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Determinants of equity return correlations: A case study of the Amman Stock Exchange

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Abstract This paper seeks to explain time-varying correlations among equity returns. The literature has shown that fundamental and economic factors can explain stock returns or the volatility of markets. Here, panel data analysis is employed to examine whether these factors can also explain the comovement of stock returns. Time-varying correlations among sectoral indexes are estimated using a restricted multivariate threshold GARCH model with dynamic conditional correlation (DCC-MTGARCH) controlling for the asymmetric effects of news and the influence of financial crises. The empirical results from this panel data analysis show that equity return correlations can be explained not only by macroeconomic variables but also by fundamentals within an industry.

JEL classifications: C58; G12; G14; G17

Keywords: Equity returns correlations; Risk factors; Multivariate threshold GARCH; Dynamic conditional correlation; Panel data analysis

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1 Introduction

According to the Efficient Market Hypothesis (EMH), current share prices reflect all available information such that investors should not be able to outperform the market consistently by trading on relevant information (Fama 1970). Recently, a growing literature on market efficiency has started to examine the linkages between stock markets, or study the relationship between various risk factors and equity returns/volatility (e.g., Fama and French 1992; Ho et al. 2005; Eiling et al. 2012; Garcia et al. 2015; Vidal-Garcia et al. 2016). Some researchers have investigated return comovements across international stocks (Bekaert et al. 2009; Bekaert et al. 2011; Chiang and Chen 2016). Others have studied the effects of the 2008 financial crisis on the comovement of asset returns (Baur 2012; Simmons and Tantisantiwong 2014). Evidence of price predictability or patterns among equity return correlations would suggest that a market is inefficient; any such inefficiency may have implications for the hedging strategies of investors and the ability of traders to make profits in the market.

Recent studies testing for the EMH have tended to investigate linkages among various regional and international markets. The literature on return and volatility spillovers in developed markets is sizeable (e.g., Hamao et al. 1990; Theodossiou and Lee 1993; Gallagher and Twomey 1998; Kanas 1998). Most studies that have examined data for developing countries have investigated return and volatility spillovers in the emerging markets of East Asia, Central Europe, and Middle East and North Africa (MENA) (e.g., Malik and Hammoudeh 2007; Li 2007; Li and Majerowska 2008; Fayyad and Daly 2011; Maghyereh and Awartani 2012; Chiang and Chen 2016)[1]. A small but growing literature has started to investigate linkages among international stock markets at the sectoral level (e.g., Phylaktis and Xia 2009; Chiang et al. 2015; Kim and Sun 2016). Although Chiang et al. (2015) focused on

[1] Some of these studies focus on the transmission of shocks and volatility from the oil market to the stock markets of the Gulf Cooperation Council countries (Malik and Hammoudeh 2007; Fayyad and Daly 2011).

cross-country correlations of returns for a number of industrial sectors, they claimed that the asymmetric dynamic conditional correlation (ADCC) approach employed in their study could also be used in the investigation of dynamic linkages among sectors within a particular country. The literature that has investigated linkages between sectoral returns within a country has employed various econometric methods, such as cointegration, Granger Causality tests, Vector Error Correction models (VECM), and the bivariate or trivariate Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models (Malik and Hassan 2004; Wang et al. 2005; Harris and Pisedtasalasai 2006; Hassan and Malik 2007; Hammoudeh et al. 2009).

Among a handful of studies that have looked at the factors associated with return correlations, Chiang and Chen (2016) and Kim and Sun (2016) discovered that the conditional correlations of returns in the Chinese and developed stock markets were related to a number of economic variables: for example, the P/E ratio, sector-level growth opportunities, implied volatilities. More generally, however, there is not a great deal of emphasis on factors explaining correlations between domestic sectoral returns in the literature, particularly sectoral return correlations of stock markets in the Middle East.

The current paper aims to fill this gap by investigating whether asset return correlations for industries within the same economy are related to variations in fundamentals within sectors as well as changes in macroeconomic variables. Past studies have suggested that current share returns in a market such as Jordan's Amman Stock Exchange (ASE) can be explained by past share price changes or risk factors (Omet et al. 2002; Maghyereh 2005; Al-Zoubi and Al-Zu'bi 2007; Abdmoulah 2010). In addition, Al-Fayoumi et al. (2009) employing cointegration and VECM approaches found short-run and long-run relationships among four ASE sectoral index returns. To capture dynamic return relations as well as volatility clustering and spillover, the current paper employs a dynamic conditional correlation (DCC) model; such a model has been used in several prior studies (Chiang and Chen 2016; Kim and Sun 2016).

Specifically, we employ a restricted multivariate threshold GARCH model with dynamic conditional correlation (DCC-MTGARCH) to examine the linkages between returns on sectoral indexes; in this case, 10 sectoral indexes of the ASE are chosen. A total of 10 sector-specific variables and 7 macroeconomic variables are included in this investigation about the determinants of asset correlations. The findings from this paper should help investors and policymakers understand the comovement between equity returns for different industries and the interdependence between sectors in a particular country. This knowledge can be useful for risk management decisions and the development of well-diversified portfolios for domestic investors. Moreover, it can indicate whether a particular sector or set of economic conditions can cause contagion and give rise to a crisis.

The remainder of this paper is organized as follows. Section 2 provides a brief outline of the existing literature on the dynamic linkages between equity returns. Section 3 discusses the data used and provides a number of descriptive statistics for the dataset. The econometric methodology underpinning the analysis is set out in Section 4. In Section 5, the dynamic linkages between the sectors in terms of return and volatility as well as the determinants of asset correlations are presented. Section 6 concludes.

2 Review of the relevant literature

A number of academics have examined financial contagion or systemic risk by investigating return, variance or covariance spillovers (see, for example, Chuang et al. 2007, Phylaktis and Xia 2009, Billio et al. 2016). Some theories explain the contagion of shocks based on multiple equilibria, capital market liquidity and investor psychology (Forbes and Rigobon 2002). Crisis-based contagion theories define “Contagion” as a significant increase in cross-market linkages after a shock to an individual country or a group of countries (Claessens and Forbes 2013). Many papers in this area study the contagion of shocks by examining return and volatility spillovers from the developed markets of Japan, the US and the UK to their less developed counterparts (e.g., Ng 2000; Baele 2005; Sok-Gee and Abd Karim 2010). Most of these studies have documented unidirectional spillover effects from the markets of developed countries - especially those of the US - to other emerging markets. However, different explanations have been advanced as to why such spillovers occur.

For example, David and Simonovska (2016) have demonstrated that the correlated beliefs of analysts can lead to comovements of stock returns. Simmons and Tantisantiwong (2014) have developed a theoretical framework explaining how investors' reaction to shocks in asset markets can determine the lower bound of the correlations between asset returns. The authors report that covariances between stock returns are time-varying and are higher during crisis periods. As investors' reaction to shocks or the correlation between analysts' beliefs can change over time, return correlations may vary as well. Chiang et al.'s (2015) investigation supports the finding of Simmons and Tantisantiwong (2014) about the impact of a crisis on the dynamic relationship between stock returns. Other researchers have also found that return correlations often change over time and applied DCC or ADCC models to obtain time-varying correlations of stock returns (see, for example, Chiang and Chen 2016; and Kim and Sun 2016).

Relatively fewer papers have examined interdependence across different sectors within the same market. This dearth of studies on the topic is surprising since a shock to one sector can have significant impacts on other sectors (Riedle 2016). For instance, The Group of Ten (2001) specifies the channels through which a shock in the financial sector can transmit to real sectors of the same economy: namely, disruptions in the payment system, interruptions to credit flows, and a collapse in asset prices. The contagion between sectors can also occur through trade (Hernández and Valdés 2001), financial links (Allen and Gale 2000), financial competition (Hernández and Valdés 2001), or geographical proximity (Hernández and Valdés 2001; Pritsker 2001). Amini et al. (2016) theoretically show that institutions with high levels of connectivity and a large number of contagious links are the main contributors to network instability. Empirically, Harris and Pisedtasalasai (2006) estimated an asymmetric trivariate GARCH model to examine daily return and volatility spillover effects between FTSE large- and small-capitalization equity indices: FTSE 100, FTSE 250 and FTSE SmallCap indices. Their results indicated an asymmetric return and volatility spillover from large firms' shares to small firms' shares in the UK over a period of 16 years ending in December 2002. Thus, they concluded that new information is initially incorporated into the prices of large companies' shares before being impounded into the equity returns for small firms. In a subsequent investigation, Hassan and Malik (2007) employed a trivariate GARCH model and US daily price data from January 1, 1992 to June 6, 2005 to examine volatility transmission among six different sectors studying three at a time[2]. As a result, the authors did not capture all of the interactions in the conditional variance between the six sectors simultaneously. Hammoudeh et al. (2009) also employed a trivariate VAR(1)-GARCH(1,1) model to investigate shock and volatility transmissions between the equity sectors of the Gulf Cooperation Council stock markets during the period from December 31, 2001 to December 31, 2007. In particular, they examined shock and volatility spillovers among three sectors in each country; namely, Banking, Industrial and Services sectors for Kuwait, Qatar and Saudi Arabia, and Financial, Insurance and Services sectors for the United Arab Emirates. Hassan and Malik (2007) and Hammoudeh et al. (2009) documented evidence of spillovers between sectors within individual countries. Their findings pointed to the potential impact of cross-market hedging and the possible sharing of information among investors in different sectors. Their results indicated that the impact of 'news' on one industry eventually spread to the other two sectors because of

[2] Hassan and Malik (2007) used the daily close returns for the financial, industrial, consumer (services), health, energy (oil and gas), and technology sectors in their analysis. When they tried a four-variable GARCH model the system didn't converge. Therefore, they estimated two trivariate BEKK-GARCH: one for the consumer, financial and technology sectors and the other for the energy, health and industrial sectors. They documented significant transmissions of shocks and volatility among consumer, financial and technology sectors and among energy, health and industrial sectors.

their interdependencies. However, they did not attempt to explain the reasons behind any spillovers detected.

While a vast literature has explained stock returns and volatility with fundamental as well as macroeconomic factors (Binder and Merges 2001; Kolluri and Wahab 2008), some recent investigations have attempted to explain stock return correlations (see, for example, Chiang et al. 2007, Chiang et al. 2015, Chiang and Chen 2016, Kim and Sun 2016). Most studies focus on stock return correlations within a sector of a particular country or across countries (for example, Chiang et al 2015; Phylaktis and Xia 2009) or the correlation of international stock market returns (for example, Chiang et al. 2007). Patro et al. (2013) found that the correlation between banks' individual risks could explain their stock return correlations. Moreover, De Nicolo and Kwast (2002) and Binici et al. (2013) documented that return correlations among banks' stocks could be explained by bank-specific factors such as their market shares, the size of their total loan portfolios and the level of their non-performing loans. Further, studies of international markets such as Eiling et al. (2012) found that equity returns were mainly driven by global industry and currency risk factors. Chiang et al. (2015) and Chiang and Chen (2016) found that conditional correlations of returns in Chinese stock markets and the stock markets of the EU, the US and some Asian countries depended on economic variables, such as the variance of oil price changes, the variance premium of the stock market and implied volatilities. Chiang and Chen (2016) also documented that a decrease in the correlation of stock returns was associated with the divergence of the P/E ratios in the two markets. With some control variables such as Gross Domestic Product (GDP) growth, CPI, real lending rate, firm size and gross profit margin, Kim and Sun (2016) found relatively higher correlation between a Chinese sector's return and the US S&P500 index return if the sector's growth opportunity was higher but book-to-market ratio was lower.

The current paper adds to the small but growing literature on linkages among different sectors of a stock market. It does this by analyzing volatility spillovers among a large number of sectors and seeks to explain the conditional correlations between sectoral index returns using some observable variables. These variables can be systematic risk factors as well as various idiosyncratic risk variables. We examine whether the interaction between these two factors can also play an important role in explaining equity return correlations.

3 Data and descriptive analysis

The paper chooses the Jordan's stock market, the Amman Stock Exchange (ASE), as the research site for the current analysis for a number of reasons. First, the literature has reported that ASE market returns are related to past price changes (Omet et al. 2002; Maghyereh 2005; Al-Zoubi and Al-Zu'bi 2007; Abdmoulah 2010), so return correlations in the ASE may also be predictable. Second, the ASE has grown significantly in terms of market capitalization and trading volume over the past number of years (Al-Jarrah et al. 2011) and its role in the economic development of Jordan has increased in prominence (El-Nader and Alraimony 2012). According to ASE (2013), the total market capitalisation increased by 446.10% from 2000 to 2012 amounting to 19,414.5 JD million. In addition, the market capitalisation as a percentage of GDP reached almost 300% of GDP in 2005, which is very high by international standards. The value of equity traded has also risen sharply during the period 2000- 2005. In 2008, trading volume on the ASE experienced a 65% increase from that in 2007. However, due to the global financial crisis trading volume decreased after 2008. Third, while several studies have investigated the stock market efficiency for the ASE in the past, no investigation has used the new classification of sectors adopted by the ASE in 2006[3] (ASE Annual Report 2006). Most

[3] By the end of 2006, the number of companies listed on the ASE had reached 227 indicating an increase in market depth as well as the diversity of investment opportunities provided (ASE Annual Report 2006). The rise in the prominence of the ASE has occurred at the same time as a number of regulatory changes and new listing

of the previous studies, which have investigated the efficiency of the ASE either on its own or within a group of countries, have studied the returns earned by whole market index or analyzed the old sectoral classification. Fourth, research on return and volatility spillovers using Jordanian data is scarce. Indeed, the only article in this area that studied the ASE was carried out by Al-Fayoumi et al. (2009). They found evidence of cointegration among the daily returns earned by four ASE sectoral indices (General, Financial, Industrial and Services indices) during the period from September 3, 2000 to August 30, 2007. Their VECM results indicated strong evidence of a short-run causality running from the general, financial, and industrial sectors to the service sector. The variance decomposition and impulse response analyses indicated that the financial sector was the most influential industry in the ASE, while the services sector was the least integrated with other sectors. However, their study ignored important characteristics of share prices analyzed in the current investigation such as volatility and correlations.

3.1 Data

The data set consist of daily sector indexes (in local currency)[4] for the 10 largest sectors in the ASE in terms of market capitalization and number of constituent firms[5]. These 10 sectors ordered by size are Banking (BNK), Mining and Extraction (MIX), Hotel and Tourism (HNT), Real Estate (RES), Educational Services (EDS), Diversified Financial Services (DFN), Commercial Services (COM), Insurance (INS), Food and Beverages (FOB) and Transportation (TRP). The sample period is from January 2, 2003 to December 31, 2012[6]; all weekends,

requirements have been introduced (ASE Annual Report 2012). The ASE adopted a new sector classification that was in line with international standards and reflected a more "accurate" image of the listed companies to investors in terms of the nature of the work. The Standard and Poor's classification has been adopted with some changes to accommodate the unique features of Jordanian companies. Listed companies are regrouped into three main sectors (financial, industrial and services sectors) with 23 sub-sectors.

[4] These sectoral equity indices are based on the free float shares, whereby the index is calculated using the market value of the free float shares of the companies and not the total number of listed shares of each company.

[5] Specifically, all of the 23 sectors in the ASE under the new industry group were ranked according to (i) their percentage of the total market capitalisation and (ii) their number of constituent firms. Both rankings were jointly used to identify the top 10 most important sectors (by size) for the ASE.

[6] The ASE retroactively calculated sectoral equity indices of the new industry grouping for all sectors back to 2000 except for the telecommunication sector which was only calculated back to 2003.

holidays and days on which the ASE was closed are excluded, so the final sample involved 2,462 observations for each sector. The data is obtained from the ASE website (www.ase.com.jo) and values are checked against numbers in the DataStream database.

A few prior studies using a cointegration approach found linkages between sectoral returns of the ASE (see, for example, Al-Fayoumi et al. 2009). In addition, AlZoubi and Al-Darkazaly (2013) analysed input-output tables for the Jordanian economy and found strong linkages between the different sectors. They discovered that the backward linkages of RES became stronger over the period 1987-2009[7]. Alomari (2015) recalculated backward and forward linkages in the Jordanian economy using input-output data for the year 2010. He found that TRP and BNK have strong forward linkages with the other sectors in Jordan; this is hardly surprising as one would expect that other sectors use funds from BNK and transportation services from TRP, so the growth of the banking and transportation sectors depend on the growth of other sectors. In terms of backward linkages, his results indicated that HNT had the largest backward linkages among the sectors studied. He attributed this finding to the fact that growth in HNT boosted the demand for products from other sectors. These findings suggest that there may be return and volatility spillovers as well as return correlations between the Jordanian sectors.

Fig. 1 illustrates that correlations between the returns of BNK and other sectors vary over time. In particular, these correlations became higher in 2006 and declined after the 2008 global financial crisis. In addition, return correlations between BNK and EDS changed from positive to be negative in year 2012. Thus, the current paper attempts to find the factors that can explain these changes in return correlations.

[7] According to Miller and Blair (1985), the backward linkages of a sector indicate that an expansion in its production is valuable to the economy as it causes a rise in productive activities of other sectors. On the other hand, the forward linkages of a sector indicate that its production is sensitive to changes in other sectors' output.

[Insert Fig. 1 about here]

To examine the determinants of the time-varying return correlations, a number of financial ratios and macroeconomic variables were studied. The selection of these explanatory variables draws on both theoretical insights and empirical findings in the literature. For example, multifactor frameworks such as arbitrage pricing theory (APT)[8] suggest that shocks to macroeconomic variables can explain why actual returns differ from their expected values. In particular, Ross (1976) suggested that in a risk-averse economy a risk premium should be earned on assets that are affected by systematic risk factors; macroeconomic variables provide information on numerous sources of systematic risk factors through their influence on the firm's expected cash flow and required rate of return (Mun 2012). In addition, some empirical models (e.g., Fama and French 1992; Fama and French 2015) argue that corporate characteristics such as company size, market-to-book value, profitability, investment and gearing systematically explain share returns. According to this strand of the literature, these factors may also help explain the correlation between the returns of any two assets.

In the current paper, 10 financial ratios over the sample period were obtained from the ASE website for the 10 sectors examined[9]. These ratios consisted of five stock market performance ratios (turnover ratio (TR), price-to-earnings ratio (PE), dividend yield (DY), dividend pay-out (DP) and market-to-book ratio (MB)), two profitability ratios (return on assets (ROA) and return on equity (ROE)), a gearing ratio (debt ratio (DR)), a liquidity ratio (current

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[8] For example, the APT developed by Ross (1976) asserts that asset returns are related in a linear fashion to k-different orthogonal risks, which arise from shocks to macroeconomic factors. Therefore, the k-different risk factors and their sensitivities can be the main source of correlation among returns.

[9] The Statistics and Publication Division, under the Research and International Relations Department of the ASE, calculated these ratios. The ratios are available at http://ase.com.jo/en/node/543.

ratio (CR)) and a size measure (relative size (RS)). The definition of these financial ratios is provided in Appendix 1[10].

As mentioned above, the choice of macroeconomic variables is based on economic deliberations as well as on rational pricing models. The macroeconomic variables used in this analysis include variables measuring price/monetary stability, economic activity, economic reliance on domestic and external demand, and the debt level of the economy. Three variables measuring price/monetary stability are the inflation rate (INF), the six-month Treasury bill rate (IR) and the growth in broad money supply (MS2). The real GDP growth rate (RGDP) is used as a proxy for economic activity. In this paper, the degrees of economic reliance on domestic demand and external demand are measured by the ratio of domestic private consumption to GDP (C/GDP) and the trade balance to GDP ratio (TB/GDP) respectively while the domestic lending to GDP ratio (TDL/GDP) represents the level of leverage for the economy.

3.2 Descriptive statistics

3.2.1 Sectoral index returns

An inspection of Table 1, which reports the descriptive statistics calculated for the 10 ASE sectoral index returns, reveals a number of interesting points. For example, the average return varied slightly across the 10 sectors during 2003-2012. MIX performed the best, followed by BNK; such a result was not surprising as financial transactions in Jordan are mainly intermediated through the banking sector and minerals are one of the country's main exports. Over the period examined, HNT, TRP, COM and FOB performed relatively worse than the other six sectors. In addition, the returns of the 10 sectors were volatile with DFN being the riskiest sector and FOB being the least risky sector. Moreover, the spread between the

[10] The Statistics and Publication Division calculates up to 16 financial ratios for different industries; however, these are not uniformly available across sectors. Only 10 financial ratios were common across all the sample industries (See Appendix 1).

maximum and minimum values shows that the prices in those sectors tended to deviate a great deal away from their average returns. RES recorded the highest spread of 0.18% while EDS documented the lowest spread of 0.083%.

The returns in all of the sectors studied were not normally distributed. Indeed, returns in all sectors were negatively skewed, with the exception of INS, EDS and HNT. The kurtosis values were all significant; all sectors, especially FOB, had a higher preponderance of extreme return values relative to what one might expect in a normal distribution. Thus, an analysis of sector returns using a GARCH framework was thought appropriate.

[Insert Table 1 about here]

3.2.2 Financial ratios

A number of points emerge from the descriptive statistical analysis for the financial ratios reported in Table 2. First, the mean value of RS varied across the sectors from a low of 0.99% for FOB to a high of 51.55% for BNK. The Jordanian economy relies heavily on remittances from Jordanians working abroad transferred through banks. BNK is bigger and more important in Jordan than in some other Middle East countries. According to World Bank (2003), Jordan is considered to have a bank-based financial system where banks play a key role in financing economic activities. The second largest sector is MIX, with a market capitalization that represented 17.76% of the whole market.

[Insert Table 2 about here]

Second, shares in different sectors tended to be traded with different levels of intensity. While the TR ratio for six sectors (BNK, INS, EDS, HNT, FOB and MIX) was less than 50%, it was greater than 100% for DFN, RES and COM suggesting that the typical investor usually held shares of companies in these three sectors for less than a year. This finding may explain why DFN, RES and COM had the widest spread of returns shown in Table 1. Most sectors had a PE multiple of between 10 and 40 times, offered investors a DY of 1 to 4% and paid out between 30% and 70% of their earnings as dividends. In addition, all industries except for TRP had an MB ratio of more than one indicating that shares of companies in these sectors were typically valued at more than the book value of the equity.

Third, the Jordanian companies in the sample were generally profitable over the 10-year period and operated with varying levels of debt. BNK and INS had high debt ratios due to the nature of their business. Apart from these two sectors, TRP had the next highest debt ratio of 61.21%. While TRP had an ROE of only 3.15%, EDS with the lowest debt ratio of 25.63% had a much higher ROE of 12.37%.

Finally, the data indicates that companies in most sectors were able to meet their financial obligations over the period studied. For instance, DFN recorded the highest CR (3.08 times) followed by MIX (2.25 times). However, BNK, EDS and HNT recorded a CR of less than one implying that companies of these sectors on average had short-term obligations, which were typically higher than their current assets during the 10-year period.

3.2.3 Macroeconomic variables

Table 3 reports that the Jordanian economy experienced a steady growth in income from 2003 until 2008. The RGDP decreased from 7.2% to 2.3% in 2009- presumably as a result of the global financial crisis (Ahid and Augustine 2012), and showed an improvement in 2010 as a result of the different measures implemented by the government to create an attractive investment climate in Jordan. Clearly, the figures have been influenced by the civil war within Syria, which commenced on March 15, 2011 (Mackey 2013); more recent GDP growth figures have declined as Jordan tried to cope with the influx of refugees as well as the uncertain financial climate caused by this regional conflict (World Bank 2013). However, this decline has been modest since the Jordanian and Syrian economies are weakly integrated (World Bank 2013).

[Insert Table 3 about here]

According to Table 3, Jordan's economy seems to rely mainly on domestic consumption; the average C/GDP ratio was nearly 80%. The Jordanian economy also had a trade balance deficit because of the high level of imports needed to fulfil the growing level of demand within the country, particularly given the narrow production base in Jordan (Mousa 2010). Considering domestic lending, the TDL/GDP ratio was initially low at 25.11% but followed an upward trend from the beginning of the sample period until the end reaching its highest level of 57.72% in 2012. One possible explanation for the low average TDL/GDP ratio of 36.45% is that most of the population are Muslim and follow Islamic teachings that prohibit interest.

Over the period examined, the Jordanian economy did not experience a great deal of inflationary pressure; this might be because the country was a net importer of goods and services over the examined period[11]. The inflation rate was below 7% over a decade. An exception to this generalization was in 2008 when the inflation rate reached double digits possibly due to continuous rises in world oil and commodity prices. In 2009, the price level declined by 0.67% possibly because of falls in world oil and commodity prices, a 50% fall in the growth rate of money supply, and a slight decline in consumption (See Table 3). Finally, changes in the interest rate followed the trend of the inflation rate. That is, the interest rate increased (decreased) when the inflation rate increased (decreased).

[11] Imports of goods and non-factor services of Jordan were estimated at 72% of total consumption in 2011 (World Bank 2013).

4 Methodology

Both variances and correlations of asset returns can evolve over time as new information on the whole economy or a particular sector is released (Cappiello et al. 2006). As shown in Fig. 1, the correlations between sectoral returns in the ASE are time-varying. A restricted multivariate threshold GARCH model with dynamic conditional correlation (DCC-MTGARCH) is used to examine the interactions between the 10 ASE sectors in term of both return and volatility[12]. Time-varying conditional correlations between each pair of sectors are extracted from this process. In addition, principal component analysis (PCA) is employed to distil the sectors' financial ratios and macroeconomic variables into their principal components (PCs). Finally, panel data analysis is used to identify the determinants of time-varying sectoral return correlations.

The analysis begins by estimating a restricted DCC-MTGARCH model. The model assumes that the returns follow a first order autoregressive (AR(1)) process[13]. Following Ling and McAleer (2003), conditional volatility follows a restricted MGARCH process – that is, the conditional variance can be characterized as a first order vector autoregressive moving average (VARMA(1,1)) process. In addition, the conditional variance equation includes a threshold parameter to control for the presence of any asymmetric effect of shocks. Thus, the model allows for both shock and volatility spillovers between sectors and captures any asymmetric volatility spillovers. The model includes Eqs (1) – (5) as follows:

[12] Huang et al. (2010) documented that the forecasting performance of the DCC-GARCH model is better than that of the GARCH-BEKK model. While the ADCC model of Cappiello et al. (2006) incorporates the leverage effect of shocks in the conditional correlation, Laurent et al. (2012) employing data for 10 stocks from five different sectors of the NYSE documented that the forecast of this ADCC model is not significantly better than that of the Engle's (2002) DCC model with the leverage effect in the conditional variance.

[13] The results from VAR(1) in Appendix 3 indicate that equity returns for the ASE sectors are mainly predictable from their own historical share prices changes; there are only a few cases where return changes from other sectors have an influence. An AR(1) process was therefore chosen for the mean equation instead of VAR(1). The reduction in parameters also helps getting a convergent estimation for the DCC-MTGARCH (1,1) for 10 sectors.

$$R_t = A + B(R_{t-1}) + C(local_t) + E(global_t) + \varepsilon_t, \qquad \varepsilon_t | \Omega_{t-1} \sim (0, H_t) \tag{1}$$

where R_t is the column vector of log returns of the 10 sectors ($r_{i,t}$ where i = 1 for BNK, 2 for INS, 3 for DFN, 4 for RES, 5 for EDS, 6 for HNT, 7 for TRP, 8 for COM, 9 for FOB and 10 for MIX). $local_t$ a dummy variable that takes account of a local crisis in the stock market and which has a value of one for observations from November 8, 2005 to December 17, 2006 and zero for the rest of period. The $global_t$ dummy variable represents the global financial crisis takes a value of zero before June 18, 2008 and the value of one for all the observations after that. In Eq. (1), the coefficient matrices are given by the following:

$$A = \begin{bmatrix} a_1 \\ \vdots \\ a_{10} \end{bmatrix}, B = \begin{bmatrix} b_{11} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & b_{1010} \end{bmatrix}, C = \begin{bmatrix} c_1 \\ \vdots \\ c_{10} \end{bmatrix}, \ E = \begin{bmatrix} e_1 \\ \vdots \\ e_{10} \end{bmatrix}, \text{ and } \varepsilon_t = \begin{bmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{10,t} \end{bmatrix}.$$

A graph of the ASE free float index[14] and the Chow breakpoint test results show that the ASE has two structural breaks (See Fig. 2)[15]. The first break occurred when the ASE free float index dropped from 4260 points at the end of 2005 to 3014 points at the end of 2006, equivalent to a fall of 29.2%. This drop in the whole market index represented a correction in equity prices from a previous overvaluation that had not been reinforced by a growth in the real operational profits achieved by companies (Al-Saket 2007). This structural break is deemed to be a "local crisis" and the dummy $local_t$ added into the analysis. The second break started from June 18, 2008; it was deemed to be associated with the global financial crisis and a second dummy variable $global_t$ is also added to the investigation.

[Insert Fig. 2 about here]

[14] The ASE market capitalization weighted index is calculated using the pre-2006 industry categories, but the ASE free float index is calculated using the new industry categories introduced in 2006. The Chow breakpoint test was therefore performed using the ASE free float index.

[15] The Chow breakpoint test was conducted to determine the dates of structural changes. The findings indicated structural changes at three points: November 8, 2005, December 17, 2006, and June 18, 2008.

The vector C in Eq. (1) measures the effect of the local crisis ($local_t$) while the vector E measures the impact of the global financial crisis ($global_t$). ε_t is the column vector of Student-t distributed random error terms conditional on the past information set Ω_{t-1} with a mean of zero and a conditional variance-covariance matrix:

$$H_t = D_t P_t D_t \tag{2}$$

Following Cappiello et al. (2006)[16], P_t is the time-varying correlation matrix and D_t is the diagonal matrix of conditional standard deviations individually modelled in Eq. (3):

$$\sigma_{i,t}^2 = \omega_{ii} + \sum_{j=1}^{10} \alpha_{ij} \varepsilon_{j,t-1}^2 + \sum_{j=1}^{10} \beta_{ij} \sigma_{j,t-1}^2 + \gamma_i \varepsilon_{i,t-1}^2 I_{i,t-1} + \lambda_i local_t + \theta_i global_t \tag{3}$$

where $\sigma_{i,t}^2$ is the conditional variance of sector i at time t. $\varepsilon_{j,t-1}^2$ refers to own past shocks for $j = i$ and past shocks of other sectors for $j \neq i$. $\sigma_{j,t-1}^2$ refers to own past variance for $j = i$ and past conditional variances of other sectors for $j \neq i$. γ_i measures the asymmetric responses to good and bad news in the i^{th} sector where $I_{i,t} = 1$ if $\varepsilon_{i,t} < 0$, and $I_{i,t} = 0$ otherwise. λ_i and θ_i represent the effects of the local and global financial crises on the volatility of sector i, respectively.

A square matrix of conditional correlations with $\rho_{ii} = 1$ is calculated using

$$P_t = diag\{Q_t\}^{-1} Q_t diag\{Q_t\}^{-1} \tag{4}$$

for

$$Q_t = (1 - a_{dcc} - b_{dcc}) Q_0 + a_{dcc} u_{t-1} u'_{t-1} + b_{dcc} Q_{t-1} \tag{5}$$

where u_t is the vector of standardized residuals.

In order to estimate Eqs. (1) – (5) efficiently and consistently, the full information maximum likelihood method was used. With 10 sectors and T (=2462) observations, the joint log-likelihood L can be defined as:

[16] However, the correlation evolution equation in this paper (Eq. (5)) follows the standard DCC model introduced by Engle (2002).

$$L = \sum_{t=1}^{T} \left(\frac{10}{2} \ln(2\pi) - \frac{1}{2} \ln \left| D_t P_t D_t \right| - \frac{1}{2} \varepsilon_t ' (D_t P_t D_t)^{-1} \varepsilon_t \right) \quad (6)$$

Under the assumption that the random errors are Student-t distributed, Eq. (6), corresponding to the system of Eqs. (1) - (5), is maximized using the quasi-maximum likelihood approach (Bollerslev and Wooldridge 1992). The Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm is used to produce maximum likelihood estimators and their corresponding asymptotic standard errors. After the estimation, the time-varying correlations among the sectoral returns are extracted.

Next, two separate PCA investigations are employed to extract the PCs from the group of 10 financial ratios and seven macroeconomic variables. According to Kaiser (1960), components should be retained if their eigenvalues are greater than one. However, in some circumstances, a strict interpretation of Kaiser's criterion may possibly result in discarding of PCs that, although small, may be important. Therefore, the Kaiser criterion was relaxed slightly in this paper to retain some of those components with a latent root slightly below one. Specifically, enough components were retained such that at least 85.0% of the variation in the data was accounted for. According to Dunteman (1994), the variable with the highest loading or weight for a PC should be used as a representative of that PC. However, this paper follows Fifield et al. (2002) and Khan et al. (2015) considering loadings for all variables in construction of the PC. This approach permits each variable, even those with small weights, to contribute to the construction of the PC.

In order to find the determinants of asset correlations, panel data analysis with sector fixed effects[17] is performed to identify any association between the return correlations and the sector-specific and economic factors. The dependent variable is the time-varying conditional

[17] Three panel data models, namely the pooled regression model, the fixed effect model and the random effect model, were first estimated. In order to determine which of the three models is the most appropriate for the analysis, the Hausman test was applied. The test result showed that the fixed effect model was the appropriate specification (see Section 5.4).

correlations between 10 sectors obtained from the restricted DCC-MTGARCH model, which are annualized to match the frequency of the financial ratios and macroeconomic variables used in the current analysis[18]. For each pair of sectors, daily conditional correlations of returns are averaged over each calendar year to obtain the annual correlation. The 45 different annual pairs of sectoral return correlations over the period from 2003 to 2012 are stacked and regressed on the sector-specific and economic factors (for each pair of sectors). Specifically, for the dependent variable, all 10 annual correlations for the first pair of sectors (sector 1 with sector 2) are followed by all 10 annual correlations for the second pair of sectors (sector 1 with sector 3) and so on until the data for the last pair of correlations is included (sector 9 with sector 10). In total, there are 450 observations in the panel regression. Regarding independent variables, the macroeconomic factors are macroeconomic PCs constructed from the PCA while the sector-specific factors are computed using financial ratio-based PCs. For example, each value of the first sector-specific factor is the product of the values for the first financial ratio-based PC of the two correlated sectors[19]. For each of the sector-specific factor, all 10 values for 45 different pairs are stacked in a similar fashion as the dependent variable. For each economic factor, the 10 values of each macroeconomic PC over the period from 2003 to 2012 are stacked on top of each other.

5 Results

This section first discusses volatility spillovers across 10 sectors. Then, it examines the association of the time-varying correlations with a number of sector-specific and macroeconomic factors.

[18] Evidence suggesting that it is reasonable to use annual data when analysing time varying correlations is provided by several studies such as David and Simonovska (2016).
[19] The results of a correlation test indicated that the PCs of any two sectors are independent, so the products of PCs are used instead of the average values of PCs. The test results are available upon request from the authors.

5.1 Volatility spillovers

The results of the DCC-MTGARCH model estimated for the entire period are shown in Table 4[20]. Panel A of Table 4 reports coefficients of the conditional variance equation for each sector at time *t* while Panel B shows the DCC specification estimates. A visual inspection of Panel A reveals a number of interesting points. For instance, the sectoral indices in the ASE show a significant and positive sensitivity to own past shocks and volatility in the long run, but to varying degrees. Two exceptions to this generalization are BNK and FOB, for which β_{ii} are insignificant. Consistent with findings reported by Hammoudeh et al. (2009), the regression results show that a sector's own past volatilities were more important than its own past shocks in explaining the future volatility.

[Insert Table 4 about here]

In addition, Panel A in Table 4 reveals several significant values of the coefficients of α_{ij} and β_{ij} (for $i \neq j$), indicating that cross-sector spillovers of shocks and volatility exist between the sectors. More specifically, volatility spillovers between industries are more common from the financial and industrial sectors to the service sectors than the other way around, while spillovers between the financial and industrial sectors are bi-directional. Consistent with the results of Al-Fayoumi et al. (2009), these findings suggest that the service sectors appear to include the least influential equities in terms of volatility spillovers within the ASE. Like many countries, the real estate sector is important to Jordan's economy. Table 4 shows that RES is the most influential sector in terms of volatility spillover. Meanwhile, the findings show that MIX's volatility is not affected by a change in volatility for other sectors,

[20]The likelihood ratio statistic in Panel C of Table 4 suggests that the DCC model used in this paper performs better than a CCC model.

but its change can affect the volatility of other sectors via BNK and DFN. In terms of shock spillovers among the sectors, the contagion effect on current volatility varies across the sectors with FOB being the most sensitive sector. In addition, shock spillovers between industries are more common from the financial sectors to the service sectors than the other way around. Moreover, there are uni-directional shock spillovers from the financial and service sectors to the industrial sectors. These shock spillovers indicate that the financial sectors, especially DFN, are the most influential sectors while the industrial sectors appear to be the least important in terms of transmitting shocks. The findings on shock and volatility spillovers suggest that the impact of a shock on one sector seems to be transmitted to all sectors as result of their interdependence.

According to Table 4, the local crisis had no significant impact on the volatility of returns for most of the sectors except EDS and FOB. Presumably, this is because the firms in these two sectors are all domestic. On the other hand, the companies in other sectors have international activities; this might explain why they were not affected by the local crisis. There is evidence that there was an increase in volatility in the EDS sector and a decrease in volatility in the FOB sector during the period from November 8, 2005 to December 17, 2006. The effect of the global financial crisis on return volatility was more pronounced than its local crisis counterpart. Specifically, BNK had a decrease in volatility while there was an increase in volatility for INS, DFN, and COM during the global financial crises. This may have been because these sectors were to some extent more connected with global financial markets.

Furthermore, there is an asymmetric impact of news for BNK, DFN, RES, COM and FOB. The negative value for γ_i indicates that good news increased volatility more than bad news. This might be explained by corporations' attempts to manage information; companies in these sectors tried to spread good news and hide bad news (Al-Zoubi and Al-Zu'bi 2007). Finally, the estimates of Eq. (5) shown in Panel B of Table 4 support the notion that correlations between the 10 ASE sectors are time varying and that the result in prior studies assuming a constant correlation for returns between the sectors may be questionable. The sum of estimated coefficients (a_{dcc} and b_{dcc}) suggests that the correlation is highly persistent between each pair of sectors and always reverts to some long term mean.

The daily conditional correlations are obtained from the model. Table 5 reports statistics for these conditional correlations among the 45 pairs of sectors. From the table, it is apparent that these conditional correlations vary over time; the standard deviations are relatively sizeable (e.g. for conditional correlations between COM and BNK) while the gap between the maximum and minimum conditional correlation values is often large (e.g. between DFN and INS). Annual conditional correlations for different 45 pairs of sectors are then calculated and analyzed in Section 5.3.

[Insert Table 5 about here]

5.2 The PCA

PCs were extracted from the PCA applied (i) to each sector's fundamental variables and (ii) to the common set of macroeconomic data. Table 6 summarizes the proportionate weight of each variable for every PC retained in the analysis, also known as the factor loadings. In particular, only those variables with relatively higher loadings were considered in the representation of that PC. In addition, the last row in each panel indicates the label given for each PC. Panel A shows that the first PC for the financial ratios has a high negative weighting for the DR ratio and a high positive weighting for the CR ratio. The first PC is labelled as 'Liquidity' because liquid companies are characterized by low debt and high liquidity. By contrast, the second PC is constructed mainly from the ROA and ROE ratios where loadings are both positive; hence, the second PC is labelled as 'Profitability'. The third PC has the highest weightings for the PE and DP ratios. As companies characterized by high growth and high dividend payout are companies with good stock market performance, the third PC is labelled as 'Stock Market Performance'. The fourth PC has the MB, the RS and the CR as the factors with highest weights. Therefore, the fourth PC is labelled as 'Size'. A negative weighting for the DY ratio and a positive weighting for the TR ratio are sizeable in the fifth PC. Those sectors with companies characterized by a low dividend yield and a high turnover ratio tend to have high growth (Walter 1956). Therefore, the fifth PC is labelled as 'Growth'. These five PCs combined explained 85.4% of the variation in the financial ratios.

Panel B of Table 6 reports the results when the seven macroeconomic variables are analyzed with PCA. The weightings for C/GDP, IR and TB/GDP are relatively high in the first PC. Consequently, the first PC is more related to consumption and trade and is therefore labelled as 'Aggregate Demand'. On the other hand, INF and MS2 have relatively high loadings in the second PC and thus this PC is labelled as 'Inflation'. The third PC is deemed to measure 'Economic Vulnerability' because the high positive weighting is placed on the TDL/GDP ratio followed by the high negative weighting for the RGDP. Together, these three macroeconomic PCs explained 86.8% of the variation in seven macroeconomic variables.

[Insert Table 6 about here]

5.3 Determinants of equity correlations across sectors

To examine the determinants of equity return correlations, a fixed effect model is estimated as follows.

$$\rho_{mn,t} = \delta + \mu_{mn} + \Phi X_{mn,t} + \Pi Z_t + \Theta X_{mn,t} Z_t + v_{it} \qquad v_{it} \sim \text{IID}\ (0, \sigma_v^2) \qquad (7)$$

$$\Phi = [\varphi_l \quad \varphi_{pr} \quad \varphi_{sm} \quad \varphi_s \quad \varphi_g]; \Pi = [\pi_{ad} \quad \pi_{inf} \quad \pi_{ev}];$$

$$\Theta = [\theta_{l,ad} \quad \theta_{l,inf} \quad \theta_{l,ev} \quad \theta_{pr,ad} \quad \cdots \quad \theta_{g,ev}].$$

where $\rho_{mn,t}$ is the correlation of sector *m* with sector *n*. $X_{mn,t}$ is the vector of sector-specific factors which are the products between financial ratios-based PCs of sectors *m* and *n*. The five sector-specific factors are liquidity (L), profitability (PR), stock market performance (SM), size (S) and growth (G). Z_t is the vector of economic factors including aggregate demand (AD), inflation (INF) and economic vulnerability (EV). v_{it} is an error term. δ is a common constant term and μ_{mn} are correlation-specific fixed effects.

[Insert Table 7 about here]

It is evident from the results shown in Table 7 that both sector-specific and economic factors have effects on return correlations. For example, the results indicate that equity return correlations increase when inflation or aggregate demand increases[21]. Moreover, there are significant interaction effects between sector-specific factors and some economic factors. In other words, the relationship between a sector-specific factor and the degree of return correlation depends on economic performance. For instance, the effects of liquidity, profitability and stock market performance on equity return correlations are non-linear, depending on the level of aggregated demand. Specifically, the total effect of liquidity and stock market performance on equity return correlations can be positive or negative depending on how strong the whole economy is performing. The effect of liquidity on the correlation between the ASE sectoral returns declines with an increase in aggregate demand. That is, low equity return correlations were associated with illiquidity (liquidity) during an economic

[21] The conditional correlations of sectoral return seem to be associated with a number of common factors. One of these, for example, is inflation; there is a positive relationship between inflation and the conditional correlation among sectoral stock returns. The correlation values between these two variables are positive in 44 out of 45 instances; the only instance of a negative correlation is between the conditional correlation between BNK and MIX ($\rho_{1,10}$) and inflation where a value of -0.10 is documented. For all other correlations, the values range from a low of 0.19 between inflation and the conditional correlation between INS and RES ($\rho_{2,4}$) to a high of 0.69 between inflation and the conditional correlation between EDS and FOB ($\rho_{5,9}$).

recession (an economic boom). By contrast, the effect of stock market performance on return correlations rises with an increase in aggregate demand. During an economic boom (recession), if stock market performance of a sector improves (deteriorates), ceteris paribus, the correlations between returns earned by this sector and other sectors tend to increase. This finding somehow reflects the contagious effect when there is a stock market bubble or crash. Moreover, an increase in the profitability of a sector can increase the correlations between sectoral returns, but the size of this effect depends on the level of aggregate demand. This may be due to speculative trading in the ASE where investors hope to generate quick profits during periods when aggregate demand is high. It may indicate that investors in the ASE tend to follow the trend in the market where small investors, who trade on the exchange without any knowledge of company fundamentals, mimic large investors in the hope of earning quick profits as happened during the local crisis that hit the market in 2005 (Al-Saket 2007). Further, the results indicate that if a sector is growing, correlations between returns earned by this sector and other sectors will increase, but the size of correlation increments depends on the degree of economic vulnerability. Return correlations are more sensitive to the growth of a sector when the economy has low economic growth and high levels of lending. However, there is no association between the size of sectors and the degree of interdependence between sectoral returns.

To sum up, not only are the time-varying correlations between sectoral index returns associated with macroeconomic factors, but also they are associated with sector-specific factors such as liquidity, profits, stock market performance and growth. Further, there is strong evidence of interactions between sector-specific and macroeconomic factors.

5.4 Robustness Checks

This subsection complements the comprehensive findings provided in the previous subsections by undertaking further robustness checks. We carry out the same analyses using a random effect model (Model 2 in Table 7) and find that the significance and sign of coefficients are the same as the fixed effect model (Model 1 in Table 7); further, the size of the coefficients in Model 2 is about the same as that in Model 1. The Hausman test result shows that the fixed effect model was the appropriate specification (see Table 8). We also reestimate the fixed effect model with economic-based PCs only (Model 3) and show that the significance and sign of coefficients are similar to those in Model 1[22]. Next, we apply a stricter Kaiser (1960) criterion and obtain four financial ratio-based PCs (liquidity, profitability, stock market performance and size) as well as three economic-based PCs (aggregate demand, inflation and economic vulnerability). We then reestimate both the fixed and random effects models without the growth PC (Model 5 and Model 6). Similar results were obtained when a smaller number of PCs was retained[23]. Finally, we replace annual conditional correlations with annual unconditional correlations, which are calculated by dividing the annual covariance between returns for each pair of sectors by the product of the standard deviations of returns for the pair. The estimation results are shown in the last column of Table 7 (Model 7). The signs of the significant coefficients are the same as in the fixed effect model (Model 1) with the exception of the coefficient for the interaction term between the growth of sectors and economic vulnerability. However, the size of coefficients in Model 7 is larger than those reported in Model 1. These results confirm our findings in the previous subsection that both macroeconomic variables and fundamentals within sectors can explain sectoral stock return correlations and that there are interaction between the effects of sector-specific and economic factors on return correlations[24].

[Insert Table 8 about here]

[22]In addition, we estimate the fixed effect model without interaction terms; the estimation result is shown as Model 4 in Table 7.
[23] Nonetheless, the likelihood ratio statistic reported in Table 8 suggests that the growth PC is an important factor that can explain conditional correlations between sectoral returns earned in the ASE.
[24] The likelihood ratio statistics reported in Table 8 confirm that macroeconomic variables are important determinants of the correlations of stock index returns and that there are significant interactions between sector-specific and economic factors.

6 Conclusion

This paper has examined the determinants of correlations between returns on assets traded in an inefficient stock market. The paper estimated time-varying correlations between daily returns on 10 sectoral indices of the ASE using a restricted DCC-MTGARCH model. Then, fundamental and macroeconomic principal factors were extracted using the PCA method and studied for their impacts on return correlations using a fixed effect model.

The preliminary findings indicated that the future returns of the sample sectors are found to have a significant relationship with their own past values; hence, the returns earned by sectors in the ASE violated the weak-form of the EMH. Given that several significant spillovers of shocks and volatility were found between the 10 sectors of the ASE, this result provides crucial and useful information for a number of applications in finance. For example, potential gains from diversification across sectoral level investment are limited. News or shocks in one sector will eventually be transmitted to other sectors of the market through their linkages. This finding suggests that investors should keep a close eye on all sectors because shocks affecting a certain sector will eventually impact all sectors through their interdependence.

The interdependence of sectors might be due to cross price effects on traders' diversified investment strategies (Simmons and Tantisantiwong 2014), correlated beliefs of analysts (David and Simonovska 2016), trade or financial linkages (Hernández and Valdés 2001; Allen and Gale 2000) or that these sectors may be affected by the same risk factors (Hassan and Malik 2007). The empirical results from panel data analysis highlight that both systematic and idiosyncratic risk factors are the main drivers of the time-varying correlation between the ASE sectoral returns. Specifically, equity return correlations increased as inflation increased, and there is evidence that the effects of liquidity, profitability, and stock market performance (growth) on return correlations depended on aggregate demand (economic vulnerability) within the economy.

These results should help investors and policymakers understand the comovement between equity returns for different industries and the interdependence between major sectors. In particular, the knowledge can be useful for creating well-diversified portfolios and monitoring asset correlations for domestic investors; the interdependence between equity returns requires portfolio managers' to quantify the optimal weights and hedging ratios for their portfolios in order to deal adequately with the risk associated with their investment in the ASE. In terms of policymakers or regulators, the results of this paper imply the need for a mechanism that will help prevent the possibility of contagious effect of any crises, which may occur in the future, especially crises originating in financial sectors found to be one of the most influential sectors in the ASE.

Appendix 1 Definitions of the financial ratios

Name	Code	Measurement Units	Definition
Panel A: Stock Market Performance			
Turnover Ratio	TR	Percentage	The number of shares traded in the sector divided by the number of shares of the same sector times by 100
Price-Earnings Ratio	PE	Times	The market capitalization of the sector divided by the net income pertaining to shareholders of the same sector
Dividend Yield	DY	Percentage	The proposed cash dividend of the sector divided by the market capitalization of the same sector times by 100
Dividend Pay-out	DP	Percentage	The proposed cash dividend of the sector divided by net income pertaining to shareholders of the same sector times by 100
Market-to-Book Ratio	MB	Times	The market capitalization of the sector divided by the total shareholders' equity of the same sector
Panel B: Profitability			
Return On Assets	ROA	Percentage	The net income of the sector divided by the total assets of the same sector times by 100
Return On Equity	ROE	Percentage	The net income of the sector divided by the total shareholders' equity of the same sector times by 100
Panel C: Leverage (Gearing)			
Debt Ratio	DR	Percentage	The total liabilities of the sector divided by the total assets of the same sector times by 100
Panel D: Liquidity			
Current Ratio	CR	Times	The total current assets of the sector divided by the total current liabilities of the same sector
Panel E: Size or Market Share			
Relative Size	RS	Percentage	The value of shares in a sector divided by the value of shares of the whole market times by 100

Notes: This table shows the name, code, measurement unit and definition for each financial ratio considered in the current paper. For BNK, the current ratio = (cash and balances at the Central Bank + balances at other banks and financial institutions + deposits at banks and financial institutions + trading investments)/ (all customers deposits + banks and financial institutions deposits). Source: ASE website http://ww.ase.com.jo/en/glossary accessed on 7 February 2014.

Appendix 2 Definitions of the macroeconomic variables

Name	Code	Measurement Units	Definition
Panel A: Price or Monetary Stability			
Inflation Rate	INF	Percentage	Change in consumer price index which measures the general price level of a fixed basket of goods and services consumed by the Jordanian family (851 commodities and services), including those imported from abroad times by 100
Interest Rate	IR	Percentage	The six-month treasury bill rate is the rate on short term bills which are issued by the Treasury
Growth in Broad Money Supply	MS2	Percentage	Change in money supply (MS2) which is equal to money supply (M1) plus quasi-money times by 100.
Panel B: Economic Activity			
Growth in Real Gross Domestic Product	RGDP	Percentage	A measure of economic growth from one year to another expressed as a percentage and adjusted for inflation.
Panel C: Economic Reliance on Domestic and External Demand			
Domestic Private Consumption to GDP Ratio	C/GDP	Percentage	The ratio of domestic private consumption which is the market value of all goods and services, including durable products purchased by households to GDP times by 100
Trade Balance to GDP Ratio	TB/GDP	Percentage	The ratio of exports less imports in the Balance of Payments to GDP times by 100.
Panel D: Level of Leverage for the Economy			
Domestic Lending to GDP Ratio	TDL/GDP	Percentage	The ratio of domestic lending to GDP times by 100 which represent the level of debt for the economy

Notes: This table shows the name, code, measurement unit and definition for each macroeconomic variable considered in the current paper. Source: Central Bank of Jordan Statistical Database accessed online on March 21, 2014, www.cbj.gov.jo.

Appendix 3 Estimated coefficients of the var (1) model

	Dependent Variables									
	BNK	**INS**	**DFN**	**RES**	**EDS**	**HNT**	**TRP**	**COM**	**FOB**	**MIX**
BNK(-1)	16.1038* (2.8759)	7.9533* (2.4352)	7.5622 (4.6110)	4.6374 (4.3679)	2.79014 (3.1615)	3.998 (2.8173)	4.9414 (3.8419)	-1.3524 (3.2749)	0.7812 (1.8633)	5.0814 (4.0936)
INS(-1)	0.8076 (2.5530)	9.1774* (2.1618)	-3.0671 (4.0933)	-0.8154 (3.8775)	2.4839 (2.8066)	-1.1404 (2.5009)	-3.7367 (3.4105)	-0.3646 (2.9072)	-0.4348 (1.6541)	-5.6949 (3.6339)
DFN(-1)	-0.6908 (1.7807)	-0.4331 (1.5078)	20.1767* (2.8551)	2.0795 (2.7045)	-1.9483 (1.9576)	0.9020 (1.7444)	-3.1966 (2.3788)	0.8865 (2.0278)	-2.6550* (1.1537)	-3.0886 (2.5346)
RES(-1)	2.0911 (1.8678)	1.7836 (1.5816)	5.0210 (2.9947)	24.5763* (2.8368)	-1.5968 (2.0533)	0.1784 (1.8297)	1.9368 (2.4952)	3.2147 (2.1270)	0.5146 (1.2101)	0.6201 (2.6587)
EDS(-1)	3.1678 (1.8857)	0.0383 (1.5968)	4.1250 (3.0235)	-0.4619 (2.8640)	5.3611* (2.0730)	1.3295 (1.8473)	3.2860 (2.5191)	1.9766 (2.1474)	0.3396 (1.2217)	-0.9777 (2.6841)
HNT(-1)	-1.1719 (2.2809)	0.7346 (1.9314)	0.0833 (3.6571)	-2.8202 (3.4643)	3.5001 (2.5075)	10.0846* (2.2344)	4.8829 (3.0471)	1.4270 (2.5974)	1.8981 (1.4778)	1.0155 (3.2467)
TRP(-1)	0.8902 (1.9059)	0.3309 (1.6139)	-1.6886 (3.0559)	0.1970 (2.8948)	1.8672 (2.0953)	3.7694* (1.8671)	13.2774* (2.5462)	3.1301 (2.1704)	1.3265 (1.2349)	0.3457 (2.7129)
COM(-1)	-3.4407 (1.9599)	0.5769 (1.6596)	-3.5898 (3.1424)	-1.2944 (2.9767)	2.6176 (2.1546)	-0.6044 (1.9199)	0.3358 (2.6182)	9.4599* (2.2318)	1.6455 (1.2698)	2.3972 (2.7897)
FOB(-1)	-0.4642 (3.1948)	-3.3599 (2.7053)	3.5376 (5.1224)	-0.0064 (4.8522)	0.3360 (3.5121)	2.5057 (3.1297)	-2.3229 (4.2679)	0.6798 (3.6381)	4.1651* (2.0699)	-3.7102 (4.5475)
MIX(-1)	0.3850 (1.6352)	1.8156 (1.3847)	-3.0593 (2.6218)	-1.3130 (2.4835)	2.2048 (1.7976)	0.9815 (1.6019)	0.5661 (2.1845)	1.3797 (1.8621)	1.1452 (1.0594)	25.7994* (2.3276)
Constant	0.16875* (0.0326)	0.1376* (0.0276)	0.2258* (0.0524)	0.1773* (0.0496)	0.0284 (0.0359)	0.0664* (0.0320)	0.1225* (0.0436)	0.0408 (0.0372)	0.0919* (0.0211)	0.2002* (0.0465)
Local crisis	-0.3300* (0.0725)	-0.2797* (0.0614)	-0.5385* (0.1163)	-0.2572* (0.1102)	0.1004 (0.0798)	-0.1025 (0.0711)	-0.3593* (0.0969)	-0.0236 (0.0826)	-0.1053* (0.0470)	-0.2521* (0.1033)
Global crisis	-0.2087* (0.4568)	-0.1974* (0.0386)	-0.3503* (0.0732)	-0.2884* (0.0693)	-0.0313 (0.0502)	-0.1066* (0.0447)	-0.2131* (0.0610)	-0.1127* (0.0520)	-0.1646* (0.0295)	-0.2866* (0.0650)
R^2	0.0501	0.0575	0.0806	0.0819	0.0122	0.0349	0.0386	0.0286	0.0222	0.0823
F-statistic	10.8*	12.5*	17.9*	18.2*	2.5*	7.3*	8.2*	6.0*	4.6*	18.2*
LL	7725.0	8134.2	6563.7	6696.9	7492.1	7775.6	7012.6	7405.4	8792.7	6856.5
SIC	-6.2	-6.6	-5.3	-5.4	-6.0	-6.2	-5.6	-5.9	-7.1	-5.5
Model Statistics										
LL	7746.0									
SIC	-6.2									

Notes: All coefficients and standard errors are multiplied by 10^2. Numbers in parentheses are standard errors. The R^2, F-statistics, the Log likelihood (LL) and the Schwarz Information criterion (SIC) for the different equations are shown. An * denotes significance at the 5% level.

References

Abdmoulah W (2010) Testing the evolving efficiency of Arab stock markets. International Review of Financial Analysis 19: 25-34

Ahid M, Augustine A (2012) The impact of global financial crisis on Jordan. International Journal of Business and Management 7: 80-88

Al-Fayoumi NA, Khamees BA, Al-Thuneibat AA (2009) Information transmission among stock return indexes: Evidence from the Jordanian stock market. International Research Journal of Finance and Economics 1: 194-208

Al-Jarrah IM, Khamees BA, Qteishat IH (2011) The "turn of the month anomaly" in Amman Stock Exchange: Evidence and implications. Journal of Money, Investment and Banking 21: 5-11

Al-Saket B (2007) Secretes of falling stock prices in the stock market. Al-Hadath. Amman. Translated from Arabic to English

Al-Zoubi H, Al-Zu'bi B (2007) Market efficiency, time-varying volatility and the asymmetric effect in Amman Stock Exchange. Manage Financ 33: 490-499

AlZoubi OM, Al-Darkazaly WA (2013) Inter-sectoral linkages in Jordan economy: Input-output analysis. Global Journal of Management and Business Research Finance 13: 34-42

Allen F, Gale D (2000) Financial contagion. J Polit Econ 108: 1-33

Alomari M (2015) Market efficiency and volatility spillovers in the Amman Stock Exchange: A sectoral analysis. Dissertation, University of Dundee

Amini H, Cont R, Minca A (2016) Resilience to contagion in financial networks. Math Financ 26(2): 329-365

ASE (2013) Amman Stock Exchange [online] www.ase.com.jo

ASE Annual Report (2006) Amman Stock Exchange annual report. http://www.ase.com.jo/en/node/536. Accessed 28 February 2012

ASE Annual Report (2012) Amman Stock Exchange annual report. http://www.ase.com.jo/en/node/536. Accessed 11 January 2013

Baele L (2005) Volatility spillover effects in European equity markets. J Financ Quant Anal 40:373-401

Baur DG (2012) Financial contagion and the real economy. J Bank Financ 36: 2680-2692

Bekaert G, Harvey CR, Lundblad CT, Siegel S (2011) What segments equity markets? Rev Financ Stud 24: 3841-3890

Bekaert G, Hodrick RJ, Zhang X (2009) International stock return comovements. J Financ 64: 2591-2626

Billio M, Caporin M, Frattarolo L, Pelizzon L (2016) Network in risk spillovers: A multivariate GARCH perspective. Department of Economics Working Paper no. 03/WP/2016, Ca' Foscari University of Venice

Binder JJ, Merges MJ (2001) Stock market volatility and economic factors. Rev Quant Finan Acc 17:5-26

Binici M, Koksal B, Orman C (2013) Stock return comovement and systemic risk in the Turkish banking sector. Central Bank of the Republic of Turkey Working Paper no. 13/02, Ankara

Bollerslev T, Wooldridge JM (1992) Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances. Economet Rev 11: 143-172

Cappiello L, Engle RF, Sheppard K (2006) Asymmetric dynamics in the correlation of global equity and bond returns. J Financ Economet 4(4): 537-572

Chiang TC, Chen X (2016) Empirical analysis of dynamic linkages between China and international stock markets. Journal of Mathematical Finance 6: 189-212

Chiang TC, Jeon BN, Li H (2007) Dynamic correlation analysis of financial contagion: Evidence from Asian markets, J Int Money and Financ 26: 1206-1228

Chiang TC, Lao L, Xue Q (2015) Comovements between Chinese and global stock markets: Evidence from aggregate and sectoral data. Rev Quant Finan Acc (Forthcoming)

Chuang IY, Lu JR, Tswei K (2007) Interdependence of international equity variances: Evidence from East Asian markets. Emerging Markets Review 8: 311-327

Claessens S, Forbes K (2013) International financial contagion. Springer Science & Business Media

David JM, Simonovska I (2016) Correlated beliefs, returns, and stock market volatility. J Int Econ 99: S58-S77

De Nicolo G, Kwast ML (2002) Systemic risk and financial consolidation: Are they related? J Bank Financ 26: 861-880

Dunteman GH (1994) Principal components analysis. In: M.S. Lewis-Beck (ed). Factor Analysis and Related Techniques, International Handbooks of Quantitative Applications in the Social Sciences, 5. Sage Publications, London, 157-245

Eiling E, Gerard B, Hillion P, De Roon FA (2012) International portfolio diversification: Currency, industry and country effects revisited. J Int Money Financ 31: 1249-1278

El-Nader HM, Alraimony AD (2012) The impact of macroeconomic factors on Amman stock market returns. International Journal of Economics and Finance 4: 202-213

Engle RF (2002) Dynamic conditional correlation: A simple class of multivariate general autoregressive conditional heretoskedasticity models. J Bus and Econ Stat 20: 339-350

Fama EF (1970) Efficient capital markets: A review of theory and empirical work. J Financ 25: 383-417

Fama EF, French KR (1992) The cross-section of expected stock returns. J Financ 47: 427-465

Fama EF, French KR (2015) A five-factor asset pricing model. J Financ Econ 116(1): 1-22

Fayyad A, Daly K (2011) International transmission of stock returns: Mean and volatility spillover effects in the emerging markets of the GCC countries, the developed markets of UK & USA and oil. International Research Journal of Finance and Economics 67:103-117

Fifield SGM, Power DM, Sinclair CD (2002) Macroeconomic factors and share returns: An analysis using emerging market data. Int J Financ Econ 7: 51-62

Forbes KJ, Rigobon R (2002) No contagion, only interdependence: Measuring stock market comovements. J Financ 57(5): 2223-2261

Gallagher LA, Twomey CE (1998) Identifying the source of mean and volatility spillovers in Irish equities: A multivariate GARCH analysis. Econ Soc Rev 29: 341-56

Garcia R, Mantilla-Garcia D, Martellini L (2015) A model-free measure of aggregate idiosyncratic volatility and the prediction of market returns. J Financ Quant Anal (Forthcoming)

Group of Ten (2001) Report on consolidation in the financial sector. IMF, Washington

Hamao Y, Masulis RW, Ng V (1990) Correlations in price changes and volatility across international stock markets. Rev Financ Stud 3: 281-307

Hammoudeh SM, Yuan Y, McAleer M (2009) Shock and volatility spillovers among equity sectors of the Gulf Arab stock markets. Q Rev Econ Financ 49: 829-842

Harris RDF, Pisedtasalasai A (2006) Return and volatility spillovers between large and small stocks in the UK. J Bus Finan Account 33: 1556-1571

Hassan SA, Malik F (2007) Multivariate GARCH modeling of sector volatility transmission. Q Rev Econ Financ 47: 470-480

Hernández LF, Valdés RO (2001) What drives contagion: Trade, neighborhood, or financial links? International Review of Financial Analysis 10: 203-218

Ho C, Lee C, Lin C, Wang E (2005) Liquidity, volatility and stock price adjustment: Evidence from seasoned equity offerings in an emerging market. Rev Pac Basin Financ Mark Polic 8:31–51

Huang Y, Su W, Li X (2010) Comparison of BEKK GARCH and DCC GARCH models: An empirical study. In: Cao, L., Zhong, J. and Feng, Y. (ed), Advanced Data Mining and

Applications Part II, Lecture Notes in Computer Science Volume 6441, Springer-Verlag, Berlin/Heidelberg

Kaiser HF (1960) The application of electronic computers to factor analysis. Educ Psychol Meas 20: 141-151

Kanas A (1998) Volatility spillovers across equity markets: European evidence. Appl Fin Econ 8: 245-256

Khan MN, Tantisantiwong N, Fifield SGM, Power DM (2015) The relationship between South Asian stock returns and macroeconomic variables. Appl Econ 47: 1298-1313

Kim MH, Sun L (2016) Dynamic conditional correlations between Chinese sector returns and the S&P500 index: An interpretation based on investment shocks. Asian Finance Association 2016 Conference. Available at SSRN: http://ssrn.com/abstract=2713602

Kolluri B, Wahab M (2008) Stock returns and expected inflation: Evidence from an asymmetric test specification. Rev Quant Finan Acc 30: 371-395

Laurent S, Rombouts JVK, Violante F (2012) On the forecasting accuracy of multivariate GARCH models. J Appl Econ 27: 934–955

Li H (2007) International linkages of the Chinese stock exchanges: A multivariate GARCH analysis. Appl Fin Econ 17: 285-297

Li H, Majerowska E (2008) Testing stock market linkages for Poland and Hungary: A multivariate GARCH approach. Research in International Business and Finance 22: 247-266

Ling S, McAleer M (2003) Asymptotic theory for a vector ARMA-GARCH model. Economet Theor 19: 280-310

Mackey R (2013) Remembering the start of Syria's uprising. The New York Times

Maghyereh A (2005) Electronic trading and market efficiency in an emerging market. Emerg Mark Financ Tr 41: 5-19

Maghyereh A, Awartani B (2012) Return and volatility spillovers between Dubai financial market and Abu Dhabi stock exchange in the UAE. Appl Fin Econ 22: 837-848

Malik F, Hammoudeh S (2007) Shock and volatility transmission in the oil, US and Gulf equity markets. Int Rev Econ Financ 16: 357-368

Malik F, Hassan SA (2004) Modeling volatility in sector index returns with GARCH models using an iterated algorithm. Journal of Economics and Finance 28: 211-225

Miller RE, Blair PD (1985). Input-Output Analysis: Foundations and Extensions, Englewood Cliffs, New Jersey, Prentice-Hall, Inc

Mousa NYA (2010) Monetary policy and the role of exchange rate: The case of Jordan. Dissertation, The University of Birmingham

Mun K-C (2012) The joint response of stock and foreign exchange markets to macroeconomic surprises: Using US and Japanese data. J Bank Financ 36: 383-394

Ng A (2000) Volatility spillover effects from Japan and the US to the Pacific-Basin. J Int Money Financ 19: 207-233

Omet G, Khasawneh M, Khasawneh J (2002) Efficiency tests and volatility effects: Evidence from the Jordanian stock market. Appl Econ Lett 9: 817-821

Patro DK, Qi M, Sun X (2013) A simple indicator of systemic risk. Journal of Financial Stability 9(5): 105-116

Phylaktis K, Xia L (2009) Equity market comovement and contagion: A sectoral perspective. Financ Manage 38(2): 381-409

Pritsker M (2001) The channels for financial contagion. In: S. Claessens & K. Forbes, K. (ed) International Financial Contagion, Springer Science & Business Media

Riedle T (2016) Measuring the contribution to systemic risk of sectors in the United States, the UK and Germany using ΔCoVaR. SSRN Working paper. Available at SSRN: http://ssrn.com/abstract=2741294

Ross SA 1(976) The arbitrage theory of capital asset pricing. J Econ Theory 13:341-360

Simmons P, Tantisantiwong N (2014) Equilibrium moment restrictions on asset returns: Normal and crisis periods. Eur J Financ 20:1064-1089

Sok-Gee C, Abd Karim MZ (2010) Volatility spillovers of the major stock markets in ASEAN-5 with the U.S. and Japanese stock markets. International Research Journal of Finance and Economics 44: 161-173

Theodossiou P, Lee U (1993) Mean and volatility spillovers across major national stock markets: Further empirical evidence. J Financ Res 16:337-350

Vidal-García J, Vidal M, Nguyen DK (2016) Do liquidity and idiosyncratic risk matter? Evidence from the European mutual fund market. Rev Quant Finan Acc 47: 213-247

Walter JE (1956) Dividend policies and common stock prices. J Financ 11: 29-41

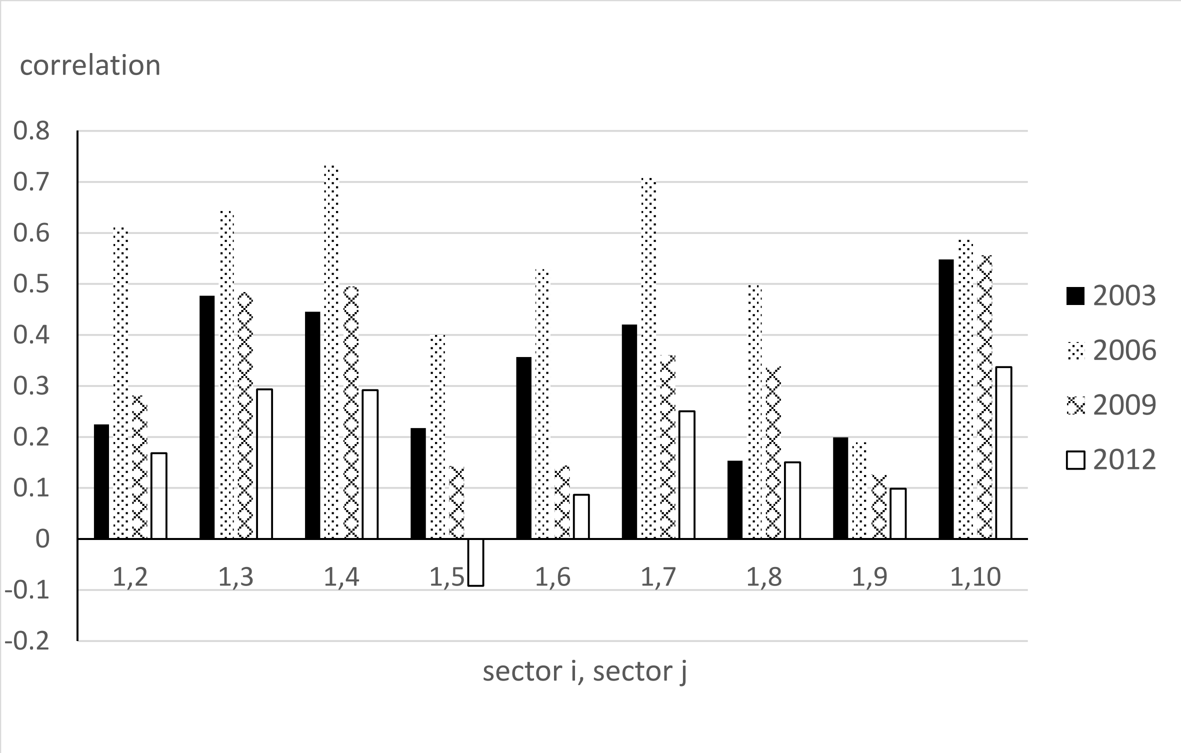
Wang Z, Kutan AM, Yang J (2005) Information flows within and across sectors in Chinese stock markets. Q Rev Econ Financ 45: 767-780

World Bank (2003) The Hashemite Kingdom of Jordan country assistance evaluation, Report No.26875-JO. Accessed 16 May 2014

World Bank (2013) Jordan economic monitor: Maintaining stability and fostering shared prosperity amid regional turmoil. Poverty Reduction and Economic Management Unit, Middle East and North African Region. The World Bank. www.worldbank.org/content/dam/Worldbank/document/MNA/Jordan_EM_Spring_2013.pdf. Accessed 25 March 2014

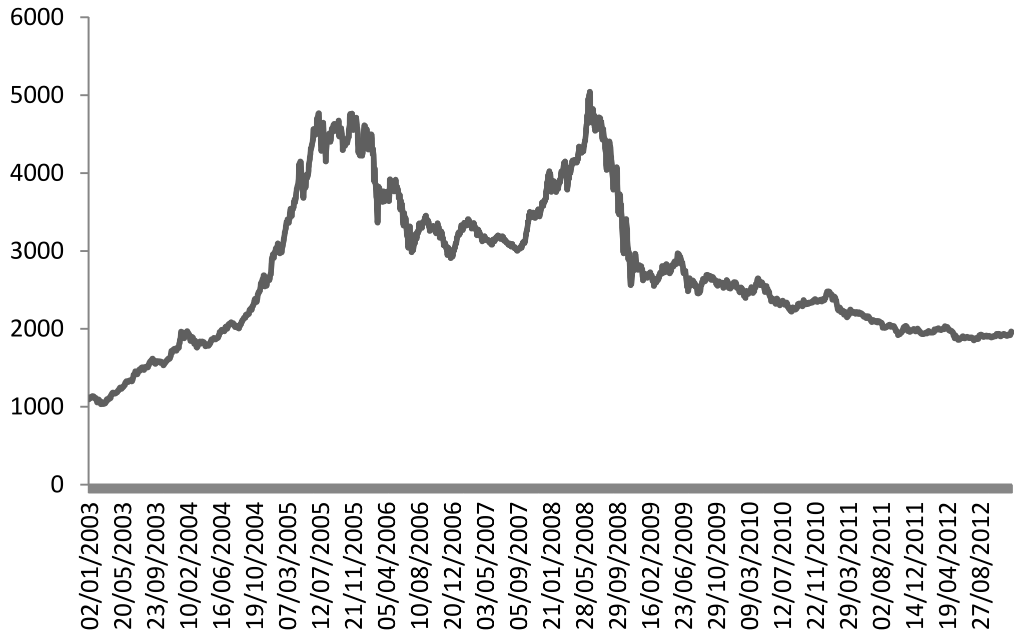
Figures

Fig. 1 Return correlations between banking and other sectors



Note: Figure shows the correlations between index returns of the BNK sector (1) and the nine other sectors: INS (2), DFN (3), RES (4), EDS (5), HNT (6), TRP (7), COM (8), FOB (9) and MIX (10).

Fig. 2 ASE free float index over the period 2003 - 2012



Break Point Dates	**F-statistics**	**Probability**
8 November 2005	32.96	0.0001
17December 2006	33.06	0.0005
18 June 2008	16.81	0.0000

Tables

Table 1 Descriptive statistics

Sector	Mean	SD	Max	Min	Skew	Kurt	JB-stat
BNK	0.0005	0.011	0.048	-0.050	-0.051	6.36*	1155.59*
INS	0.0002	0.009	0.044	-0.049	0.139*	5.55*	672.68*
DFN	0.0001	0.018	0.089	-0.074	-0.030	3.92*	87.23*
RES	0.0002	0.017	0.076	-0.104	-0.068	4.72*	305.59*
EDS	0.0003	0.012	0.040	-0.043	0.135*	4.44*	219.44*
HNT	-0.0001	0.010	0.045	-0.057	0.121*	5.28*	540.84*
TRP	-0.0001	0.014	0.048	-0.049	-0.041	3.69*	49.12*
COM	-0.0001	0.012	0.080	-0.092	-0.271*	5.90*	894.16*
FOB	-0.0001	0.007	0.044	-0.064	-0.433*	11.75*	7933.49*
MIX	0.0006	0.016	0.048	-0.051	-0.130*	4.70*	304.34*

Notes: Descriptive statistics of log returns for 10 sector indexes are included in the table. Mean is the equally weighted average of all the daily observation over the 10-year period. SD indicates the standard deviation of the return series. Maximum (Max) and Minimum (Min) indicates the highest and lowest returns respectively. Skew is the Kendall-Stuart measure of Skewness, Kurt is the Kendall-Stuart measure of Kurtosis. JB-stat is Jarque-Bera normality test statistic with 2 degrees of freedom. The standard error of Skewness and Kurtosis are 0.05 and 0.1 respectively. An * indicates significance at the 5% level.

Table 2 Summary statistics of sectoral financial ratios from 2003 to 2012

Sectors		Financial Ratios									
		RS	**TR**	**PE**	**DY**	**DP**	**MB**	**ROA**	**ROE**	**DR**	**CR**
BNK	Mean	51.55	25.50	21.23	2.16	41.20	2.12	1.29	9.59	86.42	0.46
	SD	5.74	18.48	5.29	1.09	12.71	1.07	0.33	2.34	2.42	0.02
INS	Mean	1.99	41.47	37.15	1.86	75.24	1.58	3.50	6.69	50.21	1.85
	SD	0.37	23.02	129.03	0.92	204.23	0.42	5.64	10.94	4.97	0.18
DFN	Mean	3.67	147.53	11.08	1.71	58.18	1.35	3.59	1.68	34.00	3.08
	SD	1.42	49.50	45.17	0.94	121.43	62.56	8.78	12.65	6.76	0.25
RES	Mean	4.40	183.12	16.49	1.23	10.12	1.32	4.06	2.68	29.51	1.53
	SD	1.26	64.04	32.95	0.77	35.22	0.67	9.15	11.48	5.78	0.79
EDS	Mean	1.45	29.47	20.04	3.03	47.81	2.27	9.66	12.37	25.63	0.82
	SD	0.30	28.87	9.47	2.08	34.42	0.34	2.85	3.87	2.55	0.14
HNT	Mean	3.09	35.53	32.40	1.17	61.54	1.47	2.00	1.86	32.35	1.05
	SD	0.24	21.15	133.55	0.59	191.43	0.36	3.02	3.64	4.72	0.23
TRP	Mean	1.19	76.05	12.50	1.50	61.44	0.94	2.86	3.15	61.21	0.92
	SD	0.42	36.82	161.93	0.70	231.69	0.36	6.11	16.36	6.96	0.26
COM	Mean	1.33	102.5	81.94	3.97	80.39	1.22	5.40	6.83	34.51	1.93
	SD	0.39	52.79	154.32	1.95	327.02	0.34	3.30	5.11	10.82	0.60
FOB	Mean	0.99	46.64	39.16	1.43	51.42	1.33	2.75	2.80	32.92	1.58
	SD	0.15	33.70	33.02	0.49	44.88	0.25	1.89	3.02	6.33	0.16
MIX	Mean	17.76	29.25	9.79	3.50	37.53	3.19	13.28	19.27	34.96	2.25
	SD	7.27	22.87	23.84	1.44	71.77	0.89	8.12	11.96	7.86	0.24

Notes: The table shows the mean and standard deviation (SD) around these means for the financial ratios of the sample sectors. Definitions of these financial ratios are presented in Appendix 1.

Table 3 Summary statistics of macroeconomic variables 2003 to 2012

Year	RGDP	C/GDP	TB/GDP	TDL/GDP	INF	IR	MS2
2003	4.16	76.94	-19.58	25.11	2.38	2.05	12.43
2004	8.57	81.56	-29.60	25.73	2.56	3.36	11.68
2005	8.15	87.82	-39.84	27.64	3.52	6.36	16.96
2006	8.09	85.02	-33.58	27.74	6.26	6.73	14.12
2007	8.18	86.65	-37.71	30.46	4.70	5.87	10.61
2008	7.23	79.54	-32.61	36.90	13.94	5.62	17.28
2009	2.31	75.03	-26.31	41.90	-0.67	2.83	9.34
2010	3.10	76.03	-25.71	42.53	5.06	2.21	11.46
2011	2.59	74.46	-30.58	48.82	4.38	2.23	8.12
2012	2.65	74.66	-34.08	57.72	4.80	3.79	3.43
Mean	5.50	79.77	-31.0	36.45	4.69	4.10	11.54
SD	2.74	5.18	6.00	11.08	3.78	1.86	4.12

Note: The table shows the actual values, mean and standard deviation of the macroeconomic variables. Definitions of these macroeconomic variables are presented in Appendix 2.

Table 4 Estimated coefficients of variance and correlation equations of the AR (1) - DCC-MTGARCH (1, 1) model

Panel A: Conditional variance equations

	BNK (*i*=1)	**INS (*i*=2)**	**DFN (*i*=3)**	**RES (*i*=4)**	**EDS (*i*=5)**	**HNT (*i*=6)**	**TRP (*i*=7)**	**COM (*i*=8)**	**FOB (*i*=9)**	**MIX (*i*=10)**
ω_i	0.017* (0.004)	0.006* (0.002)	0.005 (0.003)	0.001 (0.001)	0.007* (0.003)	0.002 (0.002)	0.023* (0.006)	0.002* (0.001)	0.035* (0.003)	0.004 (0.002)
α_{i1}	0.171* (0.033)	0.023 (0.034)	0.012 (0.030)	-0.030 (0.024)	-0.001 (0.031)	-0.021 (0.024)	-0.013 (0.037)	-0.023 (0.015)	-0.059* (0.018)	-0.035 (0.039)
α_{i2}	0.011 (0.029)	0.208* (0.031)	0.042 (0.028)	0.021 (0.019)	-0.023 (0.023)	0.023 (0.022)	0.049 (0.036)	0.024 (0.015)	0.071* (0.016)	0.058 (0.035)
α_{i3}	0.005 (0.018)	-0.038 (0.024)	0.094* (0.023)	0.007 (0.016)	0.056* (0.023)	0.040* (0.015)	-0.074* (0.020)	0.002 (0.010)	-0.050* (0.012)	-0.022 (0.025)
α_{i4}	0.018 (0.018)	-0.006 (0.023)	-0.041* (0.019)	0.079* (0.017)	-0.030 (0.016)	-0.018 (0.013)	0.045* (0.012)	0.013 (0.010)	0.065* (0.011)	0.022 (0.022)
α_{i5}	-0.016 (0.018)	-0.016 (0.024)	0.003 (0.018)	0.018 (0.014)	0.115* (0.024)	-0.016 (0.017)	0.008 (0.027)	-0.002 (0.011)	-0.009 (0.012)	-0.013 (0.029)
α_{i6}	0.025 (0.027)	-0.044 (0.027)	-0.083* (0.026)	-0.007 (0.016)	-0.048* (0.022)	0.100* (0.024)	0.098* (0.024)	-0.017 (0.014)	-0.031 (0.017)	-0.021 (0.036)
α_{i7}	-0.030 (0.020)	0.025 (0.027)	-0.007 (0.021)	-0.005 (0.014)	-0.018 (0.019)	0.008 (0.016)	0.188* (0.023)	0.002 (0.012)	0.0470* (0.010)	-0.047 (0.031)
α_{i8}	0.059* (0.021)	0.019 (0.024)	0.023 (0.019)	-0.003 (0.015)	-0.061* (0.020)	-0.002 (0.017)	-0.041 (0.032)	0.068* (0.016)	-0.045* (0.015)	-0.007 (0.030)
α_{i9}	-0.033 (0.034)	0.026 (0.040)	-0.002 (0.033)	-0.016 (0.023)	-0.001 (0.030)	-0.014 (0.029)	0.007 (0.058)	-0.024 (0.019)	0.232* (0.041)	0.117* (0.031)
α_{i10}	-0.005 (0.020)	-0.0003 (0.022)	0.009 (0.015)	0.0004 (0.012)	-0.014 (0.019)	-0.016 (0.015)	0.007 (0.021)	-0.002 (0.010)	0.012 (0.013)	0.216* (0.035)
β_{i1}	0.164 (0.153)	0.694* (0.244)	0.089 (0.158)	0.203* (0.094)	0.083 (0.209)	-0.140 (0.138)	-0.719* (0.225)	0.085 (0.074)	-0.461 (0.295)	0.153 (0.223)
β_{i2}	0.013 (0.146)	0.430* (0.075)	-0.014 (0.133)	-0.222* (0.088)	0.948* (0.279)	0.151 (0.162)	0.281 (0.277)	-0.123 (0.078)	0.882* (0.343)	-0.191 (0.165)
β_{i3}	0.497* (0.141)	-0.242 (0.189)	0.807* (0.064)	0.017 (0.040)	-0.528* (0.163)	-0.060 (0.088)	0.645* (0.201)	-0.014 (0.045)	0.365 (0.249)	-0.024 (0.187)
β_{i4}	-0.100 (0.073)	0.327* (0.152)	0.099 (0.053)	0.912* (0.021)	0.341* (0.097)	0.226* (0.088)	-0.036* (0.122)	-0.028 (0.030)	-0.737* (0.174)	-0.052 (0.071)
β_{i5}	-0.080 (0.136)	-0.263 (0.199)	-0.025 (0.084)	-0.009 (0.050)	0.737* (0.053)	-0.499* (0.173)	0.003 (0.202)	-0.004 (0.054)	0.035 (0.225)	0.060 (0.151)
β_{i6}	0.322 (0.217)	0.099 (0.225)	0.285 (0.196)	-0.135 (0.087)	-0.112 (0.224)	0.761* (0.067)	0.295 (0.203)	0.039 (0.058)	-0.385 (0.255)	0.109 (0.162)
β_{i7}	-0.068 (0.098)	0.197 (0.130)	-0.0263 (0.0696)	0.089 (0.049)	-0.546* (0.176)	-0.061 (0.064)	0.568* (0.080)	0.041 (0.033)	1.144* (0.159)	0.092 (0.100)
β_{i8}	-0.085 (0.123)	-0.447* (0.161)	-0.059 (0.071)	-0.023 (0.049)	0.066 (0.166)	0.261* (0.098)	0.178 (0.159)	0.929* (0.019)	-0.564* (0.248)	0.229 (0.148)
β_{i9}	-0.033 (0.333)	-0.407 (0.387)	0.384 (0.249)	-0.157 (0.133)	1.416* (0.462)	0.500* (0.241)	0.751 (0.428)	-0.239* (0.110)	-0.009 (0.042)	0.583 (0.385)
β_{i10}	0.253* (0.074)	0.011 (0.0998)	-0.124* (0.054)	-0.029 (0.035)	0.334* (0.111)	0.128 (0.080)	0.135 (0.082)	0.0225 (0.029)	0.050 (0.139)	0.642* (0.070)
γ_i	-0.077* (0.032)	-0.022 (0.040)	-0.032* (0.014)	-0.041* (0.011)	-0.022 (0.024)	-0.042 (0.024)	-0.090 (0.021)	-0.042* (0.014)	-0.202* (0.040)	-0.009 (0.030)
λ_i	-0.011 (0.011)	-0.001 (0.006)	0.022 (0.012)	-0.004 (0.004)	0.023* (0.010)	0.006 (0.004)	-0.007 (0.014)	0.004 (0.003)	-0.014* (0.004)	-0.001 (0.006)
θ_i	-0.016* (0.004)	0.008* (0.003)	0.008* (0.004)	0.003 (0.002)	-0.002 (0.002)	0.0001 (0.001)	-0.007 (0.007)	0.005* (0.002)	-0.006 (0.003)	0.004 (0.005)

Panel B: Dynamic Conditional Correlation

a_{dcc}	0.006* (0.001)	b_{dcc}	0.990* (0.001)

Panel C: Statistics

Log likelihood	80360.70
Likelihood Ratio: H_0: MGARCH-CCC model is preferred to MGARCH-DCC model	274.6*

Notes: All the coefficients in this table are reported as they are except for λ_i and θ_i in Panel A where they are multiplied by 10^3. Number in parentheses is standard error. An * denotes significance at the 5% level. The estimates of the mean equation are not reported here to conserve space and are available upon request from the authors.

Table 5 Time-varying Conditional Correlations between the ASE Sectors

	BNK	**INS**	**DFN**	**RES**	**EDS**	**HNT**	**TRP**	**COM**	**FOB**	**MIX**
BNK	**1.00**									
INS	0.3830 **0.0527** 0.2573 **0.6854**	**1.00**								
DFN	0.5790 **0.0411** 0.4192 **0.7472**	0.2816 **0.0569** 0.0508 **0.5964**	**1.00**							
RES	0.5726 **0.0475** 0.4248 **0.7640**	0.2884 **0.0546** 0.1370 **0.5867**	0.6717 **0.0534** 0.4441 **0.8119**	**1.00**						
EDS	0.1999 **0.0569** 0.0238 **0.5092**	0.1101 **0.0450** -0.0012 **0.4109**	0.1385 **0.0531** -0.0764 **0.3979**	0.1930 **0.0534** -0.0166 **0.4475**	**1.00**					
HNT	0.3868 **0.0544** 0.1833 **0.6221**	0.2089 **0.0490** 0.1140 **0.4873**	0.3377 **0.0527** 0.2180 **0.5766**	0.3603 **0.0528** 0.1822 **0.5651**	0.1154 **0.0508** -0.0851 **0.3474**	**1.00**				
TRP	0.5317 **0.0554** 0.4267 **0.7666**	0.2735 **0.0551** 0.1667 **0.6112**	0.5005 **0.0494** 0.3864 **0.7101**	0.4930 **0.0558** 0.3294 **0.7050**	0.1533 **0.0500** 0.0095 **0.4448**	0.3516 **0.0618** 0.1849 **0.6498**	**1.00**			
COM	0.3234 **0.0618** 0.0659 **0.5801**	0.1958 **0.0603** -0.0585 **0.4935**	0.3765 **0.0562** 0.2272 **0.5923**	0.3708 **0.0580** 0.1828 **0.5840**	0.1334 **0.0509** 0.0063 **0.4242**	0.2403 **0.0581** 0.0983 **0.5205**	0.3229 **0.0598** 0.1120 **0.5632**	**1.00**		
FOB	0.2053 **0.0529** 0.0287 **0.4800**	0.1159 **0.0429** -0.0145 **0.3296**	0.1857 **0.0522** -0.0145 **0.4256**	0.1796 **0.0515** -0.0415 **0.4148**	0.0915 **0.0436** -0.0721 **0.3115**	0.1304 **0.0501** 0.0134 **0.3794**	0.1794 **0.0528** 0.0353 **0.4240**	0.1301 **0.0544** -0.0236 **0.3798**	**1.00**	
MIX	0.4971 **0.0372** 0.3487 **0.7042**	0.2360 **0.0454** 0.1085 **0.4478**	0.4063 **0.0472** 0.2662 **0.6580**	0.4120 **0.0426** 0.2715 **0.6002**	0.1511 **0.0449** 0.0414 **0.3915**	0.2746 **0.0484** 0.1390 **0.5213**	0.4117 **0.0484** 0.2577 **0.6263**	0.2888 **0.0557** 0.0922 **0.5207**	0.1606 **0.0456** -0.0165 **0.3519**	**1.00**

Notes: The time-varying conditional correlation between the different pairs of sectors for the 10 indices is included in this table. The first, second, third and fourth line of each cell is the mean, the standard deviation, the Minimum and the Maximum of the correlation for each pair of sectors, respectively.

Table 6 Factor loadings for the dominant principal components

Variables	Factor Loadings PC1	PC2	PC3	PC4	PC5	Cum. Proportion
Panel A: Financial Ratios						
RS	-0.327	0.281	0.283	**0.457**	0.210	85.4%
TR	0.274	-0.295	-0.056	0.019	**0.564**	
PE	0.325	-0.045	**0.607**	0.011	0.057	
DY	0.158	0.335	0.043	0.091	**-0.683**	
DP	0.352	-0.038	**0.599**	0.025	-0.049	
MB	0.058	-0.308	-0.163	**0.692**	-0.141	
ROA	0.326	**0.506**	-0.204	0.053	0.213	
ROE	0.185	**0.579**	-0.106	0.137	0.283	
DR	**-0.490**	0.081	0.250	0.303	0.123	
CR	**0.420**	-0.158	-0.211	**0.436**	-0.078	
Name of PC	Liquidity	Profitability	Stock Market Performance	Size	Growth	
Panel B: Macroeconomic Variables						
C/GDP	**0.549**	-0.227	0.046	-------	-------	86.8%
INF	-0.121	**0.682**	0.138	-------	-------	
IR	**0.473**	0.185	0.330	-------	-------	
MS2	0.238	**0.607**	0.063	-------	-------	
RGDP	0.239	0.233	**-0.581**	-------	-------	
TB/GDP	**-0.510**	0.158	-0.300	-------	-------	
TDL/GDP	-0.293	-0.001	**0.661**	-------	-------	
Name of PC	Aggregate Demand	Inflation	Economic Vulnerability	-------	-------	

Notes: The table summarizes the results from applying two PCAs to the yearly standardized financial ratios as well as the macroeconomic variables over the 10-year period 2003-2012. Specifically, the factor loadings for the PCs that account for most of the variation in the data are reported. The highlighted values indicate variables which have high loadings (weight of 0.4 and above in absolute terms) in each PC.

Table 7 Results from the panel regression analysis

	Conditional Correlation						Unconditional Correlation
Variables	**Fixed Effects (1)**	**Random Effects (2)**	**Fixed Effects (3)**	**Fixed Effects (4)**	**Fixed Effects (5)**	**Random Effects (6)**	**Fixed Effects (7)**
L	0.1688* (0.0755)	0.1613* (0.0755)		-0.7233 (0.3860)	0.1813* (0.0753)	0.1743* (0.0752)	0.7521* (0.3330)
PR	-0.6429 (0.3515)	-0.6319 (0.3515)		8.3794* (1.8529)	-0.5234 (0.3339)	-0.5122 (0.3339)	-2.6995 (1.5498)
SM	-0.1070* (0.0260)	-0.1060* (0.0260)		0.2402 (0.1307)	-0.1111* (0.0253)	-0.1095* (0.0253)	-0.4280* (0.1145)
S	0.3538 (0.3893)	0.3249 (0.3892)		0.2467 (2.4010)	0.4441 (0.3781)	0.4153 (0.3780)	1.7484 (1.7166)
G	0.0178 (0.0798)	0.0163 (0.0798)		0.8072 (0.8370)			0.4816 (0.3520)
AD	10.5150* (3.6467)	10.0060* (3.6452)	9.5798* (1.909)	9.595* (1.975)	9.4075* (3.3596)	8.9788* (3.3577)	52.781* (16.079)
INF	31.4190* (7.2023)	31.5410* (7.2016)	31.824* (3.1948)	30.308* (3.132)	37.169* (5.6735)	37.607* (5.6722)	201.000* (31.756)
EV	-0.7987 (2.8783)	-0.5957 (2.8778)	-1.2891 (1.6637)	-0.870 (1.644)	2.0148 (2.5771)	2.2283 (2.5767)	-6.2198 (12.691)
L × AD	-0.0028* (0.0010)	-0.0027* (0.0010)			-0.0031* (0.0010)	-0.0030* (0.0010)	-0.0113* (0.0045)
PR × AD	0.0109* (0.0040)	0.0107* (0.0040)			0.0097* (0.0037)	0.0096* (0.0037)	0.0392* (0.0175)
SM × AD	0.0018* (0.0004)	0.0017* (0.0004)			0.0018* (0.0004)	0.0018* (0.0004)	0.0065* (0.0016)
S × AD	-0.0041 (0.0052)	-0.0037 (0.0052)			-0.0058 (0.0050)	-0.0051 (0.0050)	-0.0175 (0.0230)
G × AD	-0.0011 (0.0009)	-0.0012 (0.0009)					-0.0072 (0.0040)
L × INF	0.0015 (0.0016)	0.0013 (0.0016)			0.0019 (0.0016)	0.0018 (0.0016)	0.0036 (0.0071)
PR × INF	-0.0041 (0.0047)	-0.0039 (0.0047)			-0.0060 (0.0043)	-0.0060 (0.0043)	-0.0179 (0.0208)
SM × INF	-0.0004 (0.0005)	-0.0004 (0.0005)			-0.0004 (0.0005)	-0.0005 (0.0005)	-0.0016 (0.0024)
S × INF	-0.0081 (0.0085)	-0.0085 (0.0085)			-0.0114 (0.0084)	-0.0121 (0.0084)	-0.0248 (0.0375)
G × INF	0.0003 (0.0017)	0.0003 (0.0017)					0.0069 (0.0076)
L × EV	0.0004 (0.0006)	0.0004 (0.0006)			0.0006 (0.0006)	0.0006 (0.0006)	-0.0011 (0.0026)
PR × EV	-0.0004 (0.0039)	-0.0003 (0.0039)			-0.0016 (0.0037)	-0.0017 (0.0037)	0.0072 (0.0172)
SM × EV	-0.0001 (0.0002)	-0.0001 (0.0002)			-0.0001 (0.0002)	-0.0001 (0.0002)	0.0004 (0.0009)
S × EV	-0.0041 (0.0046)	-0.0044 (0.0046)			-0.0053 (0.0045)	-0.0057 (0.0045)	-0.0209 (0.0201)
G × EV	0.0023* (0.0011)	0.0023* (0.0011)					0.0041 (0.0048)
Log likelihood	1085.79	927.29	1034.25	1051.92	1080.96	922.65	418.13

Notes: The table reports results from regressing the financial ratios PCs as well as the macroeconomic PCs both without and with the interactions between the financial ratios PCs and macroeconomic PCs on the annual returns correlations between the 10 ASE sectors over the 10-year period 2003 to 2012. In this table, the coefficients are multiplied by 10^4. An * denotes significance at the 5% level.

Table 8 Likelihood Ratio Test and Hausman Test

Hausman Test Statistic	
H_{0a}: Random effect model (2) is preferred to fixed effect model (1) H_{1a}: Fixed effect model (1) is preferred to random effect model (2)	40.99*
Likelihood Ratio	
H_{0b}: There are no sector-specific factors and no interaction effects between sector-specific and economic factors (model 3)	103.08*
H_{0b}: There are no interaction effects between sector-specific and economic factors (model 4)	67.74*
H_{0c}: Growth has no effect on return correlation (model 5)	9.66*

Notes: The table reports results from likelihood ratio test and Hausman Test. An * denotes significance at the 5% level.