1; $REST_{it}$ is assigned a value of 1 if firm i made a restatement announcement or multiple restatement announcements in the fiscal year t; $D\&O_{it+1}$ is assigned a value of 1 if firm i has purchased D&O insurance for the fiscal year t+1; $RD\&O_{it}$ is the interaction term of restatement and D&O insurance; CFO_{it} is the operating cash flow scaled by the average total assets of firm i at the end of fiscal year t; $SIZE_{it}$ is the natural log of the total assets of firm i at the end of fiscal year t; LEV_{it} is the debt ratio of firm i at the end of fiscal year t; $INST_{it}$ is the institutional holdings of firm i at the end of fiscal year t; $INDR_{it}$ is the ratio of independent directors on the board of directors of firm i at the end of fiscal year t; BH_{it} is the

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ownership of the board director of firm i at the end of fiscal year t; $BIG4_{it}$ is assigned a value of 1 if firm i was audited by a Big Four auditor for the fiscal year t; and *IMR* is the inverse Mills ratio extracted from Eq. (1). The results are presented in Table 9.

Table 9 Effects of Restatements and Directors and Officers (D&O) Insurance on Earnings Management

	ΔDA	ΔRM
D&O	**0.042***	**0.092*****
	(0.092)	**(0.006)**
REST	**0.457*****	**0.353***
	(0.002)	**(0.075)**
REST_DO	**-0.475****	-0.019
	(0.023)	(0.937)
CFO	5.502***	7.181***
	(0.000)	(0.000)
SIZE	-0.163***	-0.092***
	(0.000)	(0.000)
LEV	0.844***	0.130
	(0.000)	(0.231)
INST	-0.062	-0.044
	(0.388)	(0.628)
INDR	-0.370***	-0.275***
	(0.000)	(0.003)
BH	-0.264**	-0.127
	(0.013)	(0.355)
BIG4	-0.082***	-0.114***
	(0.009)	(0.005)
Mills	-0.601***	0.229
	(0.000)	(0.167)
Cons	2.350***	0.722*
	(0.000)	(0.096)
Year	included	included
Ind	included	included
Observations	7351	7351
F	50.654	35.597
R^2	0.211	0.224
Adjusted R^2	0.207	0.220

a. Variable definition: $D\&O_{it+1}$ is assigned a value of 1 if firm i has purchased D&O insurance for fiscal year t+1; $REST_{it}$ is assigned a value of 1 if firm i has made a restatement announcement or multiple restatement announcements in fiscal year t; $REST\_DO_{it}$, interaction term of restatement and D&O insurance; CFO_{it}, operating cash flow scaled by average total assets of firm i at end of fiscal year t; $SIZE_{it}$, natural log of total assets of firm i at end of fiscal year t; LEV_{it}, debt ratio of firm i at end of fiscal year t; $INST_{it}$, institutional holdings of firm i at end of fiscal year t; $INDR_{it}$, ratio of independent directors on board of directors of firm i at end of fiscal year t; BH_{it}, ownership of board director of firm i at end of fiscal year t; $BIG4_{it}$ is assigned a value of 1 if firm i was audited by Big Four auditor at end of fiscal year t; IMR, inverse Mills ratio extracted from Eq. (1)
b. p-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 9 presents the results of the effects of D&O insurance in changing the earnings management strategies of firms after adjustment for restatement announcements. They reveal that D&O insurance is positively and significantly associated with earnings management for both accrual and real economic activities. After adjusting for restatement announcements, we discover that the interaction term is negatively and significantly associated with accrual earnings management. This result suggests that insurers are more focused on restatement announcements and constrains managers from implementing accrual earnings management. However, we also discover that insurers cannot constrain managers from engaging in real activity manipulation. This result may be due to the lack of regulations for real earnings; that is, managers are not required to comply with regulations related to real earnings; thus, real earnings management is difficult to detect (Kothari et al., 2016). The result supports our inference.

4.3.5 Extension of Research Period

As shown in Table 10, we extend the study period of our research sample from 2014 to 2018. In 2018, the Taiwanese government amended the Company Act and imposed the mandatory requirement that listed firms in Taiwan's capital market must purchase D&O insurance. Thus, to mitigate the effect of this mandatory purchase requirement, we exclude data from the years 2019 and 2020. Table 10 presents the results of the effects of D&O insurance and

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restatement announcements on the earnings management strategy[26]. Similar to our main results, the results for the extended research period (2014–2018) also indicate that firms that have purchased D&O insurance prefer an accrual earnings management strategy over a real earnings management strategy[27]. Furthermore, given the effects of restatement announcements combined with D&O insurance on earnings management strategies, we demonstrate that the interaction term is positively but non significantly associated with real earnings management manipulation[28]. That is, restatement announcements moderate the effect of D&O insurance on real earnings management manipulation.

Table 10 Regression Results for Extended Research Period

Panel A. Effect of D&O insurance on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-1.077***	0.000	0.685***	0.000	0.006	0.956	0.616***	0.000
SIZE	-0.088***	0.000	0.133***	0.000	0.200***	0.000	0.123***	0.000
LOSS	-0.817***	0.000	0.982***	0.000	0.484***	0.000	0.964***	0.000
INST	0.255**	0.026	-0.319***	0.005	-0.185	0.107	-0.341***	0.003
BH	-0.171	0.314	0.470***	0.003	0.519***	0.002	0.471***	0.003
BSIZE	0.004	0.729	0.001	0.922	-0.006	0.536	-0.002	0.841
INDR	0.107	0.488	-0.128	0.382	0.059	0.673	0.008	0.955
BIG4	-0.002	0.975	-0.043	0.480	-0.079	0.179	-0.045	0.447
D&O	0.075	0.101	**-0.081***	**0.059**	**-0.123*****	**0.004**	**-0.085****	**0.048**
IMR	-0.069	0.442	0.073	0.410	0.062	0.457	0.166*	0.058
Cons	1.178**	0.024	-3.065***	0.000	-3.788***	0.000	-3.056***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	12710		12710		12710		12710	
Chi²	0.069		0.112		0.038		0.108	
Pse. R^2	533.337		895.960		302.715		849.063	
Panel B. Effect of restatement announcements on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-1.077***	0.000	0.682***	0.000	0.004	0.972	0.614***	0.000
SIZE	-0.089***	0.000	0.131***	0.000	0.200***	0.000	0.122***	0.000
LOSS	-0.816***	0.000	0.979***	0.000	0.482***	0.000	0.961***	0.000
INST	0.263**	0.021	-0.326***	0.004	-0.196*	0.090	-0.349***	0.002
BH	-0.175	0.303	0.474***	0.003	0.524***	0.002	0.475***	0.003
BSIZE	0.004	0.705	0.001	0.947	-0.006	0.509	-0.002	0.831
INDR	0.113	0.461	-0.148	0.310	0.039	0.780	-0.009	0.951
BIG4	0.009	0.888	-0.052	0.385	-0.095	0.104	-0.055	0.348
REST	0.097	0.278	0.000	0.998	**-0.166***	**0.057**	-0.069	0.453
IMR	-0.103	0.245	0.101	0.251	0.114	0.166	0.199**	0.021
Cons	1.235**	0.017	-3.077***	0.000	-3.862***	0.000	-3.090***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	12710		12710		12710		12710	
Chi²	0.069		0.111		0.037		0.107	
Pse. R^2	535.333		888.531		298.299		846.511	
Panel C. Effect of D&O insurance combined with restatements on earnings management strategy								
	$A(AEM_HRM_L)$		$B(AEM_LRM_H)$		$C(AEM_LRM1_H)$		$D(AEM_LRM2_H)$	
	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value	Coef.	P-Value
LEV	-1.077***	0.000	0.685***	0.000	0.007	0.950	0.618***	0.000
SIZE	-0.090***	0.000	0.133***	0.000	0.202***	0.000	0.123***	0.000
LOSS	-0.819***	0.000	0.982***	0.000	0.486***	0.000	0.965***	0.000
INST	0.254**	0.026	-0.318***	0.005	-0.185	0.107	-0.339***	0.003
BH	-0.171	0.314	0.470***	0.003	0.518***	0.002	0.470***	0.003

[26] For the marginal effect of Table 10 please refer to Table A6 in the Appendix.

[27] The marginal effect of D&O insurance on accrual earnings management is 0.019, and the marginal effects are −0.019, −0.037, and −0.019 under the real earnings management scenario.

[28] The marginal effects of the interaction term are −0.003, 0.033, 0.052, and 0.073 for Models A–D.

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BSIZE	0.004	0.727	0.001	0.922	-0.006	0.545	-0.002	0.851
INDR	0.101	0.511	-0.127	0.386	0.069	0.625	0.015	0.919
BIG4	-0.002	0.980	-0.042	0.486	-0.079	0.178	-0.044	0.457
REST	0.106	0.481	-0.092	0.541	**-0.281***	**0.054**	**-0.283***	**0.075**
D&O	**0.075***	**0.100**	**-0.084***	**0.051**	**-0.127*****	**0.003**	**-0.092****	**0.034**
RD&O	-0.011	0.953	0.140	0.456	0.174	0.334	0.321	0.103
IMR	-0.075	0.405	0.073	0.411	0.071	0.396	0.170*	0.051
Cons	1.210**	0.405	-3.062***	0.000	-3.834***	0.000	-3.070***	0.000
Year	included		included		included		included	
Ind	included		included		included		included	
Obs.	12710		12710		12710		12710	
Chi^2	0.069		0.112		0.038		0.108	
Pse. R^2	537.185		896.139		308.525		848.514	

a. Variable definitions are provided in Table 2.

b. *p*-values are estimated by fixed year and fixed industry, corrected for firm-level clustering, and reported in parentheses. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

5. Conclusion

The Taiwanese government has implemented a series of disclosure policies to enhance information transparency and enhance corporate governance. Taiwan's Securities and Futures Bureau requires listed companies to disclose their D&O insurance purchases beginning in 2008. This public policy allows us to investigate the role of D&O insurance in Taiwan's capital market. A recent D&O insurance study suggests that D&O insurance purchases are opportunistic, but it ignores the ability of insurers to price the potential litigation risks of firms.

We use data on Taiwan's capital market to reveal a positive association between D&O insurance and accrual earnings management and a negative association between D&O insurance and real earnings management. However, restatement announcements moderate the association between D&O insurance and earnings management strategies. Moreover, through a comparison of three real earnings management factors, we discover that managers prefer to engage in sales manipulations to influence earnings when their firms have purchased D&O insurance after making restatement announcements.

The present study has several practical and academic implications: (1) It provides evidence that D&O insurance constrains managers from implementing accrual earnings management in practice, and it reveals that D&O insurance providers cannot avoid the risks related to managers' manipulation of earnings through real activities. Notably, we discover that managers prefer to engage in sales manipulation to increase earnings when their firms have made restatements. Roychowdhury (2006) argues that sales manipulation by managers increases sales volume and helps them met their short-term sales targets but also reduces their future margins. Thus, D&O insurers should focus on the risks associated with measures for increasing profitability.

(2) We address a gap in D&O insurance research by providing evidence that D&O insurance has a monitoring effect. We also verify the risk-taking hypothesis. Our results indicate that D&O insurers constrain managers from engaging in earnings manipulations, and that managers switch their earnings manipulation strategy from accrual to real earnings management after their firms make restatement announcements. The results indicate that D&O insurers absorb the risks that managers generate through the switch from accrual earnings manipulation to real earnings manipulation. Overall, our results support the D&O insurance opportunism hypothesis and partially supports the D&O monitoring hypothesis. Notably, we discover that the opportunism and monitoring hypotheses are dependent on negative event signals.

(3) We address the gap in real earnings management research by providing alternative evidence that managers are committed to increasing earnings through various real earnings manipulation methods. Notably, we reveal that in firms that have made restatement announcements, managers prefer to engage in sale manipulation and reduction of discretionary expenditure to reduce external scrutiny.

The present study has several research limitations. (1) the Taiwanese government requires listed firms to purchase D&O insurance; thus, the results of our analysis cannot be generalized to the period following the imposition of this requirement. (2) In contrast to the United States or other countries with high levels of investor protection, Taiwan's capital market is still an emerging capital market. Thus, our empirical results cannot be generalized to the mature capital market; however, they can serve as a reference for policymakers in an emerging market.

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Appendix

Table A1 The Marginal Effect of Table 4

	Marginal Effect
BH	-0.081
BSIZE	0.007
INDR	0.745
BLKH	-0.299
LOSS	0.025
LEV	-0.102
SIZE	0.066
ROA	-0.210
MTB	-0.063
HITECH	0.191

a. Variable definition: BH_{it}, ownership of board director of firm i at beginning of fiscal year t; $BSIZE_{it}$, number of board directors that firm i has at beginning of fiscal year t; $INDR_{it}$, ratio of independent directors on board of directors of firm i at beginning of fiscal year t; $BLKH_{it}$, ownership of blockholders of firm i at beginning of fiscal year t; $LOSS_{it}$ is assigned a value of 1 if firm i had a net loss in previous year; LEV_{it}, debt ratio of firm i at beginning of fiscal year t; $SIZE_{it}$, natural log of market value of firm i at beginning of fiscal year t; ROA_{it}, return on assets of firm i at beginning of fiscal year t; MTB_{it}, market to book ratio of firm i at beginning of fiscal year t; HITECH is assigned a value of 1 if firm is in electronic industry.

Table A2 The Marginal Effect of Table 5

Panel A. Effect of D&O insurance on earnings management strategy				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.191	0.108	-0.036	0.081
SIZE	-0.041	0.047	0.083	0.043
LOSS	-0.222	0.246	0.187	0.237
INST	0.061	-0.106	-0.082	-0.099
BH	-0.001	0.095	0.118	0.086
BSIZE	-0.001	0.001	-0.002	0.000
INDR	-0.074	0.048	0.133	0.088
BIG4	-0.011	-0.012	-0.011	-0.011
D&O	0.023	-0.020	-0.041	-0.022
IMR	-0.083	0.068	0.112	0.100
Panel B. Effect of restatement announcements on earnings management strategy				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.191	0.107	-0.038	0.079
SIZE	-0.041	0.047	0.083	0.043
LOSS	-0.222	0.246	0.186	0.236
INST	0.065	-0.109	-0.088	-0.103
BH	-0.005	0.098	0.124	0.089
BSIZE	-0.001	0.001	-0.002	0.000
INDR	-0.071	0.043	0.123	0.083
BIG4	-0.007	-0.014	-0.016	-0.013
REST	0.029	-0.007	-0.017	0.015
IMR	-0.093	0.075	0.127	0.108
Panel C. Effects of D&O insurance combined with restatements on earnings management strategy				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.192	0.109	-0.035	0.082
SIZE	-0.041	0.047	0.083	0.043
LOSS	-0.223	0.246	0.187	0.236
INST	0.061	-0.105	-0.082	-0.098
BH	-0.000	0.093	0.117	0.085
BSIZE	-0.001	0.001	-0.002	0.001

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INDR	-0.075	0.051	0.135	0.091
BIG4	-0.010	-0.011	-0.010	-0.010
REST	0.056	-0.087	-0.084	-0.052
D&O	0.024	-0.023	-0.044	-0.024
RD&O	-0.057	0.147	0.129	0.127
IMR	-0.084	0.070	0.113	0.102

a. Variable definitions are provided in Table 2.

Table A3 The Marginal Effect of Table 6

	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.191	0.108	-0.037	0.081
SIZE	-0.041	0.047	0.084	0.044
LOSS	-0.222	0.246	0.187	0.237
INST	0.061	-0.106	-0.083	-0.099
BH	-0.001	0.095	0.119	0.086
BSIZE	-0.001	0.001	-0.002	0.001
INDR	-0.074	0.048	0.132	0.088
BIG4	-0.011	-0.012	-0.011	-0.011
D&OA	0.002	-0.002	-0.003	-0.002
IMR	-0.084	0.069	0.114	0.101
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.192	0.109	-0.035	0.082
SIZE	-0.042	0.047	0.084	0.044
LOSS	-0.223	0.246	0.187	0.237
INST	0.061	-0.106	-0.082	-0.099
BH	-0.001	0.094	0.118	0.085
BSIZE	-0.001	0.001	-0.001	0.001
INDR	-0.075	0.051	0.134	0.091
BIG4	-0.010	-0.012	-0.010	-0.010
REST	0.058	-0.086	-0.081	-0.050
D&OA	0.002	-0.002	-0.003	-0.002
RD&OA	-0.005	0.012	0.010	0.010
IMR	-0.085	0.071	0.115	0.103

a. Variable definitions are provided in Table 2.

Table A4 The Marginal Effect of Table 7

Panel A. First stage of Heckman's two-stage regression	
	Marginal Effect
Analyst	-0.005
Hab_Beatr	-0.035
Share	0.046
SIZE	0.021
ROA	0.079
LEV	0.278
MTB	0.181

Panel B. Second stage of Heckman's two-stage regression				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	0.122	0.198	-0.155	0.112
SIZE	0.011	0.008	0.093	0.010
LOSS	-0.225	0.200	0.073	0.176
INST	-0.030	-0.018	0.023	-0.033
BH	0.101	0.119	0.139	0.124
BSIZE	-0.004	-0.004	-0.006	-0.005
INDR	0.010	0.097	0.308	0.162
BIG4	-0.047	-0.042	-0.055	-0.053
REST	0.099	-0.039	-0.031	-0.015

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D&O	-0.006	-0.055	-0.081	-0.055
RD&O	-0.056	0.135	0.118	0.164
DOIMR	0.107	0.130	0.220	0.196
EMIMR	-0.077	-0.980	-0.927	-0.962

a. Variable definitions are provided in Table 2. Additional variable definitions: Analyst, degree of analyst coverage; Hab_Beat, frequency with which earnings forecasts of analysts are met or exceeded; Share, natural logarithm of number of shares outstanding; Size, firm size; ROA, return on assets; LEV, firm leverage; MTB, market to book ratio.

Table A5 The Marginal Effect of Table 8

	$REM1_H$ Marginal Effect	$REM2_H$ Marginal Effect	$REM3_H$ Marginal Effect
LEV	0.086	0.167	-0.075
SIZE	-0.014	0.050	0.083
LOSS	0.240	0.246	0.175
INST	-0.039	-0.074	-0.059
BH	-0.054	0.096	0.098
BSIZE	0.003	0.002	-0.002
INDR	-0.046	0.078	0.129
BIG4	0.007	-0.028	-0.011
REST	-0.118	-0.061	-0.070
D&OA	0.000	-0.012	-0.044
RD&OA	0.158	0.093	0.120
IMR	-0.029	0.097	0.095

a. Variable definitions are provided in Table 2.

Table A6 The Marginal Effect of Table 10

Panel A. Effect of D&O insurance on earnings management strategy				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.268	0.161	0.002	0.140
SIZE	-0.022	0.031	0.060	0.028
LOSS	-0.203	0.232	0.144	0.219
INST	0.063	-0.075	-0.055	-0.077
BH	-0.043	0.111	0.154	0.107
BSIZE	0.001	0.000	-0.002	-0.000
INDR	0.026	-0.030	0.018	0.002
BIG4	-0.000	-0.010	-0.023	-0.010
D&O	0.019	-0.019	-0.037	-0.019
IMR	-0.017	0.017	0.019	0.038*
Panel B. Effect of restatement announcements on earnings management strategy				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.268	0.161	0.001	0.139
SIZE	-0.022	0.031	0.060	0.028
LOSS	-0.203	0.231	0.144	0.218
INST	0.065	-0.077	-0.058	-0.079
BH	-0.044	0.112	0.156	0.108
BSIZE	0.001	0.000	-0.002	-0.000
INDR	0.028	-0.035	0.012	-0.002
BIG4	0.002	-0.012	-0.028	-0.012
REST	0.024	0.000	-0.049	-0.016
IMR	-0.026	0.024	0.034	0.045
Panel C. Effects of D&O insurance combined with restatements on earnings management strategy				
	$A(AEM_HRM_L)$ Marginal Effect	$B(AEM_LRM_H)$ Marginal Effect	$C(AEM_LRM1_H)$ Marginal Effect	$D(AEM_LRM2_H)$ Marginal Effect
LEV	-0.268	0.162	0.002	0.140
SIZE	-0.022	0.031	0.060	0.028
LOSS	-0.203	0.232	0.145	0.219
INST	0.063	-0.075	-0.055	-0.077
BH	-0.043	0.111	0.154	0.107
BSIZE	0.001	0.000	-0.002	-0.000

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INDR	0.025	-0.030	0.020	0.003
BIG4	-0.000	-0.010	-0.023	-0.010
REST	0.026	-0.022	-0.084	-0.064
D&O	0.019	-0.020	-0.038	-0.021
RD&O	-0.003	0.033	0.052	0.073
IMR	-0.019	0.017	0.021	0.039

a. Variable definitions are provided in Table 2

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Exploring Digitalisation Adaptation of Agro-food Firms: Evidence from Greece

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ABSTRACT

Purpose: The present study aims to investigate the primary tools and digitalisation applications used by agro-food firms in Greece. These factors encourage or discourage digitalisation and identify which policies are in place to ensure an effective digitalisation in the food sector.

Design/methodology/approach: Primary data were gathered through a quantitative survey with a structured questionnaire on a sample of agro-food firms in Greece. The sample consisted of 51 executives of firms from the food sector. Data analysis was performed raw data using the SPSS statistical software version 26 and applying a mix of multivariate methods.

Findings: The results indicate that the implementation of digital technologies in agro-food firms in Greece remains in an embryonic phase, only taking advantage of the key digital platforms and the Internet.

Research limitations/implications: 1. The coronavirus pandemic (Covid-19) did not allow lifelong data collection. 2. The non-response of some companies to the invitation to participate in the research and their desire not to participate in the research.

Originality/value: The digital adaptation of the agro-food firms will contribute to the protection of the environment in the context of green growth. We believe that the present study will contribute to shaping the appropriate environment for the adaptation of the food industry to the new conditions.

1. Introduction

Today, technological developments are rapidly reflected globally, in a highly competitive internationalised environment, where digitalisation is gaining interest among firms, as it helps them increase their value (Salvi et al., 2021). Digitalisation is usually defined as the combination of the intensive development of new or significantly modified digital technologies and systems and, at the same time, their intensified diffusion and application at distinct productive levels (e.g., digitalisation and data analysis, digital firm models, digital processes, digital products, and services) in the sectors of economic and social activity (Oliveira et al.,2021). Tilson et al. (2010) state that digitalisation refers to applying digital technologies and infrastructures in business, economy, and society.

Digitalisation offers new technical possibilities and firms opportunities, changing how firms operate in the markets, significantly affecting firms' value chains (Oliveira et al., 2021) and waste management processes (Sarc et al., 2019). It is also one of the main factors in changing how firms operate, evolving firm models through digital processes and influencing employee satisfaction (Bueechl et al., 2021). Digitalisation affects many aspects of organisations, including information technology, strategy and firm models, products and services, internal and external processes, corporate organisation and culture, human resource management resources and employee

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satisfaction levels (Parviainen et al., 2017; Bueechl et al., 2021; Oliveira et al., 2021; Ragazou, 2021). Examples include intelligent houses (such as applications for entertainment, security, childcare, electricity, and heating), eHealth, smart mobility, and smart cities (Dudzevičiūtė et al., 2017; Lyons, 2019; Okkonen, 2020). The expansion of digital technology and its emergence in many areas of everyday life ensures better performance in the design of services and the development of environmental infrastructure, as exemplified by the cases of the cities of Tromsø in Norway and Rovaniemi in Finland, combining growth, sustainability, and high prosperity as "smart" cities (Cartaxo et al., 2021). Other known examples refer to smart cities in Canada (Spicer et al., 2021), South Korea (Kim et al., 2021), and in Australia (Yigitcanlar et al., 2021).

Many areas may benefit significantly, since cultural objects and assets (e.g., works of art, historical relics, and documents) can be digitised and preserved over time. In a firm's environment, digitalisation shows how a firm can advertise its assets, produce, and deliver them effectively to the customer, and maintain effective contact with the customer while also involving the customer in the joint creation of the customer value to satisfy his needs (Chernova et al., 2019). In production, digitalisation also means designing products in digital form and the virtual composition of components before producing the product (Meissner et al., 2018) In addition, it affects lean production methods, which can be further improved by using new technologies, achieving a transition to a digital system that opens up new possibilities in the production process As literature supports, both lean manufacturing and factory digitalisation individually contribute to improved operational performance (Buer et al., 2021) Finally, in water and energy supply, as well as in the transport sector, digitalisation can inform the state, physical distribution or location of things and people, providing detailed information on the necessary and future capabilities related to sustainability and scalability in a specific area (Gray and Rumpe, 2015).

Bearing in mind the above mentioned, the present work explores the concept of firms' digitalisation in the agri-food sector in Greece. The objective is threefold: first, to investigate the primary tools and digitalisation applications used by firms in the agro-food sector in Greece and the factors that encourage or discourage digitalisation. Second, to identify which policies are in place to ensure effective digitalisation in the agro-food sector and third, to explore whether differences exist regarding the degree of application of the digitalisation tools, depending on the firm's size. The remainder of the paper includes a theory background on the digitilisation of firms in the next section and the materials and methods employed in the third section. Section four presents and discusses the results, and the final section concludes.

2. Digitalisation in the Agri-Food Sector

The food supply sector consists of fresh and processed foods (Weaver et al., 2014), accounting for a significant portion of the household expenditure. Hong Kong has the highest per capita food expenditure globally (the USA $ 5,002.2 in 2018) (Knoema, 2021). According to Eurostat (2020), households in the EU spent 2019 over 956 billion euros (equivalent to 6.8% of EU GDP) on food and non-alcoholic beverages. This accounts for 13.0% of total household expenditure and is the third-largest household expenditure category after housing, water, electricity, gas and other fuels, accounting for 23.5% of household expenditure and transport (13.1%). Households in Romania spent the most considerable amount on food and non-alcoholic beverages, about a quarter of total household consumption (26.0%), followed by households in Lithuania (20.2%) (Eurostat, 2020). Greece's average household budget expenditures for food and non-alcoholic beverages increased to 23.1% from 20% in 2019 (National Statistical Service of Greece, 2021).
Agro-food firms confront global challenges, which can be addressed with the support of information technologies (Demartini et al., 2018). For example, intelligent packaging is one of the most critical technologies in food packaging, which is still evolving and offers vast potential for issues related to improving food safety, quality and traceability, and convenience for consumers. Nowadays, such packaging systems protect from chemical, biological and physical alterations. At the same time, it also protects food from mechanical damage against vibrations during distribution, facilitates transportation and storage and reduces the cost of marketing and advertising (Forghani et al., 2021; Ghaani et al., 2016). Due to the growth of the world population (the world population increased from 1 billion in 1804 to 7,794,798,739 today) (Worldometer, 2021), combined with changing customer demands and market dynamics, new challenges arise for the agro-food sector. Among the significant market, challenges are safety standards in the Covid-19 era (Ceniti et al., 2021; Rizou et al., 2020; Trmcic et al., 2021). There is an urgent need for the agro-food sector to ensure compliance with measures to protect food workers from Covid-19 contamination. However, it also prevents exposure or transmission of the virus and enhances food hygiene practices (World Health Organization/ WHO, 2020).

According to Sen et al. (2017), new approaches based on digitalisation can contribute to the practical and reliable coverage of current and future needs, aiming at higher efficiency, productivity, and quality and improving firms' position with simultaneously optimised resource and waste management. Digital processes and automation increase accuracy, convenience, and productivity, while helping to reduce unit costs. Furthermore, the investment and development of digital tools aim to ensure the highest possible food safety. Digital technologies offer an excellent solution for improving the sustainability of food systems (Bahn et al., 2021; Marvin et al., 2022; Samoggia et al., 2021).

Within a turbulent socio-economic and operating environment, there is a strong tendency for firms to exploit the high potential of innovation resulting from the continuing impact of the rapid technological development of information and communication technology in the agro-food sector (Massari, 2021; Oltra-Mestre et al., 2021). Indeed, firms in this sector face global challenges that can be met with the support of information technology and digitalisation and result in improved competitiveness and efficiency (Jorge-Vázquez et al., 2021). According to Annosi et al. (2020), digitalisation can significantly address several current challenges facing the agro-food sector, such as

growing food demand and resource use. Their study showed that the existing challenges in the field affect the sustainable development of digital technology for firms. Additionally, as reported by Ranta et al. (2021), the impact of digitalisation is positive on the adoption of innovation in corporate firm models. It brings significant benefits-improved resource flows, and value creation.

As Stephens and Barbier (2021) argue, digitalisation brings new perspectives to developing and exploring alternative food networks, offering a decentralised network of local functions that converge around a digital platform and providing innovative virtual hardware intermediation between producers and consumers. This further engages consumers in the cogeneration of products in various sectors and activities and contributes to restructuring global food flows towards sustainability and reduced environmental impacts, as Cronin and Halog (2021) support the case of Australian alternative food networks.

In addition, alternative sourcing becomes more "feasible" through digital platforms allowing consumers to engage in healthier and more sustainable food practices (Dal Gobbo et al., 2021). Digital platforms are also discussed by Shree et al. (2021), stating that their evolution has transformed the way firms operate in business-to-business (B2B) markets. Further, concerning the B2B and B2C sectors, Bernardi and Moggi (2021) showed that digitalisation can play a pivotal role in generating and transferring data, stimulating innovation and sustainability-oriented behaviours; the digitalisation of the agri-food sector is a strategic priority in the political agenda of institutions. Among the highest strategic priorities are investments and funding in the agri-food sector, organic farming and production, energy, sustainability, water resources management, smart farming, food safety and precision agriculture (Andronova et al., 2021; Ehlers et al., 2022; Garske et al., 2021; Şerbănel, 2021). The opportunity to improve the competitiveness and efficiency of the sector offered by new technologies comes in conjunction with the sector's potential to meet new economic and environmental challenges. Such technologies are related to automation, robotics, artificial intelligence and forecasting systems, the blockchain of agricultural products, and cybersecurity issues in the agro-food chain. According to Jorge-Vázquez, et al. (2021), the adoption of digital tools in the food sector, along with other structural and organisational variables, is essential in improving competitiveness, economic efficiency, and growth while contributing to the sustainability of agricultural and food systems. Furthermore, digitalisation may contribute to higher efficiency, productivity, and quality, strengthening the firms' position while optimising resource and waste management and ensuring the highest possible food safety (Sen et al., 2017).

3. Materials and Methods

In the present study, a quantitative survey was used to collect primary data through a structured questionnaire on the digitalisation of firms in the food sector in Greece. The sample consisted of 51 executives of firms from the food sector in Greece. Regarding the data collection process, it is necessary to mention that the respondents agreed to participate voluntarily in the research and were selected via simple random sampling. After telephone communication with the firms, the questionnaire was sent electronically via e-mail and social media to 51 randomly selected firms operating in Greece's agro-food sector and various parts. The data collection lasted from October 5, 2021, to October 15, 2021, and the questionnaire was distributed to the participants through the Google Forms platform. By simple random sampling each unit of the aggregate sample has the same chances of being included in the sample (Singh and Masuku, 2014). A similar method was applied by Salam et al. (2021) to food industry employees with a total of 120 questionnaires answered and by Abd Aziz and Samad (2016) to small and medium-sized food processing companies in Malaysia.

The research methodology was based on exploratory questions stemming from extant digital economy literature (Batt et al., 2020; Cirillo et al., 2021; Kostyaeva and Chernyakov, 2020; Sanchez-Riofrio et al., 2021). The data collected seek to identify the main digitalisation tools and applications firms use in the agro-food sector and the factors that encourage and discourage digitalisation. It is worth noting that they also seek to identify the policies implemented to ensure effective digitalisation in the agro-food sector. These were achieved through the application of descriptive statistics. To investigate whether the factors encouraging and discouraging the implementation of digitalisation in the agro-food sector in Greece depend on the firm's size, a one-way Analysis of Variance was employed. Compared to other statistical methods such as the use of multiple t-tests, one-way and two-way ANOVA require fewer measurements to show significant effects (Burke, 1998). A similar methodology has been applied by Salavou and Sergaki (2013) to identify differences in generic business strategies between 31 companies and 30 organisations in the agro-food sector in Greece.

The survey instrument employed closed-ended questions and was designed in such a way that it is clear and understandable to all individuals surveyed. The questionnaire consisted of five sections. Specifically, the first section of the questionnaire entitled "Demographic Data" aimed to collect demographic information about the participants and some initial data on the characteristics of each company. The second section entitled "Digitalisation tools and applications" comprised three questions to investigate the digital situation of the firm. The first question mentioned nine digital tools and asked each respondent to answer whether these tools were used by each firm. In the second question, respondents were asked whether the company aspired for investments in new technologies, whereas in the third and final question respondents were asked to what extent the company employed a series of digital tools that were given to them. The third section of the questionnaire aimed to identify the factors encouraging the application of digitalisation in the agro-food sector, and five factors and six positive consequences of the implementation of digitalisation were given. The fourth section intended to investigate the factors that discourage the application of digitalisation in the agro-food sector, whereas the last section listed five policies that can be implemented for the effective digitalisation of agro-food firms and respondents were asked to state their degree of agreement with these policies. All questions were gauged through a 5-point Likert scale ranging from 1= "I totally disagree", 2= "I

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disagree", 3= Neither agree/nor disagree", 4 = "I agree", 5= "I fully agree", except for the first two questions of the second section that were dichotomous (Yes, No) variables.

Data analysis was performed on raw data using the SPSS statistical software version 26. A specific data collection procedure was performed to ensure the validity and reliability of the questions included in the survey instrument. In particular, the anonymity of the research tool, which was distributed electronically and did not contain any secured branding questions, is one of the most critical factors in ensuring reliability and validity (Willig, 2001). The electronic distribution of the questionnaire was a necessary action in combination with the absence of the researcher when completing the research tool, as it was not possible to intervene in the answers and, therefore, the objectivity and honesty of the responses were encouraged. It is noteworthy that fully informing about the necessity of participating in the research and its objectives, providing clarifications, voluntary participation, and the right to leave at any time desired by the participants strengthened the effort to ensure the validity and reliability of the research tool.

The sample size selected was satisfactory and appropriate for the subject under consideration regarding validity. In addition, there were no extreme values in terms of participants' responses, and the sample was homogeneous in terms of demographic characteristics. To ensure the reliability of this research tool, the reliability index of Cronbach's alpha was calculated. In the present survey for the second-and third-party questions, the reliability index was equal to 0.886, indicating acceptable reliability.

4. Results

Most of the participants in the research were men (52.9%), while 47.1% were women (Table 1) aged 40 to 49 years and 35.3% 50 years old. In addition, the majority had more than twenty years of employment in the agro-food sector (31.4%), whereas 11.8% were young employees with up to 2 years of employment. Regarding the position held by the participants in the firm, most were owners with a percentage of 43.1%, 15.7% were managers and executives, and 41.2% were employees. Most of the firms in the sample were very small (56.95), 5.9% were medium enterprises, 25.5% were small, and 11.8% were large firms (Table 1).

Table 1: Profile of the sample firms

Features of the sample	Number	%
Object of activity of the firm		
Owner / Businessman	22	43.1
Manager / Executive	8	15.7
Employee	21	41.2
Total	51	100.0
Firm size		
Very small	29	56.9
Small	13	25.5
Medium	3	5.9
Big	6	11.8
Total	51	100.0

The second part of the questionnaire examined digitalisation tools and whether firms know and use them. As shown in Table 2, almost all digital tools were used by a few firms. For example, 68.6% of respondents use digital platforms, and 43.1% use the Internet remaining tools to a minimum (Table 2). Regarding digital platforms, most respondents (68.6%) answered that the firm uses them, while 31.4% responded that they do not.

Regarding Artificial Intelligence, most respondents at 96.1% answered that the firm does not use it, while only 3.9% answered it. The same holds for Robotic Systems where 90.2% responded that the firm does not use them, the 3D printers (96.1%) and the cryptocurrencies, which the sample firms do not employ. At the same time, most participants claimed that they do not use the Internet (56.9%), while 43.1% answered that they use it, whilst Cloud Computing was used by only 19.6% of the sample. The rest of the digital applications, i.e., Big Data and Blockchain, are not widespread in the sample agro-food firms, as 90.2% and 98% do not use them.

Table 2: Features of the digitalisation tools

Digital tools used by firms		Number	%
Digital Platforms	No	16	31.4
	Yes	35	68.6
Artificial Intelligence	No	49	96.1

	Yes	2	3.9
Robotic Systems	No	46	90.2
	Yes	5	9.8
3D Printing	No	49	96.1
	Yes	2	3.9
Cryptocurrencies	No	51	100.0
	Yes		
Internet	No	29	56.9
	Yes	22	43.1
Cloud Computing	No	41	80.4
	Yes	10	19.6
Big Data	No	46	90.2
	Yes	5	9.8
Blockchain	No	50	98.0
	Yes	1	2.0

Table 3 illustrates the eight digital tools/applications mentioned to the respondents, asking them to state how their firm uses them. For most applications, the average usage rate moved a little closer to 2. The application that stood out was Digital Marketing/Website/social media, where the average score exceeded 3 (M = 3.17, TA = 1.19), and the Digital Procurement / Orders Management that averaged 2.7 (MO = 2.7, TA = 1.28).

Table 3: Statistics for the digitalisation tools

	N	Mean	Std. Deviation
Digital Marketing /Website/social media	51	3.1765	1.19509
Automation Applications in the Production/Commercial Process	51	2.4314	1.23701
Digital Procurement/Order Management	51	2.7059	1.28521
Electronic Sales System/E-Shop	51	2.2745	1.38677
Use Applications for customer experience / profile / needs / behavior	51	2.0196	1.10436
Participation in an Online Platform	51	2.4706	1.17223
Data Processing and Analysis of the Production / Commercial Process	51	2.4902	1.31716
Use Applications for After Sales Services	51	2.2745	1.13276

Respondents were then asked to indicate how they agree with several factors that encourage digital applications in the agro-food sector (Table 4). The most important factors that can act positively in helping a firm to digitise and adopt all the above digital tools were the specialisation/knowledge of entrepreneurs in the sector with new technologies and the digital environment, with an average score of 3,86 (MO = 3.80, TA =. 89). Following, was the increase in the workforce's digital skills employed in the agro-food sector that averaged 3.84 (MO = 3.84, TA =. 89), the special conditions with 3.8 (MO = 3.80, TA = 1.03), the same as the competitive environment. Finally, state aid received the lowest score of 3.6 (MO = 3.60, TA =. 87).

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Table 4: Statistics for the factors encouraging the implementation of digitalisation in the Agro-food Sector

	N	Mean	Std. Deviation
State Aid in the Agro-food Sector	51	3.607	0.87358
The competitive environment in the Agro-food Sector	51	3.803	0.89487
The specialisation/knowledge of entrepreneurs in the sector with new technologies and the digital environment	51	3.862	0.80049
Increasing the digital skills of the workforce employed in the agro-food sector	51	3.843	0.88029
Special conditions (e.g., Covid Pandemic 19)	51	3.803	1.03961

As concerns the positive effects of digitalisation on agro-food firms, the respondents gave the highest average score of 3.82 (MO = 3.82, TA = .76) to the increase in the quality of the services provided to the customers, while the lowest was 3.52 (MO = 3.52, TA = .78) in Improving Resource and Waste Management. In these cases, the scores ranged between 3.5 and 3.82 points, with three corresponding to the neither agree nor disagree answer and four respondents to the agree answer. Therefore, the participants' tendency to converge toward the agreement on the following factors had positive consequences for digitising the firms in the sector (Table 5).

Table 5: Statistics for the positive effects of business digitalisation in the Agro-food Sector

	N	Mean	Std. Deviation
Increase Business Efficiency	51	3.7255	0.80196
Increase business productivity	51	3.7059	0.67213
Increasing the profitability of the firm	51	3.6471	0.74360
Increasing the quality of services provided to customers	51	3.8235	0.76696
Improving the business position of the firm	51	3.7647	0.76389
Improving resource and waste management	51	3.5294	0.78366

Table 6 shows the average degree of agreement of the respondents on the four factors that are reported to discourage firms from digitising. Lack of funding seems to be the first inhibitory factor with an average score of 3.86 (MO=3.86, TA =.82), while the least important factor is the lack of specialised skills in human resources with a score of 3.6 (MO=3.60, TA =.98). Also, the second important factor is the high cost of purchase and maintenance of digital systems and applications, with an average score of 3.82 (MO = 3.82, TA =. 97). Finally, the lack of information structures and guidance received a score of 3.70 (MO = 3.70, TA =.92). Again, it is important to mention that the respondents were asked to choose from the possible answers 1 = I do not agree at all, 2 = I agree a little, 3 = I agree moderately, 4 = I agree, 5 = I agree. Therefore, the answers that moved close to 4 answered that they agreed with the respective statement.

Table 6: Statistics for the factors acting as barriers to the digitalisation of firms in the Agro-food Sector

	N	Mean	Std. Deviation
Lack of Funding	51	3.8627	0.82510
High cost of purchasing and maintaining digital systems and applications	51	3.8235	0.97377
Lack of information structures and guidance	51	3.7059	00.92291
Lack of specialised skills in human resources	51	3.6078	0.98140

Concluding, the descriptive analysis regarding the policies that should be followed to help agro-food firms in their digitalisation revealed that the most important policy was the subsidised programs for the digital upgrade of firms with an average score of 3.98 (MO. = 3.86, T.A. =. 73). The result shows that respondents agreed on the importance of this policy. On the contrary, the Digital Economy Fund set up received an average score of 3.47 (MO = 3.47, TA =. 87), which means that respondents neither disagreed nor agreed with the importance of this policy. Also, the Tax Incentives for firms investing in digital technologies and the Configuration of digital centres and infrastructure of education and training received an average score of 3.76. Finally, the Collaboration Platforms - development of new digital collaboration schemes received an average score of 3.60 points (Table 7).

Table 7: Statistics for the policies for the effective digitalisation of firms in the Agro-food Sector

	N	Mean	Std. Deviation
Establishment of a Digital Economy Fund	51	3.4706	0.87984
Tax Incentives for Businesses Investing in Digital Technologies	51	3.7647	0.95054
Configuration of digital centres and infrastructure of education and training	51	3.7647	0.78964
Collaboration Platforms - development of new digital collaboration schemes	51	3.6078	0.82652
Subsidised programs for the digital upgrade of businesses	51	3.9804	0.73458

In the second part of the analysis, the aim was to control the effect of the views regarding the factors encouraging and discouraging the implementation of digitalisation in the agro-food sector in Greece, depending on the firm's size. Accordingly, the results of Table 8 indicate that the implementation of digitalisation tools differs statistically significantly depending on the size of the firm (very small/small/medium/large) (p-value> .00).

Table 8: One-way ANOVA for factors that discourage the implementation of digitalisation tools depending on the size of the business

		Sum of squares	df	Mean square	*F*	Sig.
State Aid in the Agro-food Sector	Between groups	2.374	3	.791	1.040	.384
	Within groups	35.782	47	.761		
	Total	38.157	50			
The competitive environment in the Agro-food Sector	Between groups	1.272	3	.424	.514	.675
	Within groups	38.767	47	.825		
	Total	40.039	50			
The specialisation/knowledge of entrepreneurs in the sector with new technologies and the digital environment	Between groups	.899	3	.300	.452	.717
	Within groups	31.141	47	.663		
	Total	32.039	50			
Increasing the digital skills of the workforce employed in the agro-food sector	Between groups	1.553	3	.518	.654	.584
	Within groups	37.192	47	.791		
	Total	38.745	50			
Special conditions (e.g., Covid Pandemic 19)	Between groups	2.119	3	.706	.639	.593
	Within groups	51.920	47	1.105		
	Total	54.039	50			
Increase Business Efficiency	Between groups	.454	3	.151	.224	.879
	Within groups	31.703	47	.675		
	Total	32.157	50			
Increase business productivity	Between groups	.960	3	.320	.695	.560
	Within groups	21.629	47	.460		
	Total	22.588	50			
Increasing the profitability of the firm	Between groups	.755	3	.252	.440	.725
	Within groups	26.892	47	.572		
	Total	27.647	50			
Increasing the quality of services provided to customers	Between groups	1.127	3	.376	.624	.603
	Within groups	28.285	47	.602		
	Total	29.412	50			
Improving the business position of the firm	Between groups	2.614	3	.871	1.542	.216
	Within groups	26.562	47	.565		
	Total	29.176	50			
Improving resource and waste management	Between groups	2.734	3	.911	1.531	.219
	Within groups	27.972	47	.595		
	Total	30.706	50			

Finally, at the level of statistical significance $\alpha = 0.05$, none of the factors discouraging the implementation of digitalisation tools differs significantly depending on the firm's size (very small/small/medium/large), as indicated in Table 9.

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Table 9: One-way ANOVA for factors encouraging the implementation of digitalisation tools depending on the size of the business

		Sum of squares	df	Mean square	*F*	Sig.
Lack of Funding	Between groups	1.501	3	.500	.723	.543
	Within groups	32.538	47	.692		
	Total	34.039	50			
High cost of purchasing and maintaining digital systems and applications	Between groups	6.946	3	2.315	2.689	.057
	Within groups	40.466	47	.861		
	Total	47.412	50			
Lack of information structures and guidance	Between groups	6.022	3	2.007	2.580	.065
	Within groups	36.566	47	.778		
	Total	42.588	50			
Lack of specialised skills in human resources	Between groups	1.727	3	.576	.583	.629
	Within groups	46.430	47	.988		
	Total	48.157	50			
Establishment of a Digital Economy Fund	Between groups	3.400	3	1.133	1.509	.224
	Within groups	35.305	47	.751		
	Total	38.706	50			
Tax Incentives for Businesses Investing in Digital Technologies	Between groups	1.097	3	.366	.390	.761
	Within groups	44.080	47	.938		
	Total	45.176	50			
Configuration of digital centres and infrastructure of education and training	Between groups	.225	3	.075	.114	.952
	Within groups	30.951	47	.659		
	Total	31.176	50			
Collaboration Platforms - development of new digital collaboration schemes	Between groups	.545	3	.182	.254	.858
	Within groups	33.611	47	.715		
	Total	34.157	50			
Subsidised programs for the digital upgrade of businesses	Between groups	.425	3	.142	.251	.860
	Within groups	26.555	47	.565		
	Total	26.980	50			

5. Discussion

According to the analysis, most of the participants in the research were men aged 40 and over, employees with more than 20 years of employment in the sector, mainly owners. In addition, 56.9% of the participants worked in very small enterprises, 25.5% worked in small enterprises, 5.9% in medium enterprises and 11.8% in large enterprises. When it comes to digitalisation tools and how well firms know and use them, almost all digital tools are operated by a few firms. The low digitalisation of firms in Greece was also confirmed in the literature (Laitsou et al., 2020; Organization for Economic Co-operation and Development/OECD, 2019). Most respondents use digital platforms and the Internet, a finding that is consistent with Demartini et al. (2018) and Kosior (2018). The rest of the tools are used to a minimum (Artificial Intelligence, Robotic Systems, 3D Printing, Cloud Computing, Big Data, Blockchain), while Cryptocurrencies are not used.

In contrast, other research in the literature reports extensive use of the above tools (Demartini et al., 2018; Kosior, 2018; Liu et al., 2021). Digital Marketing / Website / social media stood out among the digital applications used and Digital Procurement / Order Management. Firms using digitised technologies in the Middle East and North Africa (MENA) appear to be reaping the benefits of increased productivity and resource efficiency. In contrast, digital technologies are already being used in Morocco's National Land Registry (Bahn et al., 2021).

Regarding the factors that encourage the use of digital applications in the agro-food sector, it seems that the specialisation/knowledge of entrepreneurs in the sector with new technologies and the digital environment is the most essential factor. Therefore, there is an increase in the workforce's digital skills in the agro-food sector, special conditions, and a competitive environment. At the same time, state aid seemed to encourage less than all other actors.

These findings are consistent with extant literature (Bičkauskė et al., 2020; Jorge-Vázquez et al., 2021; Anastasiou et al., 2021).

Regarding the consequences of digitalisation in agro-food firms, the respondents highlighted the most substantial increase in the quality of the services provided to the customers. In general, the tendency of the participants converges towards the agreement on the positive effects of the digitalisation of the enterprises of the sector, concerning the increase of the efficiency and productivity of the enterprise, its profitability, the quality of the services provided to the customers, the improvement of firm positioning and improving resource and waste management. These findings align with other research, which emphasises that digitalisation contributes to increasing productivity and enhancing competitiveness and efficiency in the sector, ensuring more sustainable use of resources, transforming production, promoting agro-food safety etc. (Debrenti 2020; Jorge-Vázquez et al., 2021). As for the factors that are reported to discourage firms from going digital, the lack of funding was the main one, followed by the high cost of purchasing and maintaining digital systems and applications, the lack of information and guidance structures, and the lack of specialised skills, consistent with the study of Bičkauskė et al. (2020). In addition, the logistics departments play a strategic role in the agro-food industry. Therefore, digitisation technologies and, more specifically, blockchain technology can have many uses. A typical example is the management of transport documents, the monitoring of transport progress and the corresponding deliveries, the geolocation as well, and the statistical analysis of all digital data in real-time (Remondino and Zanin, 2022; Dobrovnik et al., 2018; Al-Rakhami and Al-Mashari, 2021; Borowski, 2021; Adamashvili et al., 2021).

As for the policies that should be followed to help agro-food firms in their digitalisation, the most important was the subsidised programs for the digital upgrade of firms. Furthermore, according to Jorge-Vázquez et al. (2021), there is a need to promote public policies that guarantee high-performance digital connectivity, improve digital skills training, and promote collaborative integration processes. Under these policies, digitising and upgrading firms will be feasible. Finally, according to the analysis, none of the factors encouraging or discouraging the application of digitalisation tools differs statistically depending on the firm's size (very small/small/medium/large). In contrast, the international literature reports differentiation in the adoption of digitalisation according to the size of firms (Jorge-Vázquez et al., 2021).

Another typical example that highlights the importance and significance of using digital technologies is that of Spain. Research shows the importance of these technologies, but Spanish cooperatives do not invest in this direction (Marín and Gómez, 2021). While according to Bernal-Jurado et al. (2021), wine cooperatives should use digital technologies to be more competitive.

Conclusively, the main tools and digitalisation applications used by firms in the agro-food sector in Greece are primarily the digital platforms and the Internet. Digital Marketing / Website / social media and Digital Procurement / Order Management dominate the digital applications used. The factors that most encourage digitalisation are first the specialisation/knowledge of entrepreneurs in the sector with new technologies and the digital environment and then the digital skills of the staff. On the other hand, factors that discourage digitalisation mainly lack of funding and high purchase costs. The most crucial policy implemented to ensure effective digitalisation in the agro-food sector is the subsidised programs for the digital upgrade of firms. The respondents' views do not differ as to the degree of application of the digitalisation tools in the agro-food sector in Greece, depending on the size of the firms.

6. Conclusion

The objective of the present study was to investigate the primary tools and digitalisation applications used by firms in the agro-food sector in Greece. These factors encourage or discourage digitalisation and identify which policies are in place to ensure effective digitalisation in the agro-food sector. The results indicate that the implementation of digital technologies in Greece remains in an embryonic phase, only taking advantage of the key digital platforms and the Internet. Other digital applications that may facilitate the operation of these firms in a rather turbulent and competitive environment remain unexploited. Practical, the specialisation/knowledge of entrepreneurs in the sector with new technologies and the digital environment and the digital skills of the staff should be strengthened through training programs and seminars offered by the state and the competent commercial bodies. In addition, funding needs to be found to improve firms' digitalisation efforts. Possible avenues for future research may include a larger sample that could reveal more reasons for not adopting digital tools and targeted policies for amelioration.

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