ICIC Express Letters ICIC International ©2013 ISSN 1881-803X
Volume **7**, Number **9**, September **2013** pp. **2461–2466**

HAS CEPA INCREASED STOCK MARKET DEPENDENCE BETWEEN HONG KONG AND CHINA? THE APPLICATION OF CONDITIONAL COPULA TECHNIQUE

Chung-Chu Chuang[1,*] and Jeff T. C. Lee[1,2]

[1]Department of Management Sciences
Tamkang University
No. 151, Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan
[*]Corresponding author: ccchuang@mail.tku.edu.tw

[2]Department of Finance
Lunghwa University of Science and Technology
No. 300, Sec. 1, Wanshou Rd., Guishan, Taoyuan County 333, Taiwan
jefftclee2003@yahoo.com.tw

Received December 2012; accepted March 2013

Abstract. *We investigate a possible change in conditional dependence between the Hong Kong and Chinese stock markets as a result of the Closer Economic Partnership Arrangement (CEPA) that took effect in 2004. Three types of conditional copula, Gaussian, Gumbel, and Clayton, are employed to measure the change in conditional dependence between these two markets. Our results indicate that the conditional dependence derived from the Gumbel copula increases significantly in the post-CEPA period. Conditional dependences derived from the Gaussian and Clayton copulas display a tendency to increase, but do not reach a significant level. These results imply that, in the post-CEPA period, conditional dependence increases significantly only when the Hong Kong and Chinese stock markets are both rising, and not when they are declining or stable. This finding contradicts some previous studies that stock markets are increasingly correlated when in decline.*

Keywords: CEPA, Copula, Conditional dependence

1. **Introduction.** During the last two decades, economic integrations have become a global trend. In Asia, economic integrations began to strengthen in the early part of the twenty-first century. Of particular note are the Closer Economic Partnership Arrangement (CEPA) between Hong Kong and China that took effect in 2004; the free trade agreements between the Association of Southeast Asian Nations (ASEAN) and China that came into effect in January 2010; and the Economic Cooperation Framework Agreement (ECFA) between China and Taiwan that became effective in September 2010. Under these agreements, most tariffs will drop to zero in the near future to boost regional trade.

Many research papers have suggested that economic integration increases dependence among financial markets. Johnson and Soenen [1] discovered a strong positive stock market co-movement among countries in the Americas that carry out significant trade with the United States. Patton [2] ascertained a strong indication of structural breaks in exchange rates between the Yen against the dollar and the Mark against the dollar after the introduction of the euro. Bartram, Taylor and Wang [3] found an increase in equity market dependence within the Eurozone after the effects of the common currency set in. Most of these studies explored the effect of economic integration on financial market dependence in North America and Europe. Only a few papers have delved into this issue among Asian economies. Moreover, most studies on Asian economic integration have focused on foreign direct investments (FDI) [4,5], while others have explored the contagion effects of extreme events [6,7] among Asian stock markets. However, the effect of economic integration on stock market dependence between the counterparties in this region has not been investigated. Thus, we adopt the conditional copula method to measure the conditional dependence between the Hong Kong and Chinese stock markets before and after CEPA. Since CEPA is Asia's first foray into economic integration with China and many economies are in the process of entering into free trade agreements (FTAs) with China, the case of CEPA can be related to how economic integration influences stock markets dependence in Asia. The following are the two reasons for adopting conditional copulas: (i) conditioning can better measure stock market dynamics; (ii) copulas can combine different marginal distributions to provide a more accurate measure of dependence.

The remainder of this article is organized as follows. In Section 2, we briefly describe our data characteristics. Next, we explain our methodology in detail in Section 3. We will illustrate a time path of the conditional correlation between the Hong Kong and Chinese stock markets and list our empirical results in Section 4. We provide some conclusions in Section 5.

2. **Data and Summary Statistics.** The daily closing prices of the Hang Seng index and the Shanghai Composite index were downloaded from Datastream to represent the Hong Kong and Chinese stock market prices. Data were collected for the period from January 5, 1999 to December 31, 2009. After excluding non-common trading days, a total of 2,564 observations were processed. We used January 1, 2004, when CEPA formally took effect, as a known break point and compared the summary statistics of both pre- and post-CEPA periods. The results are illustrated in Table 1.

Table 1. Summary statistics

Statistics	Pre-CEPA		Post-CEPA		Whole Period	
	Hong Kong	China	Hong Kong	China	Hong Kong	China
Mean	0.024	0.027	0.036	0.052	0.031	0.041
Standard Deviation	1.621	1.469	1.868	1.990	1.760	1.774
Skewness	−0.079	0.732**	0.012	−0.218**	−0.018	0.023
Excess Kurtosis	2.761**	5.571**	9.063**	2.546**	7.239**	3.619**
Jarque-Bera	368.2**	1597.1**	4815.7**	391.4**	5595.2**	1398.5**
Linear Correlation	0.112		0.432		0.321	

Note: **(*) represents the significance at 0.01 (0.05) level.

Both excess kurtosis and Jarque-Bera statistics are significant for the Hong Kong and Chinese stock markets, indicating the distributions for both markets are fat-tailed and non-normal. The distribution for the Hong Kong stock market is not significantly skewed. However, skewness for the Chinese stock market is significant and changes from positive, pre-CEPA to negative, post-CEPA. The linear correlation increased from 0.112, pre-CEPA to 0.432, post-CEPA. The increase in linear correlation implies a possibility of structural change after CEPA took effect.

3. **Methodology.** In this section, we first describe the methodology of combining two marginal distributions into a joint distribution. Second, we introduce the marginal models for the Hong Kong and Chinese stock markets. Third, we derive the conditional dependences from the Gaussian, Gumbel and Clayton copulas. Lastly, the conditional correlations are calculated by numerical integration.

3.1. **Models for joint distributions.** The copula combines two different marginal distributions into a joint distribution. Assume $F_t(z_{hk,t}|\psi_{t-1})$ and $G_t(z_{ch,t}|\psi_{t-1})$ are cumulated density functions (c.d.f.) for the Hong Kong and Chinese stock markets respectively. According to Sklar's theorem [8], the joint conditional c.d.f. can be illustrated below.

$$\Phi_t(r_{hk,t}, r_{ch,t}|\psi_{t-1}) = C_t(u_{hk,t}, v_{ch,t}|\psi_{t-1}) = C_t(F_t(z_{hk,t}|\psi_{t-1}), G_t(z_{ch,t}|\psi_{t-1})), \quad (1)$$

where $u_{hk,t} = F_t(z_{hk,t}|\psi_{t-1})$ and $v_{ch,t} = G_t(z_{ch,t}|\psi_{t-1})$. ψ_{t-1} is the information set at time $t-1$. Therefore, the conditional probability density function (p.d.f.) is

$$\varphi_t(z_{hk,t}, z_{ch,t}|\psi_{t-1}) = c_t(u_{hk,t}, v_{ch,t}|\psi_{t-1}) \times f_t(z_{hk,t}|\psi_{t-1}) \times g_t(z_{ch,t}|\psi_{t-1}), \quad (2)$$

where $f_t(z_{hk,t}|\psi_{t-1})$ and $g_t(z_{ch,t}|\psi_{t-1})$ represent marginal densities for Hong Kong and China, respectively.

3.2. **Specification of marginal distributions.** Based on different skewness in Table 1, we choose GJR-GARCH$(1,1)$-t as a marginal distribution for the Hong Kong stock market and GJR-GARCH$(1,1)$-skewed t for the Chinese stock market. The marginal distribution models are defined by

$$r_{i,t} = \alpha_{i,t} + \varepsilon_{i,t}, \ i = hk, ch \quad (3)$$

$$\sigma_{i,t}^2 = c_i + b_i\sigma_{i,t-1}^2 + a_{i,1}\varepsilon_{i,t-1}^2 + a_{i,2}I_{i,t-1}\varepsilon_{i,t-1}^2, \quad (4)$$

$$\varepsilon_{hk,t}|\psi_{t-1} = \sigma_{hk,t}z_{hk,t}, \ z_{hk,t} \sim t_v(0, \sigma_{hk,t}), \text{ for the Hong Kong stock market} \quad (5)$$

$$\varepsilon_{ch,t}|\psi_{t-1} = \sigma_{ch,t}z_{ch,t}, \ z_{ch,t} \sim \text{ skewed } t(\eta, \varsigma), \text{ for the Chinese stock market} \quad (6)$$

where $r_{i,t}$ is the index return at time t. Indication function $I_{i,t-1}$ will be equal to 1 when the residual $\varepsilon_{i,t-1}$ is negative at time $t-1$; otherwise, $I_{i,t-1}$ will be 0. Standardized residual $z_{hk,t}$ follows t distribution with v degree of freedom, while $z_{ch,t}$ follows skewed-t distribution with skewness parameter ς and kurtosis parameter η.

3.3. **Specification of dependence structure.** Different conditional copula densities have different functional characteristics. The Gaussian copula assumes that the probabilities of dependence on two tails are very slim. The Gumbel copula has high probabilities on right-tail dependence, while the Clayton copula has high probabilities on left-tail dependence. These three copula functions can be found in many reference papers [7,9] and thus can also be employed in this study.

Conditional dependences are assumed to follow ARMA processes [2,3,9]. To detect the structure break for January 1, 2004, we add a dummy variable in this process. The modified ARMA processes are

$$\rho_t = \omega + \beta\rho_{t-1} + \alpha\sum_{j=1}^{10}|u_{t-j} - v_{t-j}|/10 + \lambda D_t, \quad (7)$$

$$\tau_t = \omega + \beta\tau_{t-1} + \alpha\sum_{j=1}^{10}|u_{t-j} - v_{t-j}|/10 + \lambda D_t, \quad (8)$$

in which ρ_t is the conditional dependence for the Gaussian copula at time t and τ_t is the conditional dependence for the Gumbel and Clayton copulas at time t. The parameter β for ρ_{t-1} and τ_{t-1} represents the persistence of conditional dependence. The average of 10 previous absolute differences, $\sum_{j=1}^{10}|u_{t-j} - v_{t-j}|/10$, captures the variability for these dependences. The more variability between u_{t-j} and v_{t-j}, the less dependence for ρ_t and τ_t. Therefore, the parameter α is expected to be negative. The dummy variable D_t is equal to 1 when the dates are beyond January 1, 2004; otherwise, it will be 0.

After estimating dependence in the Gumbel and Clayton copulas, conditional correlations are obtained by the following equation

$$corr = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} z_{hk,t}z_{ch,t}\varphi(z_{hk,t}, z_{ch,t}|\psi_{t-1})drds, \quad (9)$$

in which $\varphi(z_{hk,t}, z_{ch,t}|\psi_{t-1})$ is referred to Equation (2).

4. **Empirical Results.** The estimated parameters for the marginal models are presented in Table 2. In every time period, most parameters are significant for both the Hong Kong and Chinese stock markets. For example, the significances of $a_{i,1}$ and b_i show the existence of ARCH and GARCH effects in Hong Kong and Chinese stock markets. Both parameters comply with the restrictions of $a_{i,1} > 0$, $b_i > 0$, $a_{i,1} + b_i < 1$. Except for post-CEPA in the Chinese stock market, the significances of $a_{i,2}$ also show the asymmetry effects in both markets. The levels and the significances of η and ς characterize high kurtosis and negative skewness in the Chinese stock market. Moreover, the significances of parameters in pre- and post-CEPA time periods are stable, implying the chosen marginal models are suitable for both stock markets.

Table 2. Parameter estimates for marginal models

	Hong Kong			China		
Parameters	Pre-CEPA	Post-CEPA	Whole Period	Pre-CEPA	Post-CEPA	Whole Period
$\alpha_{i,t}$	0.0017	0.0755**	0.0512*	−0.0279	0.0639	0.0101
c_i	0.0340*	0.0158**	0.0139**	0.0834**	0.0446*	0.0457**
$a_{i,1}$	0.0052	0.0442**	0.0246**	0.0761**	0.0575**	0.0746**
b_i	0.9501**	0.9125**	0.9367**	0.8267**	0.9223**	0.8875**
$a_{i,2}$	0.0643**	0.0779**	0.0687**	0.1620**	0.0223	0.0687**
v	7.1052**	7.2521**	7.3472**			
η				4.2751**	5.7745**	4.8077**
ς				−0.0339	−0.0854*	−0.0609*
Log-likelihood	−2117.5	−2410.8	−4533.8	−1888.8	−2797.6	−4704.0

Note: **(*) represents the significance at 0.01 (0.05) level.

In Table 3, we present the estimated parameters for the conditional dependences. All β are over 0.99 and significant, indicating that all conditional dependences are highly persistent. A shock between the Hong Kong and Chinese stock markets could influence their dependences for a significant time period. All α are significant, also implying that variations from the last 10 lags fully explain the conditional dependence.

Table 3. Parameter estimates for marginal models

Parameters	Gaussian copula	Gumbel copula	Clayton copula
ω	0.0127*	0.0362**	0.0074**
β	0.9939**	0.9921**	0.9924**
α	−0.0386*	−0.1825**	−0.0228**
Log-likelihood	116.8	100.3	97.2

Note: **(*) represents the significance at 0.01 (0.05) level.

In Figure 1, we first display the time path of conditional correlation for the Gaussian, Gumbel and Clayton copulas without a dummy variable. All conditional correlations show a tendency for increase after CEPA took effect in 2004. To test for the significance of a dependence change that is due to the CEPA, we add a dummy variable to the conditional dependence equations. The results are summarized in Table 4. The significance of λ represents a significant change in conditional dependence.

Consequently, the Gumbel copula is the only copula that shows a significant change in conditional dependence. Conditional dependence derived from either the Gaussian copula or Clayton copulas does not change significantly. These results imply that conditional dependence increases significantly after CEPA only when both markets are rising, and not when they are declining or stable. This might be attributed to the differences in liberalization degree between the Hong Kong and Chinese stock markets, since a major part of Shanghai Composite index is comprised by A shares, which do not allow investment

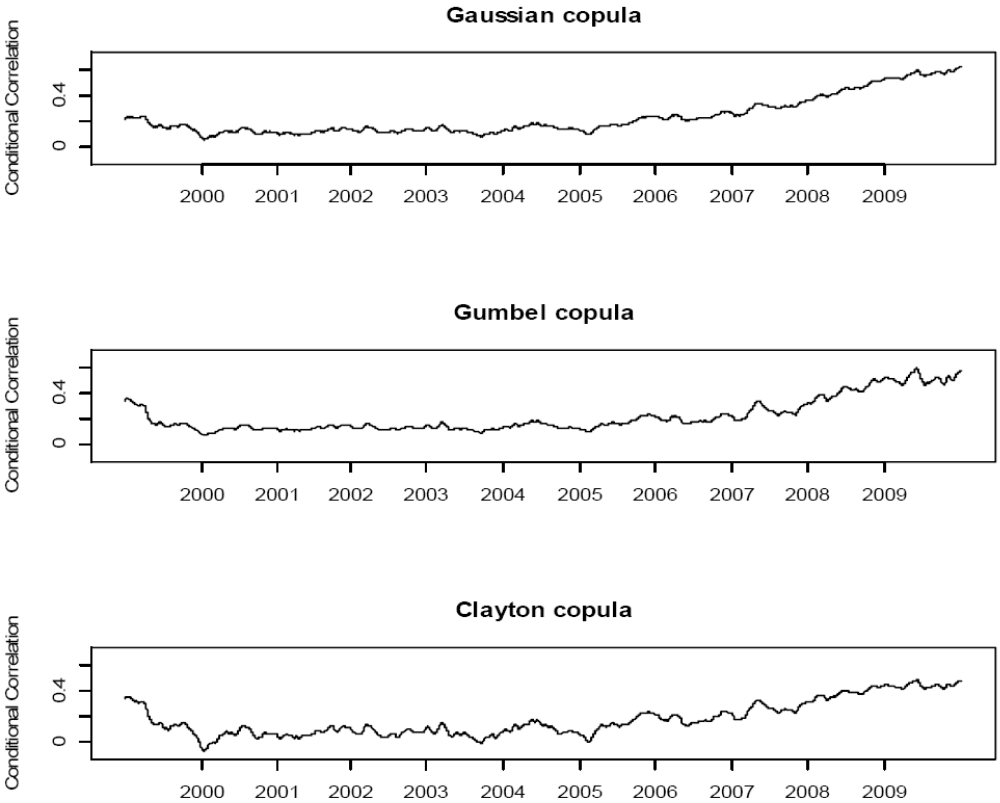

Figure 1. Conditional correlation for the Gaussian, Gumbel and Clayton copulas

Table 4. Parameter estimates for conditional dependences

Parameters	Gaussian copula	Gumbel copula	Clayton copula
ω	0.0604	−0.0335*	0.0066*
β	0.8859**	0.9988**	0.9911**
α	−0.1601	−0.0720	−0.0203*
λ	0.0225	0.0166**	0.0004
Log-likelihood	109.7	113.2	98.5

Note: **(*) represents the significance at 0.01 (0.05) level.

by foreign investors. When the Hong Kong stock market suffers from foreign capital retreat and falls sharply during a financial tsunami, the Chinese stock market does not experience serious foreign capital flight, declining only moderately.

5. **Conclusions.** We presented two major empirical findings. First, all conditional dependences display a tendency to increase after the CEPA took effect, regardless of the market situation. Second, the only significant conditional dependence increase is derived from the Gumbel copula. Conditional dependences increase under the Gaussian copula and Clayton copulas do not reach significant levels. These results indicated that, in the post-CEPA era, conditional dependence significantly increases only when both Hong Kong and Chinese stock markets are rising, and not when they are declining or stable. This finding contradicts those in some previous studies, which reported that stock markets are more closely correlated when markets are in decline [10].

We reviewed the co-relationship between economic integration and stock market dependence for Asian economies, thereby filling a gap in the research. We hope our findings identify the positive implications for economic integration among Asian economies. To extend the research on this topic, one might examine additional factors that possibly influence change in conditional dependence.

REFERENCES

[1] R. Johnson and L. Soenen, Economic integration and stock market comovement in the Americas, *Journal of Multinational Financial Management*, vol.13, pp.85-100, 2003.

[2] A. J. Patton, Modeling asymmetric exchange rate dependence, *International Economic Review*, vol.47, no.2, pp.527-556, 2006.

[3] S. M. Bartram, S. J. Taylor and Y. H. Wang, The Euro and European financial market dependence, *Journal of Banking & Finance*, vol.31, pp.1461-1481, 2007.

[4] M. J. Fry, How foreign direct investment in Pacific Asia improves the current account, *Journal of Asian Economics*, vol.7, no.3, pp.459-486, 1996.

[5] T. Gao, Foreign direct investment and growth under economic integration, *Journal of International Economics*, vol.67, no.1, pp.157-174, 2005.

[6] A. S. M. Sohel Azad, Efficiency, cointegration, and contagion in equity markets: Evidence from China, Japan and South Korea, *Asian Economic Journal*, vol.23, no.1, pp.93-118, 2009.

[7] A. C. Johansson, Financial markets in East Asia and Europe during the global financial crisis, *The World Economy*, pp.1088-1105, 2011.

[8] A. Sklar, Fonctions de réepartition à n dimensions et lers marges, *Publications de l'nstitut Statistique de l'niversit' de Paris*, vol.8, pp.229-231, 1959.

[9] K. Wang, Y.-H. Chen and S.-W. Huang, The dynamic dependence between the Chinese market and other international stock markets: A time-varying copula approach, *International Review of Economics and Finance*, vol.20, pp.654-664, 2011.

[10] F. Longin and B. Solnik, Extreme correlation of international equity markets, *The Journal of Finance*, vol.LVI, no.2, 2001.