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TAIWAN AND U.S. EQUITY MARKET INTERDEPENDENCE AND CONTAGION: EVIDENCE FROM FOUR-FACTOR MODEL

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ABSTRACT

A four-factor model is used to measure the interdependence's co-movement and crisis' contagion effect on portfolio returns of 23 Taiwanese industries during tranquil and the U.S. subprime mortgage crisis periods. By incorporating the control variables of economic and financial fundamentals, we deconstruct the relevance of returns on industrial assets' channels. The empirical results show that the co-movement effect on Taiwan's industrial portfolios returns are affected by "global," "regional," and "domestic" factors. Additionally, in the subprime mortgage crisis period, the contagion effect of Taiwan's industrial portfolios returns was affected by the domestic and crisis factor. Based on our empirical study, the transmission of Taiwan's industrial portfolio returns channel is significantly impacted by the instrument variables of interest rate, trade integration, political stability, and government budgets of the economy fundamentals.

JEL: G12, G15

KEYWORDS: Co-Movement, Contagion, Financial Crisis, Factor Model

INTRODUCTION

Increasing globalization and networkization raises the importance of mutual relationship among various countries. Most countries intend to establish regional economic cooperation to improve relationships and guarantee their interests. For example, countries attempt to improve regional economic integration through alliances such as the EU, CPTPP (Comprehensive and Progressive Agreement for Trans-Pacific Partnership, formerly known as the Trans-Pacific Partnership (TPP)), RCEP, and B&R (Belt and Road known as the Silk Road Economic Belt and the 21st-Century Maritime Silk Road). Such alliances have affected the relationship between countries in recent years. However, some countries have adopted anti-alliance propositions, such as the Grexit of Greece, Brexit of the United Kingdom (the U.K.), and President Trump's decision to withdraw the United States of America (U.S.) from the Trans-Pacific Partnership (CPTPP) Agreement. Overall, strengthening alliances among countries influences financial and trade markets and impacts mutual economies. Several studies in finance examine the transmission effect. Taiwan enjoys significant specialization, as it is located at the center of the Asia-Pacific region, special geopolitical ties, high volume trade, high inflows, and outflows of capital, and high degree of trade dependence. Therefore, Taiwan is a more efficient capital market with an open financial policy. However, in comparison to other countries, Taiwan, the RCEP, and CPTPP members do not have the advantages of regional economic integration, such as preferential tariffs, and the elimination of financial and trade barriers.

The U.S. has been an important trade and strategic partner of Taiwan. The trade volume between Taiwan and the U.S. was 62.1 billion USD in 2016, which was 12.34% of Taiwan's total trade volume. Taiwan has very close relations with the U.S. in terms of high frequent trading. As the U.S. has long been a leader in

the international financial market, it also has significant influence on Taiwan and is one of most important partners of Taiwan. Therefore, the motivation of this study is to explore whether Taiwan's industrial returns are affected by including partner-U.S. factors other than global, regional, and domestic factors.

Based on Bekaert, Ehrmann, Fratzscher, and Mehl (2014), this study examines the transmission phenomena in Taiwan. The first contribution of this study is different from the analysis of Bekaert et al. (2014) of a global co-movement and contagion based on global cross-country/regional industry portfolio returns. However, this study focuses on the transmission effect of only Taiwan's individual industry returns. The second feature of this study is the continuation of the three-factor model of Bekaert et al. (2014), with the addition of transmission factors from special partner countries as a four-factor model by exploring global, regional, partner countries, and domestic factors for their own national transmission effectiveness. Overall, this study, through a four-factor model coupled with the U.S. subprime mortgage crisis, understands that the industry return in Taiwan continues to have the co-movement and contagion effect during all sample and crises periods. Therefore, this study is contributes to the examination of the transmission effect of a single country.

The introduction section explores the study's background and motivation, followed by the literature review. The third section presents the data and methodology and the fourth section details the results and discussion. The final section concludes the paper.

LITERATURE REVIEW

The transmission argument begins with King and Wadhwani (1990) discussing the effect of co-movement of financial assets, which analyzes the correlation of returns between the U.S., the U.K., and Japan in the 1987 stock market crash period. Although in different economic environments, they find a market transmission phenomenon among these countries with their stock markets falling simultaneously, where one country's domestic market turmoil is the result of market fluctuations in the other countries. Additionally, they find that the markets fluctuated violently after October 1987. Since, the transmission phenomenon has been widely explored, particularly during crises periods.

Forbes and Rigobon (2002) compare the correlation of cross-sector assets return between full and crisis periods. They define "co-movement" as the transmission in full periods, including tranquility and crisis periods. Alternatively, "contagion" is the significant increase in transmission after the shock attack period. In other words, "contagion" is a significant increase in "co-movement" during a crisis period. They adopt a correlation coefficient heterogeneity bias model and conclude that there is a highly interdependent co-movement effect among all markets in all periods.

In addition to Forbes and Rigobon's (2002) correlation coefficient heterogeneity bias model, Bekaert, Harvey, and Ng (2005) propose a factor assets pricing model and define transmission as the correlation between residuals. They used global and regional stock price indices to establish a factorial model and converted these factors into a relationship through a mechanism. The relationship is called the exceed correlation factor and is beyond economic fundamentals. Furthermore, it increases correlation and factor volatility. The magnitude of increasing the correlation is determined by the factor loading. For example, if the international transmission channel collapses, resulting in weakened international transmission and increased domestic transmission, the international correlation will reduce and the domestic correlation will increase. Therefore, observing factor loadings by controlling time-variant economic or financial variables helps understand the transmission phenomenon through factors and channels.

Several studies discuss the transmission of financial crisis. For example, Rigobon (2003) explored the Mexico Tequila crisis. In addition, Baig and Goldfajn (1999), Kaminsky and Reinhart (2000), Dungey, Fry,

González-Hermosillo, and Martin (2006), Dooley and Hutchison (2009), and Longstaff (2010) discuss the transmission of financial crisis.

Governments adopt an aggressive monetary policy for financial bailouts in the aftermath of crisis. For example, the U.S. QE (Quantitative easing) is an unconventional monetary policy operated by a country's monetary authority (generally the central bank) through open market operations to increase the money supply in the real economy. Additionally, Japan's Abenomics are aggressive monetary policies that devaluate the domestic currency in order to enhance international competitiveness and boost the economy, but also indirectly affect the economies of their partner countries, forming the so-called "Beggar-Thy-Neighbor concept." Forbes and Rigobon (2002) empirically examine the "contagion" effect. In addition to exploring the crisis impact during the crisis period, they also explore various channels of shock transmission. Such channels include the strength of foreign trade, similarity among the countries' economic constitutions, financial weaknesses, and investor behaviors. Various channels affect the transmission effect differently. Bekaert, Harvey, and Ng (2005) define that the transmission among markets is more relevant than the economic fundamentals. In addition, they find that some mechanisms link the correlation between economic fundamentals and asset returns, particularly during crisis periods. However, there is considerable disagreement on the definition of economic fundamentals through which the transmission between countries is linked to the return on assets. Bekaert et al. (2014) use a number of control variables based on different hypotheses to explore the transmission channels. In addition, we use some of those relevant proxy control variables to explore the transmission channel as follows:

1. Financial institutions exposure hypothesis: Currencies circulate through monetary lending of financial institutions. Multinational financial institutions are important channels for the securities markets. Bekaert et al. (2014) state that financial institutions can impose financial constraints and adjust interest rates to affect the exposure of industrial transmission factors. They consider that financial liberalization will lead to changes in the quality of financial institutions, such as the stock market and banking industry. Therefore, liberalization will increase investment efficiency and affect the degree of transmission risk. Caramazza, Ricci, and Salgado (2004) explore financial linkage and the crises contagion, and find that financial correlation played an important role in the contagion in the Mexican, Asian, and Russian crises. Moreover, emerging markets with strong links to countries that bear the crisis will significantly increase the possibility of transmission. Kaminsky and Reinhart (2000) study the transmission mechanism of spillover effects and establish a crisis contagion model, which is analyzed by the cross-market influence of the linkage between the financial sector and the effect of international bank loans. Broner, Gelos, and Reinhart (2006) and Boyer, Kumagai, and Yuan (2006) examine that certain international funds with bilateral investments in the U.S. and outside the U.S. are forced to reduce international investments in overseas markets during crises. As a result, such international funds generate negative returns on global investment portfolios and create serious spillover effects.

2. Globalization hypothesis: Through the flow of assets, integration of financial and trade, and exchange rate variation form a linkage, which leads to the transmission phenomenon. First, Boyer, Kumagai, and Yuan (2006) empirically find evidence that crisis spreads globally through the flow of assets. It leads to a high degree of equity returns co-movement in emerging markets. Further, the globalization of economic integration has increased the exposure of transmission factors. On the other hand, there is significant decoupling between the financial industry and the exposure of transmission factors under anti-globalization. Several studies examine the integration of finance and trade, such as Forbes and Chinn (2004), which investigates the bilateral relations between the five largest economies and other markets to study their market relations. They find that the change of capital or trade among the global big powers often have a significant impact on other financial markets. Therefore, bilateral direct trade continues to be the most important factor in the co-movement of stock market returns. Baele (2005) and Bekaert and Harvey (1997) find that higher the integration level of a country's global or regional trade, the more transmission exposure there is with one's global or regional stock market return. Frankel and Rose (1998) also find a closer trade

link among countries, which will also lead to higher cross-border stock markets return under a similar economic cycle. Glick and Rose (1999) study transmission in the currency crisis and find that the alliance of the relevant countries could be tied by international trade to produce a mutually transmission effect. In addition, Bekaert and Harvey (1995) find that an open economy establishes broad links with global financial markets; Mendoza and Quadrini (2010) empirically study that more than half of the non-financial sector's net borrowing in the U.S. comes from foreign loans. When a market collapses, the impact of bank capital leads to the financial assets price spillover. The mark-to-market mechanism results in greater impact and a vicious circle. Consequently, opening up to trade and finance will speed up transmission and weaken the industry with higher financial and economic integration under the impact of the crisis. Consequently, they observe that globalization plays an important role in financial crisis. In addition, Bekaert and Harvey (1995) demonstrate that financial openness has some relation with transmission. They consider international financial assets and liabilities to be an index of financial integration, and use the size and market value of securities markets as financial depth indicators. Using purchasing power parity, Dumas and Solnik (1995) argue that stochastic fluctuations in exchange rates have linkage with changes in product prices, which is an additional time-varying exchange rate risk source of international asset pricing markets. Therefore, the four major global stock markets supported the co-movement of stock and currency foreign exchange risk premiums. Finally, Claessens and Forbes (2001) deal with the transmission channels and mechanisms resulting from soaring speculation by lowering the exports of high-technology products and higher USD. Bekaert, Harvey, Lundblad, and Siegel (2011) propose that a country's regulation of foreign capital flows and certain non-regulatory factors are important.

3. Wake-up hypothesis: The hypothesis states that investors may only experience some risk, for a particular market or crisis, and be prompted to re-examine the assessment of whether other markets experience the same crisis. Under this hypothesis, countries that do not have trade or banking links with the countries where the crisis originated, may also be exposed to the risks. However, the degree to which the factor is exposed depends on the steady state of the regulatory authorities and the economic fundamentals. Ahnert and Bertsch (2013) argue that the wake-up theory refers to speculators who increase the likelihood that speculative currencies have been attacked in the process of obtaining foreign information. They argue that the transmission mechanism of the wake-up theory provides a powerful explanation for the Asian currency crisis of 1997 and the Russian crisis of 1998. The transmissions of these two crises appear to have limited correlation with the fundamentals and connection among countries. Such transmission mechanisms may be changed by economic fundamentals to reflect in the political system, implementation of policies, coordination of external arrangements, internal employment policies, and the government budget.

4. Herding hypothesis: The herding behavior of investors or the risk appetite of investors results in unconscious transmission, which is beyond the fundamentals. The transmission phenomenon can be detected by the global risk indicators such as VIX. The volatility index (VIX) utilizes S&P 100 index option prices to generate and imply volatility from the Chicago Board Options Exchange (CBOE) established in 1997. This reflects the market's expectations of future market volatility to provide option traders with more information to plan their trading and hedging strategies, and offer a more practical and balanced perspective on the market's outlook. The VIX service reflects the change in investor sentiment, and the index is known as the "investor fear gauge." Baker, Wurgler, and Yuan (2012) constructed the VIX index as an indicator of investor sentiment. Empirical evidence shows that sentiment indicators have correlation with the relative prices of dual-listed companies. Similarly, global sentiment indicators are inverse predictors to predict the reverse of the market return. In other words, because of higher sentiment and lower yields in the future, arbitrage is relatively challenging to operate and the stocks' value is difficult to assess. Adrian and Shin (2010) argue that by the processing of investors' continually evaluation stocks, a change in equity immediately generates the reflection of asset prices changes. Besides, the trigger responses from financial intermediaries and the leverage with the characteristics of pro-cyclical can predict financial market risk based on the Chicago Board Options Volatility Index VIX index. Therefore, we can use the VIX as a proxy variable of investor risk awareness of transmission by the herding effect.

Based on the above hypothesis, we establish the proxy variables of related economic and financial control variables. As shown in Table 1, we examine the factor loading changes in instrumental variables by testing the industrial return channel in Taiwan and establish a full model to understand the implication of these economic fundamentals. There are time-varying degrees of transmission effect with different economic fundamentals. In other words, considering the shock contagion effect of different economic fundamentals, we investigate the channels of Taiwan's industrial portfolio returns.

Table 1: Control Instrument Variable (Z)

Category	Variables	Description	Unit
Banking Exposure (Banking Sector Hypothesis)	Interest rate exposure	Taiwan, Policy Rates, Discount Rate	%
External Exposure / Segmentation (Globalization Hypothesis)	Capital flows	Taiwan, Expenditure Approach, Gross Capital Formation	TWD
	Financial integration	Stock Position of Liabilities, % of Gross Domestic Product	% of GDP
	Financial depth	Taiwan, Doing Business, Getting Credit, Depth of Credit Information Index (0-8), Index	0-8
	Trade integration	United States, Exports to Taiwan, USD	USD
	Exchange rate exposure	Taiwan, Spot Exchange Rate	TWD
Domestic Macroeconomic Fundamental (Wake-up Hypothesis)	Political stability	Taiwan, Risk Rating, Political Stability	
	Sovereign rating	Taiwan, Risk Rating, Trade Credit (7 = Lowest Risk	1-7
	FX reserves	Taiwan, Reserves, Foreign Exchange, USD	US$
	Current account	Taiwan, Current Account Balance	% of GDP
	Unemployment rate	Taiwan, Unemployed Rate	% of Total Labor
	Government budget	Taiwan, General Government Structural Balance	% of GDP
Global / Common risk aversion (Herding Hypothesis)	Risk: VIX	CBOE SPX Volatility VIX (New)	ln %

The control instrument variables of four hypothesis - banking sector, globalization, wake-up and herding Data Source: DataStream

DATA AND METHODOLOGY

This study extends the three-factor model of Bekaert et al. (2014) to a four-factor model adding the partner-country factor for regression analysis. The four factors include the index of FTSE ALL WORLD, FTSE ASIA PACIFIC, FTSE UNITED STATES, and FTSE W TAIWAN. The extended the Capital Asset Pricing Model adopted as the main model for examining whether the systematic fundamental factors or the financial crisis contagion effects can explain the variations in Taiwan's industrial portfolio returns. Specifically, we implement four different hypotheses of 13 instrument variables to inspect the interdependence and financial crisis impacts in the empirical models, which can discern the main channels of Taiwan's industrial portfolio returns. The empirical sample period covers 1,119 weekly data points during the period 1996/1/1 to 2017/7/26. The 1,119 data points include variables of four market index returns: global, Asia-Pacific, U.S. and Taiwan, and 23 Taiwanese industry portfolio returns. In addition, we consider the U.S. subprime mortgage financial crisis during 2007/8 to 2009/3, and retrieve the empirical data from DataStream.

We use the factor model to define the change in factor loading (β, γ, η) as a factor transmission. First, we define the method of factor transmission, that is, the global impact on the region, the regional impact on the United States, and then the United States' impact on Taiwan by setting the impact factors of ($R_{w,t}$, $e_{reg,t}$, $e_{o,t}$, $e_{T,t}$). Dungey et al. (2005) propose that the fluctuation of returns during the crisis is attributed to three effects: common effect, idiosyncratic effect, and the contagion effect. By decomposing the three effects model, we orthogonalize country-level returns to obtain the residual as an indicator of the transmission contagion effect, after excluding the common effect and the idiosyncratic effect. The four factors are orthogonalized as follows:

$$R_{reg,t} = \alpha_{reg,0} + \beta_{reg,t}^{w} R_{w,t} + e_{reg,t} \quad (1)$$

$$R_{O,t} = \alpha_{O,0} + \beta_{O,t}^{w} R_{w,t} + \beta_{O,t}^{reg} e_{reg,t} + e_{O,t} \quad (2)$$

$$R_{T,t} = \alpha_{T,0} + \beta_{T,t}^{w} R_{w,t} + \beta_{T,t}^{reg} e_{reg,t} + \beta_{T,t}^{O} e_{O,t} + e_{T,t} \quad (3)$$

$R_{w,t}$, $R_{reg,t}$, $R_{O,t}$, $R_{T,t}$. Representing the world index excess return, regional index excess return, partner-U.S. index excess return, and the Taiwan index excess return for the FTSE country-level stock price index return minus risk-free interest rates. Besides, $e_{reg,t}$, $e_{O,t}$, and $e_{T,t}$ can be defined as the transmission factor representing the residual term obtained by orthogonalizing the excess return of $R_{w,t,}$ $R_{reg,t,}$ $R_{O,t,}R_{T,t}$. The $R_{w,t}$ represents the impact factor of "global," The $e_{reg,t}$ represents the impact factor of "regional." The $e_{T,t}$ represents the impact factor of Taiwan, and $e_{O,t}$ represents the impact factor of the United States. The impact factor is expressed as follows:

$F_t = [F_t^w, F_t^{reg}, F_t^O, F_t^T,] = [R_{w,t}, e_{reg,t}, e_{O,t}, e_{T,t}]$
F_t^w: Global factor, denoted by $R_{w,t}$
F_t^{reg}: Regional factor, denoted by $e_{reg,t}$
F_t^O: Partner-U.S. factor, denoted by $e_{O,t}$
F_t^T : Domestic factor, denoted by $e_{T,t}$

According to the direction of the spread, the global factor (F_t^w) is expressed by the world index ($R_{w,t}$). The regional factor (F_t^{reg}) is represented by the residual term ($e_{reg,t}$) derived from the regional index ($R_{reg,t}$), which regresses on the world factor (F_t^w). The partner-U.S. factor (F_t^O) is represented by the residual term ($e_{o,t}$) derived from the regression of the partner-U.S. index ($R_{o,t}$) on the world factor (F_t^w) and the regional factor (F_t^{reg}). Taiwan's domestic factor (F_t^T) is the residual term ($e_{T,t}$) derived from the regression of the Taiwan domestic index ($R_{T,t}$) on the world factor (F_t^w), regional factor (F_t^{reg}), and the partner-U.S. factor (F_t^o). $\beta_{i,t}^w, \beta_{i,t}^{reg}, \beta_{i,t}^o,$ $\beta_{i,t}^T$ are coefficients of $F_t^w, F_t^{reg}, F_t^o, F_t^T$, representing the global, regional, partner-U.S., and Taiwan's domestic factor loading, respectively.

The full model is as follows:

$$R_{i,t} = \alpha_{i,0} + \alpha_{i,0} R_{i,t-1} + \alpha_{i,2} dy_{i,t-1} + \beta_{i,t}' F_t + \eta_{i,t} CR_t + e_{i,t} \quad (4)$$

$$\beta_{i,t} = \beta_{i,o} + \beta_1' Z_{i,t-k} + \gamma_{i,t} CR_t \quad (5)$$

$$\gamma_{i,t} = \gamma_{i,0} + \gamma_1' Z_{i,t-k} \quad (6)$$

$$\eta_{i,t} = \eta_{i,0} + \eta_1' Z_{i,t-k} \quad (7)$$

For equations (4) to (7),

$R_{i,t}$: The excess returns of i-industry portfolio during week t
$R_{i,t-1}$: The excess returns of i-industry portfolio lagged by one week
dy: The dividend yield of the portfolios
F_t: Vector of the four observable factors $F_t = [F_t^w, F_t^{reg}, F_t^O, F_t^T]$
CR_t: The financial crisis proxy variable

$Z_{i,t}$: Vector of control variables lagged by 26 weeks to capture time and cross-industrial variables in factor exposures

We analyze Taiwan's industrial portfolios for both, the co-movement effect of interdependence and the contagion effect of crisis using a pooled Ordinary Least Squares (OLS) standard errors heteroskedasticity model. Further, Bekaert et al. (2014) define the United States subprime crisis period from August 2007 to March 2009. We also consider the United States subprime mortgage crisis (2007/8 to 2009/3) to be the crisis period. We then test the co-movement effect using the corresponding interdependence parameter, β_1', the contagion effect by contagion parameter γ_1', and the crisis effect by $\eta_{i,t}$. The variables $Z_{i,t}$, is lagged by 26 weeks to prevent unobservable factors from affecting same period of returns and $Z_{i,t}$ value simultaneously, resulting in a spurious regression.

To understand the well-specified factor model, we perform a correlation test on the residuals as a measure of excess co-movement indicators after performing regression on the portfolio returns. When the factor model outperforms or underperforms, there will be an excess co-movement phenomenon in residuals as follows:

$$EXCOV_t = \frac{2}{N(N-1)} \sum_{i=1}^{N} \sum_{j>i}^{N} (e_{i,t} \times e_{j,t}) \quad (8)$$

N: Represents the number of industry portfolios in Taiwan

We create a statistic that divides EXCOV by the number of sample variations to check for excess co-movement as follows:

$$ECTEST = \frac{\left[\left(\frac{1}{T}\right) \sum_{t=1}^{T} EXCOV_t\right]^2}{VAR(EXCOV_t)} \quad (9)$$

This test statistic conforms to $\mathcal{X}^2(1)$ null hypothesis.

We also establish EXCOR as another test statistic to perform cross-model and cross-period (crisis and non-crisis) analyses. First, $\rho_{i,j}$ is the correlation between the weighted average residuals of industrial portfolios i and j. The equation is as follows:

$$EXCOR = \frac{2}{N(N-1)} \sum_{i=1}^{N} \sum_{j>i}^{N} \rho_{i,j} \quad (10)$$

The empirical procedures include three steps:
First step: co-movement model (interdependence)

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,0}' F_t + e_{i,t} \quad (11)$$

The interdependent co-movement model represents the regression of the portfolios' excess returns $R_{i,t}$ on the four factors (F_t), global, regional, partner-U.S., and domestic-Taiwan. The coefficients ($\beta_{i,0}'$) are factor loadings of the co-movement effect. Besides, the model has an option of $\mathrm{CR}_t$to understand the same effect with crisis parameter.

2. Second step: contagion model

Besides the co-movement model, we add the crisis dummy variable, CR_t, as a contagion model to understand the transmission during the financial crisis. Equations (12) and (13) represent the contagion effect of the portfolios' excess returns ($R_{i,t}$) in the crisis period. The equation is as follows:

$$R_{i,t} = E_{t-1}\left[R_{i,t}\right] + \beta'_{i,t}F_t + \eta_{i,0}CR_t + e_{i,t} \quad (12)$$

$$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0}CR_t \quad (13)$$

$\beta_{i,0}$ represents the co-movement effect factor loading; $\gamma_{i,0,A}$ represents the contagion effect factor loading; $\eta_{i,0,A}$ represents the crisis effect factor loading. If there is a transmission, the factor loading value should change.

3. Third step: influential sources (channel) model

In addition, we include some financial and economic variables Z as control variables to understand the transmission channel. The equation is as follows:

$$R_{i,t} = E_{t-1}\left[R_{i,t}\right] + \beta'_{i,t}F_t + \eta_{i,t}CR_t + e_{i,t} \quad (14)$$

$$\beta_{i,t} = \beta_{i,o} + \beta'_1 Z_{i,t-k} + \gamma_{i,t}CR_t \quad (15)$$

$$\gamma_{i,t} = \gamma_{i,0} + \gamma'_1 Z_{i,t-k} \quad (16)$$

$$\eta_{i,t} = \eta_{i,0} + \eta'_1 Z_{i,t-k} \quad (17)$$

In equations (14) to (15), variables $Z_{i,t-k}$ represent the control variables by lagged two seasons, $\gamma_{i,0}$ represents the factor loading of the contagion effect, γ_1 is the factor loading of the contagion channel, $\eta_{i,0}$ represents the crisis factor loading of the interdependence effect, and η_1 represents the crisis factor loading of the interdependent effect's channel.

RESULTS AND DISCUSSION

Table 2 shows the descriptive statistics related to Taiwan's industrial portfolio returns. The statistics show zero means, right skewness, rejecting of unit root hypothesis, and no spurious regression. Table 3 shows the correlation matrix for returns of global, regional, United States, and Taiwanese industries. Panel A represents the correlation coefficients before orthogonalization. The correlation coefficient of Taiwan with global, Asia Pacific, and the United States factors is 0.474, 0.570, and 0.453, respectively. Panel B represents the correlation after orthogonalization. Apparently, all correlation coefficients fall sharply to 0 because orthogonalization removes common factors to be as well-specified as the contagion factors.

Table 2: Descriptive Statistics of Taiwan's Industrial Portfolio Returns

Panel A						
Industry	**BASIC MATS**	**CONSUMER GDS**	**CONSUMER SVS**	**FINANCIALS**	**TECHNOLOGY**	**AN HEALTH CARE**
Mean	0.0011	0.0007	0.0002	-0.0002	0.0011	-0.0008
Median	0.0007	0.0017	0.0000	-0.0003	0.0023	0.0000
Maximum	0.1926	0.2497	0.2007	0.2005	0.1880	0.2002
Minimum	-0.1599	-0.2528	-0.2260	-0.2358	-0.2490	-0.1940
Std. Dev.	0.0354	0.0437	0.0384	0.0410	0.0454	0.0366
Skewness	0.19	-0.25	-0.19	0.23	-0.25	0.12
Kurtosis	5.92	7.28	7.06	6.78	5.51	10.05
Jarque-Bera	411.2	878.6	786.1	684.6	310.3	2358.4
Probability	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1119	1119	1119	1119	1119	1119
Panel B						
Industry	**INDUSTRIALS**	**OIL & GAS**	**AUTO & PARTS**	**BANKS**	**CHEMICALS**	**ELTRO/ELEC EQ**
Mean	0.0009	0.0006	0.0005	-0.0002	0.0016	0.0007
Median	0.0013	0.0000	0.0000	0.0001	0.0000	0.0008
Maximum	0.1762	0.1890	0.7159	0.2126	0.2100	0.1762
Minimum	-0.2512	-0.1772	-0.9999	-0.2605	-0.1678	-0.2512
Std. Dev.	0.0428	0.0277	0.0522	0.0419	0.0404	0.0440
Skewness	-0.31	0.05	-3.83	0.14	0.34	-0.32
Kurtosis	6.37	11.82	152.49	6.94	5.47	6.15
Jarque-Bera	556.2	3678.5	1060473.0	737.8	309.1	488.1
Probability	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1119	1119	1119	1119	1119	1119
Panel C						
Industry	**FD PRODUCERS**	**FIN SVS L**	**INDS ENG**	**INDS TRANSPT**	**INDUSTRIAL MET**	**LIFE INSURANCE**
Mean	0.00177	-0.00046	0.00155	-0.00035	0.00060	0.00001
Median	0.00060	0.00000	0.00000	0.00000	0.00000	0.00000
Maximum	0.20025	0.18885	0.22314	0.26982	0.18043	0.77245
Minimum	-0.19403	-0.22593	-0.24717	-0.22310	-0.24800	-0.25448
Std. Dev.	0.04325	0.04308	0.05339	0.04466	0.03643	0.04895
Skewness	0.06	0.13	-0.65	0.09	-0.27	3.82
Kurtosis	5.38	6.24	6.95	6.75	8.22	60.73
Jarque-Bera	269.1	500.2	818.9	668.8	1302.1	160532.2
Probability	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1119	1119	1119	1119	1119	1119
Panel D						
Industry	**LEISURE GDS**	**OIL & GAS PROD**	**REAL EST**	**CON & MAT**	**TCH H/W & EQ**	
Mean	0.00171	0.00055	-0.00015	0.00012	0.00110	
Median	0.00072	0.00000	0.00000	0.00000	0.00234	
Maximum	0.24939	0.18897	0.24358	0.23006	0.18804	
Minimum	-0.25280	-0.17719	-0.20002	-0.20154	-0.24896	
Std. Dev.	0.05188	0.02773	0.04693	0.04724	0.04539	
Skewness	-0.15	0.05	0.71	0.01	-0.25	
Kurtosis	5.65	11.82	9.31	6.33	5.51	
Jarque-Bera	335.7	3678.5	1980.4	526.1	310.3	
Probability	0.00	0.00	0.00	0.00	0.00	
Observations	1119	1119	1119	1119	1119	

The descriptive statistics include the portfolio returns of 23 industries in Taiwan. Data Source: DataStream

Table 3: Correlation Matrix of Four Factors

Panel A: Raw Data				
	Global	**Regional**	**Partner-U.S.**	**Domestic-Taiwan**
Global	1.000	0.696	0.942	0.474
Regional	0.696	1.000	0.626	0.570
Partner-U.S.	0.942	0.626	1.000	0.453
Domestic-Taiwan	0.474	0.570	0.453	1.000
Panel B: Orthogonalized Data				
	Global	**Regional**	**Partner-U.S.**	**Domestic-Taiwan**
Global	1.000	0.000	0.000	0.000
Regional	0.000	1.000	0.000	0.000
Partner-U.S.	0.000	0.000	1.000	0.000
Domestic-Taiwan	0.000	0.000	0.000	1.000

In Panel A, "Global" represents FTSE ALL WORLD index return, "Regional" represents FTSE ASIA PACIFIC index return, "Partner-U.S." represents FTSE UNITED STATES index return, and "Domestic-Taiwan" represents FTSE W TAIWAN index return. In Panel B, the orthogonalized data follows the rule of equation from (1) to (3).

Based on the different hypotheses, we set up the instrument variables in the model to understand the channels of transmission effect. The descriptive statistics are shown in Table 4.

Table 4: Descriptive Statistics of Control Instrument Variables

	Interest Rate Exposure	Capital Flow	Financial Integration	Trade Integration	Exchange Rate Exposure	Political Stability	Current Account Balance	Unem-ployed Rate	Governme nt Budget	COBE VIX
Mean	0.62	184,792	708	4.59	25.01	1,820	-0.08	0.93	226	20.65
Median	0.47	182,543	699	4.46	25.41	1,708	-0.08	0.96	230	19.19
Maximum	1.41	249,359	1,071	27.76	30.99	2,193	-0.03	1.46	311	80.06
Minimum	0.24	91,955	429	-14.47	18.98	1,501	-0.15	0.36	131	9.77
Std. Dev.	0.33	29,166	110	8.95	3.12	216	0.03	0.22	54	8.37
Skewness	0.88	-0.10	0.13	0.20	-0.09	0.50	-0.52	0.05	0.00	1.96
Kurtosis	2.38	2.26	2.60	4.12	1.83	1.63	2.44	2.51	1.67	9.57
Jarque-Bera	163.59	27.25	10.74	66.84	65.20	135.38	65.65	11.70	83.02	2,740
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1119	1119	1119	1119	1119	1119	1119	1119	1119	1119

Data Source: DataStream

We analyze the transmission effect by performing regression on Taiwan's 23 industries' portfolio returns on global, regional, partner-U.S., and domestic Taiwan factors. We explore the co-movement or contagion effect owing to changes in the factor loading of β, γ, and η during the non-crisis period and the subprime mortgage crisis period. Finally, we combine the control variables to understand the transmission channel. According to the interdependence model represented by equation (11), Table 5 shows the co-movement effect of Taiwan's industrial portfolio returns on the four factors in the entire sampling period. To conclude, the four factors' exposures are 0.58 for the global factor, 0.55 for the regional factor, and 0.83 for the domestic factor, all of which are significant at the 1% level. The global, regional, and domestic factors have a significant co-movement effect on Taiwan's industrial portfolio returns, while the partner-U.S. factor has an insignificant co-movement effect on the returns.

Table 5: Interdependence Effect in Full Sample or Subprime Period

$R_{i,t} = E_{t-1}[R_{i,t}] + \beta'_{i,0}F_t(+\eta_{i,t}CR_t) + e_{i,t}$				
	Coef. (with CR)		**Coef. (without CR)**	
Interdependence				
β^w	0.66824	***	0.57883	***
β^{reg}	0.60408	***	0.55364	***
β^o	0.11596		0.20586	
β^d	1.06979	***	0.83216	***
Test Statistics				
ECTEST	0.00246		0.49033	
EXCOR	0.34379		0.46726	
Observation	45977		45977	
R^2	0.5460		0.3415	
Adjusted R^2	0.6188		0.3391	

*The interdependence model represented by equation (11), shows the co-movement effect of Taiwan's industrial portfolio returns on the four factors in the entire sampling period with or without CR. ***, **, and * indicate statistical significance at the 1%, 5%, and 10* levels, respectively.*

Confirming Bekaert et al. (2014)'s study, the exposure of emerging markets–except for that of the Americas–to the United States and the world is relatively small. In the test of individual residual co-movement in Taiwan's 23 industry portfolio, ECTEST and EXCOR for all periods indicated a chi-square statistic of 0.49 and 0.46, respectively, which is well below the 5% (1%) significance level; the critical value of $\chi^2(1)$-distributed variable was 3.86 (6.63). In other words, the correlation between excess co-movement residuals shows that the covariance between the industrial residuals is small.

Comparing the tests conducted in Bekaert et al. (2014) and our study, the former is a cross-border test, whereas the latter is only relevant to the domestic industry. Therefore, our conclusion is reasonable and acceptable. In addition, the results show that the domestic-Taiwan factor coefficient is 0.83 and has a stronger co-movement effect compared to the global and regional factors. The adjusted determination coefficient, R^2 is 0.34 without the parameter CR_t and 0.62 with the parameter CR_t, and the model has explanatory power.

For the contagion model represented by equations (14) and (15), Table 6 shows the contagion and interdependence effects of Taiwan's industrial portfolio returns on the four factors in the full sample. In the interdependence effect, the strongest effect is of the domestic factor with a coefficient value of 0.82, followed by coefficient values of 0.57 for the global factor and 0.53 for the regional factor, all of which are significant at the 1% significance level. The partner-U.S. co-movement factor is insignificant. On the contrary, the crisis factor η, although not economically significant, is still statistically significant at the 5% level. The adjusted determination coefficient, R^2, is 0.34 with explanatory power. Although the crisis contagion effect on the global factor, regional factor, and partner-U.S. factor are insignificant for the U.S. subprime crisis period, the domestic factor with a coefficient value of 0.27 is significant at the 10% significant level. Further, the crisis factor η in the U.S. subprime crisis spread is statistically significant at the 10% significant level, although the economy is insignificant at 0.008. For the contagion model during the U.S. subprime crisis, the adjusted determination coefficient, R^2, is 0.35 and has explanatory power.

For the crisis contagion model, we find that (1) the η coefficient of 10% is significant; however, the economy is insignificant, which indicates that Taiwan's industrial returns can be captured by the crisis factor. (2) The co-movement effect is captured by the β value; all factors other than the partner-U.S. are significant, especially the domestic factor, which shows that the transmission effect of Taiwan's industrial portfolio returns comes from global, regional, and domestic factors. In particular, the domestic factor has a strong economic significance. Therefore, most of the co-movement in Taiwan's portfolio mainly comes

from itself. Specifically, the U.S.A. factor in our study is different from that in Bekaert et al. (2014). It can be said because the sequence of orthogonalization of the partner-U.S. factor between the two studies is different; the U.S.A. factor in our study has been explained by global and regional factors, resulting in an insignificant U.S.A. factor. (3) All γ values for the crisis contagion are insignificant, indicating that during the crisis, Taiwan's industrial returns are less affected by external influences and are mainly affected by domestic factors. Comparing our study with Bekaert et al. (2014), the values of γ are significant in our study, and the result is different.

Table 6: Contagion Effect

$R_{i,t} = E_{t-1}[R_{i,t}] + \beta'_{i,0}F_t + \eta_{i,0}CR_t + e_{i,t}$
$\beta_{i,t} = \beta_{i,0} + \gamma_{i,0}CR_t$

	Coef.		Std Err.
Interdependence			
β^w	0.56857	***	0.0643
β^{reg}	0.53105	***	0.0831
β^o	0.22240		0.2113
β^d	0.81111	***	0.0672
Contagion			
γ^w	0.09172		0.1373
γ^{reg}	0.07536		0.1816
γ^o	-0.08457		0.4196
γ^d	0.27163	*	0.1686
Other			
η	0.00790	*	0.0060
Test Statistics			
ECTEST	0.51938		
EXCOR	0.46777		
Observation	2001		
R^2	0.3512		
Adjusted R^2	0.3459		

*The contagion model represented by equation (12) to (13) shows the contagion effect of Taiwan's industrial portfolio returns on the four factors and the U.S. subprime crisis. ***, **, and * indicate statistical significance at the 1%, 5%, and 10* levels, respectively.*

In the following section, the goodness-of-fit of the models are compared in four different settings: the interdependence model with and without the Taiwan market factor, and the contagion model with and without the Taiwan market factor. To make the model well-specified and for the factor exposure to fully predict the vulnerability, we use the interdependence model with and without the Taiwan factor to estimate Taiwan's industrial accumulated returns during the crisis. To test the goodness-of-fit, we regress the actual value, $R_{i,t}$ on the estimate $\hat{R}_{i,t}$. The slope parameters of Xs are 1 and statistically significant at the 0.01% level, suggesting that $\hat{R}_{i,t}$ is a good fitted value of $R_{i,t}$. In addition, we find that because the adjusted R-squared values with the Taiwan factor (0.79) and without the Taiwan factor (0.46) are significantly different, the model with the Taiwan factor is better fitted than that without the Taiwan factor. The details are as follows:

As shown in the normal probability plot in Figures 1 and Figure 2, the horizontal axis is the residual value and the vertical axis is the sample probability value. The data points generally fall near the virtual normal straight line, indicating that the data distribution is similar to the normal distribution. The residuals' range in Figure 1 is more concentrated than that in Figure 2, suggesting that the goodness-of-fit with the Taiwan factor of estimate is better than that without the Taiwan factor of estimate.

Figure 1: Normal Probability Plot of Residuals with Taiwan Factor

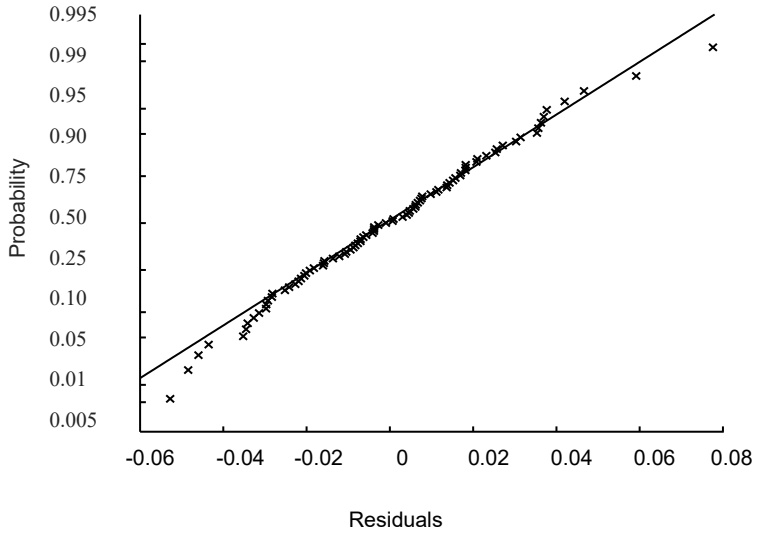


Figure 2: Normal Probability Plot of Residuals without Taiwan Factor

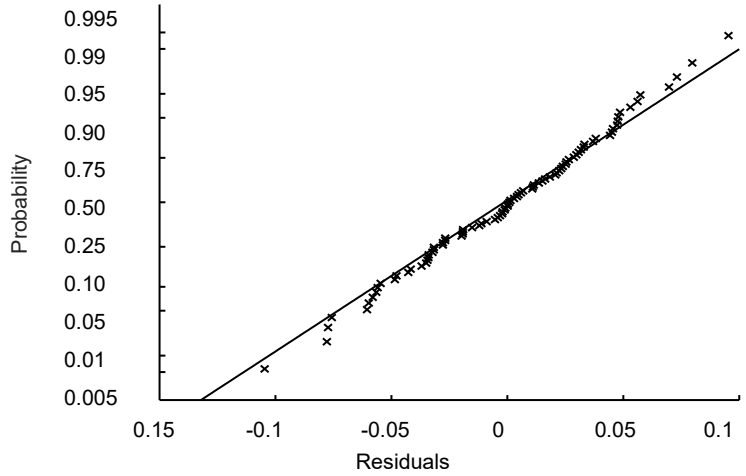


Figure 3 and Figure 4 show the bitmap of the interdependence model (Equation 11) of Taiwan industrial portfolio returns' fitted value and the actual returns and their allocation. From the graphs in Figure 3 (with the Taiwan factor) and Figure 4 (without the Taiwan Factor), it can be seen that the estimate is a goodness-of-fit, is concentrated on the mean value, and has a nonlinear relationship between fitted value and returns. The interdependence model with the Taiwan factor is better fitted than it is without the Taiwan factor. Comparing the graphs in Figure 3 (with the Taiwan factor) and Figure 4 (without the Taiwan Factor), the graph in Figure 4 (without the Taiwan Factor) is more curved than that in Figure 3 (with the Taiwan factor). This implies that the contagion model with the Taiwan factor is better fitted than that without the Taiwan factor.

Figure 3: Goodness-of-fit of Interdependence Model with Taiwan

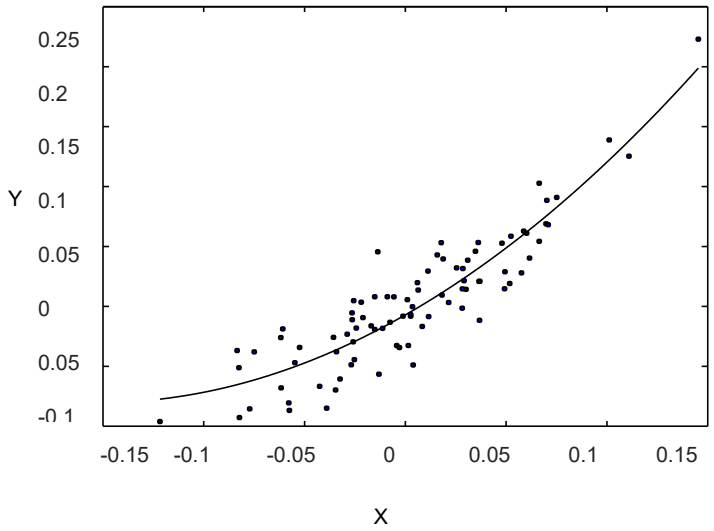
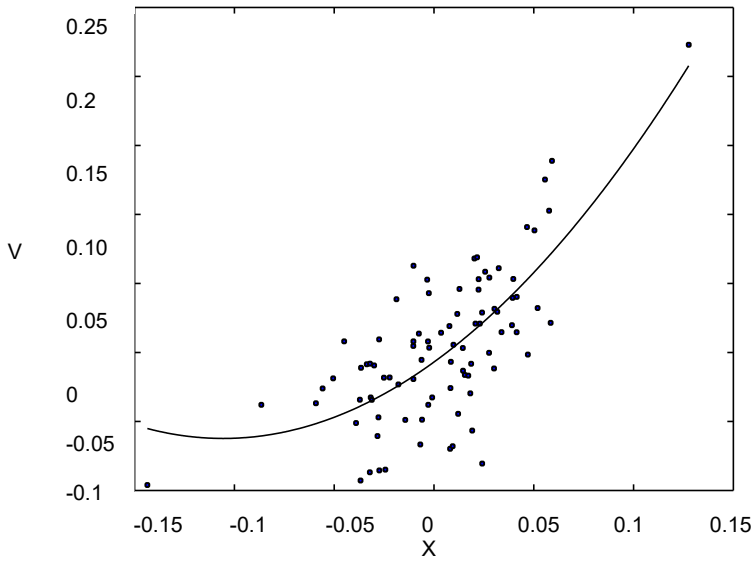


Figure 4: Goodness-of-Fit of Interdependence Model without Taiwan



Similarly, we consider the contagion model, represented by equations (14) and (15), with and without the Taiwan factor to estimate Taiwan's industrial accumulated returns during the crisis. Besides, we regress the actual value, $R_{i,t}$., on the fitted value $\widehat{R}_{i,t}$, to test the goodness-of-fit. Both slope parameters of X are 1 and statistically significant at the 0.01% level, showing evidence that $\widehat{R}_{i,t}$is a good fit value of $R_{i,t}$. Further, because the adjusted R-squared with the Taiwan factor (0.78) and without the Taiwan factor (0.44) have significant difference, the model with the Taiwan factor will have a better fit than that without the Taiwan factor. The details are as follows:

Figure 5 (with the Taiwan factor) and Figure 6 (without the Taiwan Factor) show a normal probability plot in which the horizontal axis is the residual value, the vertical axis is the sample probability value, and the data point falls roughly in the virtual space of the normal straight line; thus, the data distribution is similar to a normal distribution. The residuals range in Figure 5 is more concentrated than in Figure 6; therefore, the goodness-of-fit with Taiwan factor of estimate are better than without Taiwan.

Figure 5: Normal Probability Plot of Residuals with Taiwan Factor

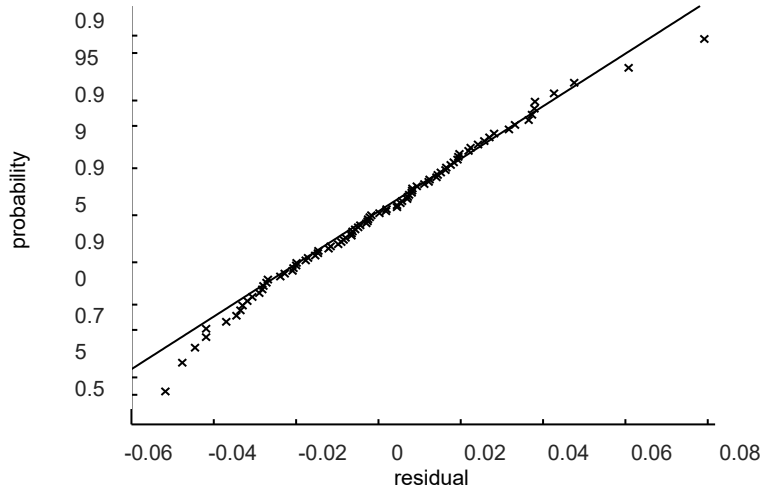
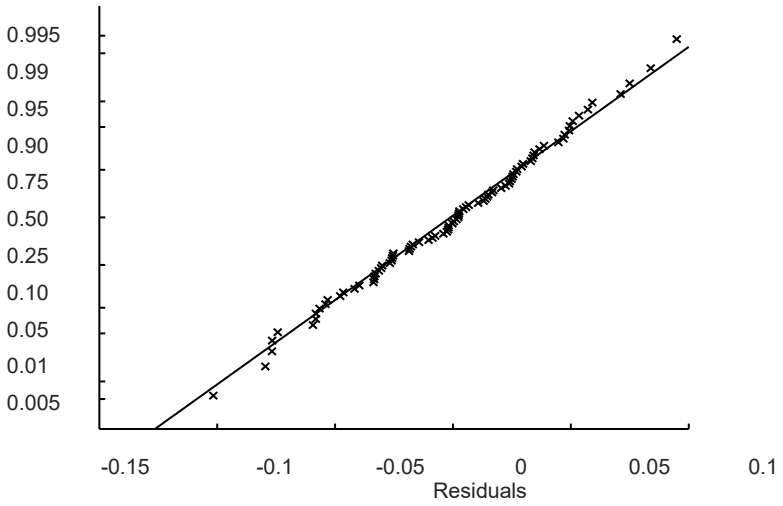


Figure 6: Normal Probability Plot of Residuals without Taiwan Factor



Comparing the graphs in Figure 7 (with the Taiwan factor) and Figure 8 (without the Taiwan Factor), the graph in Figure 8 (without the Taiwan Factor) is more curved than that in Figure 7 (with the Taiwan factor). This implies that the contagion model with the Taiwan factor is better fitted than that without the Taiwan factor.

Figure 7: Goodness-of-Fit of Contagion Model with Taiwan

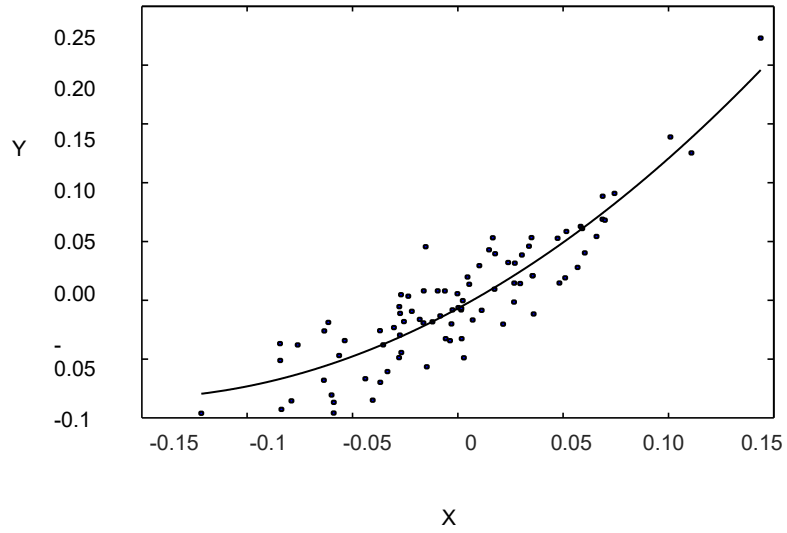
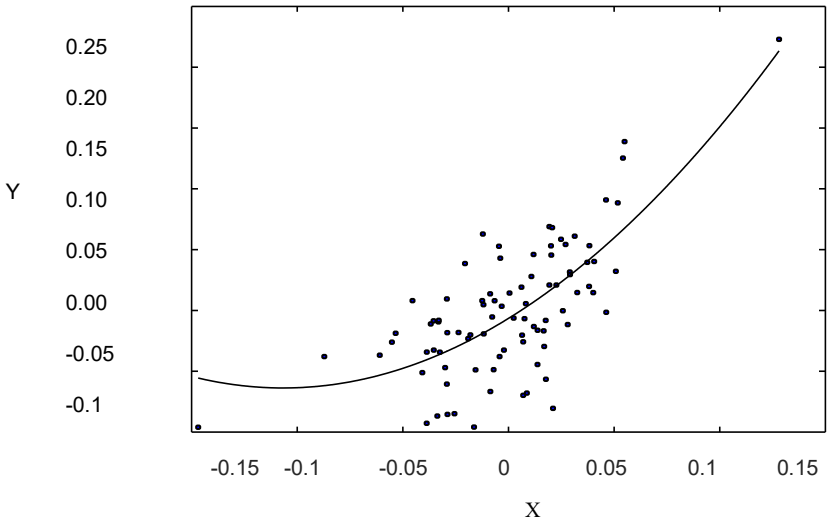


Figure 8: Goodness-of-Fit of the Contagion Model without Taiwan



The overall results strongly indicate that the interdependence models display extremely good fitness to interpret Taiwan's industrial portfolio return variations, whereas the contagion models add little additional information to understand Taiwan's industrial returns. Moreover, the domestic market factor plays an important role in determining the industrial sectors' returns, regardless of whether the full sample or financial crisis periods are considered.

In particular, based on equations (14) to (17), we combine the full model with the instrument control variables by examining factor loading - β, γ, and η changes to explore the channels of transmission of Taiwan's industrial portfolio returns. In addition, to study the co-movement and contagion effects, we first add instrument variables individually to the model (individual model), as shown in Table 7. Next, we add instrument variables simultaneously to the model (encompassing model), as shown in Table 8.

Table 7: The Interdependence and Contagion Effect (Individual Model)

	Contagion					Interdependence						
	γ^w	γ^{reg}	γ^o	γ^d	η	β^w	β^{reg}	β^o	β^d	η	R^2	Adjusted R^2
Interest rate exposure	-0.978	-0.093	-1.245	-0.071	0.086 ***	-0.383 **	-0.053	-0.478	-0.131	-0.058 **	0.370	0.360
Capital flows	-1.295	0.441	-1.420	-0.701	-0.059 *	0.528 *	-0.282	0.025	0.091	0.724 *	0.365	0.354
Financial integration	-0.001	0.000	-0.001	0.000	0.000	0.001 *	-0.001	0.000	0.000	0.026	0.364	0.353
Trade integration	0.031	-0.036	0.131	-0.017	-0.004 ***	0.001	0.004	-0.024	0.003	0.006 *	0.368	0.357
Exchange rate exposure	0.002	0.007	-0.080	-0.018	-0.001	-0.024	-0.023	-0.020	-0.007	0.036	0.363	0.353
Political stability	-0.002	-0.001	-0.005	0.000	0.000 ***	0.001 ***	0.000	0.001 *	0.000	-0.614 ***	0.378	0.368
Current account	-11.070	6.976	-120.524 *	-17.516	1.835 *	2.424	-2.616	7.649	0.963	0.102 *	0.367	0.356
Unemployment rate	-0.641	-0.375	-2.193	-0.414	0.029	0.319	-0.140	0.374	0.005	-0.020	0.366	0.355
Government budget	-0.034	0.011	-0.098	0.025	0.005 ***	0.003 ***	0.001	0.004	0.002 *	-1.138 ***	0.381	0.370
Risk: VIX	0.004	0.037	-0.020	-0.010	0.001	0.006	-0.009	-0.008	0.003	-0.010	0.362	0.351

*The individual full model represented by equation (14) to (15), shows the channels of the interdependence and contagion effect of Taiwan's industrial portfolio returns on the four factors, and the U.S. subprime crisis with instrument control variables individually. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

Table 8: The Interdependence and Contagion Effect (Encompassing Model)

	Contagion					Interdependence				
	γ^w	γ^{reg}	γ^o	γ^d	η	β^w	β^{reg}	β^o	β^d	η
Interest rate exposure	-15.430 *	2.860	-31.129	26.798 **	2.067 **	0.019	-0.883	-0.006	0.352	0.208
Capital flows	13.995	10.182	-26.026	-42.760 ***	0.140.0	-0.014	0.644	-2.113	0.097	0.208
Financial integration	0.011	-0.010	0.009	0.000	-0.491	0.001	-0.001	0.001	-0.001	0.208
Trade integration	-0.271	0.043	-1.791	-0.132	-1.391 *	0.005	-0.013	-0.009	0.003	0.208
Exchange rate exposure	-0.084	-0.029	1.654 *	1.337 **	1.893 **	-0.018	0.046	0.026	0.013	0.208
Political stability	0.113	0.078	-0.576	-0.295 *	0.158	0.000	0.000	0.002	-0.001*	0.208
Current account	314.100	251	-2,294 *	-1,034 *	-0.925	-0.977	-10.239 **	5.516	-0.938	0.208
Unemployment rate	-9.677	-3.070	-0.810	-12.480	-2.877 ***	0.047	-1.543	0.266	-0.149	0.208
Government budget	-1.075	-1.035	6.775 *	2.903 *	-0.253	0.003	0.005	-0.003	0.009**	0.208
Risk: VIX	-0.013	0.086 **	-0.167 **	0.059 *	1.274	0.011 *	-0.003	-0.025	0.006	0.208
R^2=0.45, Adjusted R^2 =0.40										

*The Encompassing full model represented by equation (14) to (15) shows the channels of the interdependence and contagion effect of Taiwan's industrial portfolio returns on the four factors and the U.S. subprime crisis with instrument control variables simultaneously. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

The co-movement in global factor β^w is statistically significant at the 1% level with respect to interest rate exposure, political stability, and government budget. Besides, it is statistically significant at the 10% level with respect to capital flow and financial integration. In addition, the crisis factor, η, is statistically significant in both the full sample and crisis periods for interest rate exposure, trade integration, political stability, and government budget, at the 1% significance level, and both capital flow and current account at the 10% significance level.

To regress the same control variable simultaneously, Table 8 reveals the statistical significance of the domestic factor in contagion effects through interest rate exposure, capital flow, exchange rate exposure, political stability, current account, government budget, and VIX channels. The crisis factor is of statistical significance in contagion effects through different channels, such as interest rate, trade integration, exchange rate, and unemployment rate. The effects of co-movement, as previously studied, are influenced by global, regional, and domestic factors. In particular, the VIX index is significant in the encompassing model. This implies that the crisis effect can be transmitted through the VIX channel.

Tables 5 and 6 reveal that Taiwan's industrial portfolio returns experience interdependent effects owing to global, regional, and domestic factors. In particular, domestic factors play a significant role in both economic and statistical influences. However, the partner-U.S. factor is insignificant, which can be explained by the fact that the global financial and economic impact on the United States is equivalent to that of the global and regional economies. By orthogonalizing global and regional factors on the U.S. factor, the global and regional factors explain most of the U.S. factors across many phenomena. In Table 6, for the contagion effect during a crisis period, domestic and crisis factor are significant, whereas the global, regional, and partner-U.S. factors are insignificant. Evidently, domestic and crisis factor have a significant impact on Taiwan's industrial portfolio returns. The returns on Taiwan's industrial portfolios were more affected by domestic and crisis factors when compared to other countries' portfolio returns during the sub-prime crisis.

We further explore the channels through which these phenomena occur and clarify them through different hypotheses. First, financial institutions' exposure shows that the co-movement and contagion effects are affected by crisis factor of financial institutions' channels. Second, through the globalization test, the globalization instrument variables influence Taiwan's industrial portfolio returns. They mainly come from the crisis factor of the co-movement and contagion effect via capital flows and trade integration channels. In particular, capital flows and trade integration in the co-movement effect have a negative impact on the contagion effect, as shown in Table 7. Essentially, the effects increased due to capital flows and good trade relations during tranquil periods, and worsened during the U.S. subprime mortgage crisis period. Third, the wake-up theory hypothesis for global and crisis factors of Taiwan's industrial portfolio returns co-movement or contagion effect through political stability, current account, and government budget channels. We find that political stability is a key factor affecting Taiwan's industrial portfolio returns. In particular, the political stability and government budget channels have the opposite sign of the value of η for co-movement and contagion. Generally, Taiwan's industrial portfolio returns will have an adverse contagion effect during crises through the impact of economic indicator channels.

CONCLUSION

In conclusion, Taiwan has a special geographical position and complicated political status. Although Taiwan is not a member of international organizations such as CPTPP or RCEP, it is still an economic entity considerably dependent on foreign trade. Therefore, its economy is easily affected by other countries, especially its relationship with the U.S., one of Taiwan's most important trading partners. Our study uses the four-factor model to investigate the co-movement effect during the full sample period and the contagion effect during the U.S. subprime crisis period. First, we regress Taiwan's industrial portfolio returns on four-factors in three progressive steps. We find that Taiwan's industrial portfolio returns are significant in global, regional, and domestic factors in both the interdependent and contagion models. It shows that the co-movement effect of Taiwan's industrial portfolio returns comes from global, regional, and domestic factors by β value. In particular, the domestic factor has strong economic significance. Therefore, most of the co-movement is domestic, whereas, it is insignificantly effective in partner-U.S. Owing to the sequence of orthogonalization of the partner-U.S. factor, global and regional factors explain the U.S.A. factor in our study, resulting in an insignificant U.S.A. factor. Additionally, it is significant in the crisis factor by η value but insignificant in the contagion effect by γ value. We then test the factor of goodness-of-fit of the

interdependence/contagion model, which suggests that the goodness-of-fit with the Taiwan factor of estimate is better than without the Taiwan factor of estimate. Finally, we study the channels of transmission in the full model. Based on the empirical study, we find that the transmission of Taiwan's industrial portfolio returns' channel is significantly impacted by the variables of interest rate, political stability, and government budgets of the economic fundamentals in the crisis factor exposure η and the co-movement global factor β^w. Further, trading with other countries as well as injected capital flow can influence Taiwan's industry to some degree. Taiwan cannot remain isolated from the world, resulting in the transmission effect of industrial portfolio returns. The limitation of these financial contagion investigations is that we only focus on U.S. subprime mortgage crisis period. Nevertheless, we also perform a test for robustness during the Asian Financial Crisis of July 1997 to December 1998, but which is not included owing to space limitations. In addition, for completeness of the test, we need to adopt more factors to confirm our finding in future research.

REFERENCES

Adrian, T. and H. S. Shin (2010) "Liquidity and leverage," *Journal of financial intermediation,* vol. 19(3), p. 418-37.

Ahnert, T. and C. Bertsch (2013) "A wake-up call: information contagion and strategic uncertainty," Available at SSRN: https://ssrn.com/abstract=2364405

Baele, L. (2005) "Volatility Spillover Effects in European Equity Markets," *The Journal of Financial and Quantitative Analysis,* vol. 40(2), p. 373-401.

Baig, T. and I. Goldfajn (1999) "Financial Market Contagion in the Asian Crisis," *IMF Staff Papers,* vol. 46(2), p. 167-95.

Baker, M., J. Wurgler and Y. Yuan (2012) "Global, local, and contagious investor sentiment," *Journal of Financial Economics,* vol. 104(2), p. 272-87.

Bekaert, G., M. Ehrmann, M. Fratzscher and A. Mehl (2014) "The Global Crisis and Equity Market Contagion," *The Journal of Finance,* vol. 69(6), p. 2597-649.

Bekaert, G. and C. R. Harvey (1995) "Time-Varying World Market Integration," *The Journal of Finance,* vol. 50(2), p. 403-44.

Bekaert, G. and C. R. Harvey (1997) "Emerging equity market volatility," *Journal of Financial Economics,* vol. 43(1), p. 29-77.

Bekaert, G., C. R. Harvey, C. T. Lundblad and S. Siegel (2011) "What segments equity markets?," *The Review of Financial Studies,* vol. 24(12), p. 3841-90.

Bekaert, G., C. R. Harvey and A. Ng (2005) "Market Integration and Contagion," *The Journal of Business,* vol. 78(1), p. 39-69.

Boyer, B. H., T. Kumagai and K. Yuan (2006) "How do crises spread? Evidence from accessible and inaccessible stock indices," *The Journal of Finance,* vol. 61(2), p. 957-1003.

Broner, F. A., R. Gaston Gelos and C. M. Reinhart (2006) "When in peril, retrench: Testing the portfolio channel of contagion," *Journal of International Economics,* vol. 69(1), p. 203-30.

Caramazza, F., L. Ricci and R. Salgado (2004) "International financial contagion in currency crises," *Journal of International Money and Finance,* vol. 23(1), p. 51-70.

Claessens, S. and K. Forbes. (2001)"International financial contagion: An overview of the issues," *International financial contagion*, p. 3-17.

Dooley, M. and M. Hutchison (2009) "Transmission of the US subprime crisis to emerging markets: Evidence on the decoupling–recoupling hypothesis," *Journal of International Money and Finance,* vol. 28(8), p. 1331-49.

Dumas, B. and B. Solnik (1995) "The World Price of Foreign Exchange Risk," *The Journal of Finance,* vol. 50(2), p. 445-79.

Dungey, M., R. Fry, B. González-Hermosillo and V. Martin (2006) "Contagion in international bond markets during the Russian and the LTCM crises," *Journal of Financial Stability,* vol. 2(1), p. 1-27.

Dungey, M., R. Fry, B. Gonzalez-Hermosillo and V. L. Martin (2005) "Empirical Modelling of contagion: a review of methodologies," *Quantitative Finance,* vol. 5(1), p. 9-24.

Forbes, K. J. and M. D. Chinn (2004) "A decomposition of global linkages in financial markets over time," *The Review of Economics and Statistics,* vol. 86(3), p. 705-22.

Forbes, K. J. and R. Rigobon (2002) "No Contagion, Only Interdependence: Measuring Stock Market Comovements," *The Journal of Finance,* vol. 57(5), p. 2223-61.

Frankel, J. A. and A. K. Rose (1998) "The Endogeneity of the Optimum Currency Area Criteria," *The Economic Journal,* vol. 108(449), p. 1009-25.

Glick, R. and A. K. Rose (1999) "Contagion and trade: Why are currency crises regional?" *Journal of International Money and Finance,* vol. 18(4), p. 603-17.

Kaminsky, G. L. and C. M. Reinhart (2000) "On crises, contagion, and confusion," *Journal of International Economics,* vol. 51(1), p. 145-68.

King, M. A. and S. Wadhwani (1990) "Transmission of Volatility between Stock Markets," *The Review of Financial Studies,* vol. 3(1), p. 5-33.

Longstaff, F. A. (2010) "The subprime credit crisis and contagion in financial markets," *Journal of Financial Economics,* vol. 97(3), p. 436-50.

Mendoza, E. G. and V. Quadrini (2010) "Financial globalization, financial crises and contagion," *Journal of Monetary Economics,* vol. 57(1), p. 24-39.

Rigobon, R. (2003) "On the measurement of the international propagation of shocks: is the transmission stable?" *Journal of International Economics,* vol. 61(2), p. 261-83.

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