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Synchronization between Financial Crisis and International Business Cycles: Evidence from Asia*

Seyed Komail Tayebi** · Zahra Zamani***

The recent financial crisis, as the most important event in the world economy, has affected countries substantially through structural changes in socio-economic and political issues. The co-movements of international business cycles have generally increased as a result of the global financial crisis and that is because of simultaneous fall in economic activity in many economies during the global financial crisis. Accordingly, Fidrmuc and Korhonen (2010) analyze the transmission of global financial crisis to business cycles in China and India, displaying a low degree of synchronization with the OECD countries, which is consistent with the decoupling hypothesis. In addition, IMF (2008) argues that the current slowdown of the world economy could have a significantly larger impact on Asian economies than earlier global downturns, because of more extensive trade and financial integration of Asian economies.

The objective of this paper is to evaluate a possible synchronized relationship between recent financial crisis and international business cycles in the selected Asian countries. By using annual data of GDP growth rates during 1980-2010, we test a relationship between recent financial crisis, arising originally from the US, and international business cycles. The paper thus analyzes moving correlations between financial crisis and business cycles in Asia, using dynamic econometric methods. In addition, it studies how the financial crisis has influenced co-movements of output in Asian economies for different frequencies in the framework of the spectral analysis.

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** Author for correspondence, Professor of International Economics, Department of Economics, University of Isfahan, Isfahan, Iran, Tel: +98-311-793-5242, Fax: +98-311-668-3116, E-mail: sk.tayebi@ase.ui.ac.ir

*** Ph.D Candidate, Department of Economics, University of Isfahan, Isfahan, Iran, Tel: +98-311-793-5242, Fax: +98-311-668-3116, E-mail: z_zamani85@yahoo.com

Overall, analyzing spectrally the determinants of the selected Asian economies' GDPs (such as Korea, Japan, China, etc.) has indicated a significant synchronized effect of the business cycles and the recent global crisis on such economies.

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1. INTRODUCTION

In the literature, the overall impression is that business cycles have become less volatile since recent developments in the world economy. However, conflicting results exist on whether or not business cycles have become more synchronized after financial crises within recent decades. In addition, trade and more generally economic integration among countries have resulted in deeper synchronization of business cycles between individual countries, since economic links serve as a channel for transmission of shocks between countries. These facts are referred to as decoupling of business cycles in the recent literature (see Akin and Kose, 2008; He, Cheung, and Chang, 2007; Kose *et al*., 2008).

Recent developments since the onset of the global financial crisis in 2008 also show that countries worldwide have not been autonomous from various economic shocks happened in different regions. IMF (2008) argues that the current slowdown of the world economy could have a significantly larger impact on Asian economies than earlier global downturns, because of more extensive trade and financial integration of Asian economies, especially with the USA. Furthermore, Hong *et al*. (2010) show that earlier worldwide financial crises often had overwhelming impacts on the Asian economies. In this regard, Fidrmuc and Korhonen (2010) find a significant link between trade ties and dynamic correlations of GDP growth rates in emerging Asian and OECD countries. Their results show that countries with tighter

economic ties with China and India also have higher dynamic correlation with these economies causing an increase in international business synchronization. However, there is still a gap in the literature that no research shows an empirical relationship between business cycles and financial crisis.

The objective of this paper is to examine whether a synchronized relationship exists between financial crisis and business cycles, while the application is taken to account with the selected Asian countries and developed countries. The hypothesis is that such possible relationship should affect the selected Asian economies in the short and long runs. The co-movements of macro variables such as GDP, consumption, investment and trade may transfer related shocks to financial markets affecting relevant financial indicators within different frequencies. To test the aforementioned hypothesis, we use macroeconomic data of the selected Asian and developed countries during 1980-2010 by computing moving correlation coefficients and using dynamic econometric methods, particularly by focusing on the spectral regression analysis.

The paper is organized as follows. In the next section we provide a short literature of the theoretical contributions that form the background to our research. Section 3 explains the methods that we use to test for finding the synchronization between countries' business cycles and the recent financial crisis. Our empirical results are summarized and discussed in section 4, and the last section provides the research conclusion.

2. THE RELATED LITERATURE

2.1. Business Cycles

There are many reasons for happening business cycles and there are many studies about business cycles, for example, Iyetomi *et al.* (2011) explore what causes business cycles by analyzing the Japanese industrial production data. The methods used are spectral analysis and factor analysis. Using the

random matrix theory, they show that two largest Eigen-values are significant. Taking advantage of the information revealed by disaggregated data, they identify the first dominant factor as the aggregate demand, and the second factor as inventory adjustment. They cannot be reasonably interpreted as technological shocks. They also demonstrate that in terms of two dominant factors, shipments lead production by four months. Furthermore, out-of-sample test demonstrates that the model holds up even under the 2008-2009 recession. Because a fall of output during 2008-2009 resulted in a drop in exports, it provides another justification for identifying the first dominant factor as the aggregate demand. All the findings suggest that the major cause of business cycles is real demand shocks.

Crucini *et al*. (2008) examine the driving forces of G-7 business cycles. They decompose national business cycles into common and nation-specific components using a dynamic factor model. They also do this for driving variables found in business cycle models: productivity; measures of fiscal and monetary policy; the terms of trade and oil prices. They find a large common factor in oil prices, productivity, and the terms of trade. Productivity is the main driving force, with other drivers isolated to particular nations or sub-periods. Along these lines, they document shifts in the correlation of the G-7 component of each driver with the overall G-7 cycle.

Some studies suggest that business cycles happen since technology shocks. For example, Greenwood (2000) investigates the importance of technological change specific to new investment goods for postwar US aggregate fluctuations. They use a growth model that incorporates this form of technological change is calibrated to US data and simulated, using the relative price of new equipment to identify the process driving investment specific technology shocks. The analysis suggests that this form of technological change is the source of about 30% of output fluctuations.

Tang *et al*. (2008) say that there is a link between technical change and macroeconomic volatility. They hypothesize that a country with little technological capacity is likely to experience higher macroeconomic volatility for the following reasons. First, countries with little technological

knowhow have limited capacity to produce a variety of value-added products. Their economies tend to be heavily dependent on a single sector or even a single commodity. When an external shock such as a deterioration of the terms of trade hits, countries with little technological know-how face a more severe downturn (Koren and Tenreyro, 2007). Second, countries with little indigenous technological know-how rely primarily on foreign investment and technology in their drive for industrialization. It has been shown that industries that are more dependent on external finance are hit harder during recessions, especially when they operate under a poor financial system (Braun and Larrain, 2005). Third, if technical change is accompanied by financial development, more developed financial systems should imply a reduced impact of asymmetric information problems, as financial institutions become more capable of identifying projects with a higher probability of failure (Da Siva, 2002).

After many years of working on business cycles economists and by introducing globalization, business cycle literature confront with new concept that is called business cycle synchronization. There are two insights about synchronization. One belief that business cycles have become less volatile, a phenomenon known as business cycle moderation, while trade and financial liberalization have increased (Kose *et al*., 2003; Stock and Watson, 2002). It has been brought about by globalization, has led to an interdependent worldwide economy. According to Stiglitz (2003), cycles have become less volatile and more similar and can be characterized by the emergence of a common cycle.

Song and Sui-Lay (2011) analyze business cycle co-movement between Australia and 10 major economies in the East-Asian region by using two measures: concordance indices and correlation coefficients. The results from the concordance index suggest that Australia's business cycle is becoming increasingly synchronized with those in East Asia, particularly with China and Japan. The correlation coefficients of gross domestic product (GDP) growth and the deviation of real GDP from its trend between Australia and its East-Asian neighbors are also significantly higher since 2000, relative to

the correlation coefficients found for the 1990s. The growing importance of East Asia in Australia's economic future implies that the risks facing the economy have changed and Australia needs to engage in more macroeconomic policy dialogues with its neighboring economies to improve their policy responses.

He and Liao (2012) develop a multilevel structural factor model to study international co-movement of output and its underlying driving forces. Their method combines a structural vector auto-regression with a multilevel factor model, which helps them understand the economic meaning of the estimated factors. Using quarterly data of real GDP growth covering 9 emerging Asian economies and G-7 countries, they estimate a global supply factor, a global demand factor, and group supply and demand factors for each group of the economies. They find that although the role of the global factors has intensified over the past 15 years for most of the economies, output fluctuations in Asia have remained less synchronized with the global factor than those in the industrial countries. The Asian regional factors have become increasingly important in tightening the interdependence within the region over time. Therefore, although emerging Asian economies cannot 'decouple' completely from the advanced economies, they have, nonetheless, sustained a strong independent cycle among themselves.

They also find that synchronized supply shocks contributed more to the observed synchronization in output fluctuations among the Asian economies than demand shocks. These points to the role of productivity enhancement and transmission of other supply shocks through, for example, vertical trade integration, rather than dependence on external demand, as the primary source of business cycle synchronization in emerging Asia.

Botha (2010) use real output, consumption and investment data to extract a common factor for each country (representing the business cycle). He compares the behavior of developed economies with that of developing economies in this regard since little research have been done on the synchronization of developing economies with the world cycle. Stock and Watson (2002) use real GDP as a measure of the business cycle rather than

the reference cycle series used by the NBER. This is the reason for using the G7 countries' GDP growth as a proxy for the world business cycle.

Finally we know that a lot of debate has taken place around the existence of a common cycle and the question of synchronization between countries' business cycles has yet to receive a definitive answer because of the conflicting results reported in the literature.

In recent literature on international trade, for example, the focus has been on the discussion of how trade integration affects business cycle synchronization (Akin, 2006). According to the theoretical literature, the impact of trade integration on business cycle correlation could go either way. On the one hand, if the demand channel is the dominant force driving business cycles, we expect trade integration to increase cycle correlation. For instance, positive output shocks in a country might increase its demand for foreign goods. The impact of this shock on the cycle of the country's trading partners should depend on the depth of the trade and even financial links with each of the partners. On the other hand, if industry-specific shocks are the dominant force in explaining cyclical output, the relationship would be negative if increasing specialization in production leads to inter industry trade (as observed in developing countries). In this case, trade integration leads to specialization in different industries, which in turn leads to asymmetric effects of industry-specific shocks. In contrast, if intra-industry trade prevails (as observed in industrial countries), specialization does not necessarily lead to asymmetric effects of industry-specific shocks, since the pattern of specialization occurs mainly within industries (Calderon *et al*., 2002).

2.2. Financial Crisis

The most recent financial crisis that started in 2007 is the most serious setback of the world economy that has experienced since the great depression and it has had major effects on the world economy. What started as a credit crunch in July 2007 in the US spread to other countries and brought the

financial system to a halt and affect international business cycle. To determine the relationship between countries' business cycles and recent crisis it is necessary to review relevant literature.

Some studies try to find the origin of recent crisis like Cooper (2008) that explain why the global economy, and the US economy in particular, finds itself caught in a seemingly endless procession of asset price bubbles, followed by devastating credit crunches. It describes the processes that generate these cycles and the reasons behind the policy mistakes that have, of late, tended to exacerbate them.

Duca *et al*. (2010) express that an unsustainable weakening of credit standards induced a US mortgage lending and housing bubble, whose consumption impact was amplified by innovations altering the collateral role of housing. In countries with more stable credit standards, any overshooting of construction and house prices owed more to traditional housing supply and demand factors. They believe that housing collateral effects on consumption also varied, depending on the liquidity of housing wealth. They explain that lessons for the future include recognizing the importance of financial innovation, regulation, housing policies, and global financial imbalances for fueling credit, construction, house price and consumption cycles that vary across countries.

Some of studies try to model financial crisis like Korobeinikov (2009) that attempts to explore the development of a financial crisis mathematically, constructing and analyzing a simple qualitative mathematical model of a progressing crisis. This model brings an insight into the evolution of a crisis and enables us to evaluate the likely outcomes of the possible interventions that can slow the crisis' progress or ameliorate its consequences. The model also helps to identify the factors and actions that may enhance the global economic security.

Before the 1980s, there was a strong emphasis on business cycles. After the boom of the 1980s and through the 1990s, emphasis shifted to long-run growth. The recent recession requires a return to greater emphasis on business cycles. Blinder (2010) posits that the current macroeconomic

curriculum is the result of the relative degree of emphasis on growth versus business cycles. Accordingly, Potential output is defined as the level of output consistent with price stability or, alternatively, the trend level of output around which the economy fluctuates over the business cycle. Deviations of actual from potential output lead to output gaps. The output gap is one of the main components of price determination based on the Phillips Curve and is often used as an argument in monetary policy reaction functions (Park *et al*. 2011). Potential output can thus be considered as an important indicator which may response to an economic crisis. Park *et al*. (2011) argue that a crisis can have various possible impacts on potential output depending on the nature of the economic downturn and subsequent policy responses.

Zhu and Yang (2004) investigate the factors that contribute to financial crisis contagion. They synthesize the literature on contagion by combining all major explanatory variables into an adapted gravity model. Their finding is that financial crisis contagion is positively related to trade and financial linkages and negatively related to psychic distance between crisis — originating countries and crisis-affected countries, when macroeconomic fundamentals and institutional factors are controlled.

Claessens *et al*. (2009) provide a comprehensive empirical characterization of the linkages between key macroeconomic and financial variables around business and financial cycles, for 21 OECD countries over the period 1960-2007. Their results indicate that the interactions between macroeconomic and financial variables can play a major role in determining the severity and duration of a recession. Specifically, they find evidence that recessions associated with credit crunches and house price busts tend to be deeper and longer than other recessions. Indeed, the recession in the US is on track to be the longest on record. Furthermore, as their analysis suggests, these recessions have spread across the globe, confirmed by their results on the international dimensions of recessions.

Bertomeu and Magee (2011) examine how financial reporting regulations affect, and respond to, macroeconomic cycles by exploring a positive

framework in which regulators subject to political pressures respond to cyclical demands by borrowers and lenders. They establish that, as economic conditions initially decline, political power shifts toward interest groups favoring less financial transparency. What follows is a counter-cyclical increase in economic activity, as more non-reporting loans are financed, possibly coincidental with more aggregate uncertainty. During a recession, reporting quality is increased, potentially causing a crisis-like adjustment of economic activity to the cycle. They also discuss implications for event studies, bank lobbying, mark-to-market and cost of capital.

Recent crisis that starts from USA affect other economies especially countries which have close trade relationship with USA. Liu (2009) applies a structural vector auto-regression analysis to quantify the impact of the global financial crisis on China. It is found that the impact is indeed sizeable: 1percentdecline in economic growth in the USA, the EU and Japan is likely to lead to a 0.73 percent decline in growth in China. The article discusses whether the current measures of fiscal stimulus are adequate to offset the sharp decline in external demand. Although there is little doubt that the massive fiscal stimulus will largely offset the significant shortfalls in external demand, the current growth pattern in China will be increasingly unsustainable in the long term. China's reform cycles suggest that external shocks are often opportunities for structural reforms. Therefore, the crisis could also be a catalyst for rebalancing China's economic structure so as to return the economy to a sustainable path.

The current financial crisis has had a significant effect on economic developments in emerging Asian economies. Fidrmuc and Korhonen (2010) analyze the transmission of global financial crisis to business cycles in China and India. Applying dynamic correlations, they find wide differences for different frequencies of cyclical development. More specifically, at business cycle frequencies, dynamic correlations are typically low or negative, but they are also influenced most by the global financial crisis. Finally, they find a significant link between trade ties and dynamic correlations of GDP growth rates in emerging Asian countries and OECD countries.

Although, there is a rich literature on financial crisis but no study has focused on the effect of crisis on business cycles or vice versa. Briefly, it is believed that there is a gap in the literature, which refers to a lack of research focusing particularly on the synchronized relationship between financial crisis and business cycles. In the next sections, we try to cover relatively this gap at least for the selected Asian countries by conducting an empirical model specification and data analysis.

3. DATA DESCRIPTION ON THE CASE STUDY

An often repeated view in the popular press in recent years is that the nature of world business cycles has changed over time due to rising trade and financial linkages. For example, the cumulative increase in the volume of world trade is almost three times larger than that of world output since 1960. Moreover, there has been a striking increase in the volume of international financial flows during the past two decades as these flows have jumped from less than 5% to approximately 20% of GDP of industrialized countries (Kose *et al*., 2008). Decoupling is happened if trade causes more specialization in countries and if trade causes more relationship between two countries, business cycles synchronization occurs. Table 1 and figure 1 report the data description of the selected countries' growth rate trend during 1970-2010, to illustrate co-movement of their growth in this period.

According to these results, some of countries like Iran, Kuwait, Saudi Arabia and United Arab Emirates have fluctuations in GDP growth rate during this period mostly are economies that emphasize on oil export and they confront by fluctuations because of existing oil shocks during 1970-2010. The USA, UK and Australia are developed countries and they follow similar trends.

Regarding to business cycles literature, both convergence and decoupling of RBC happen in different region of the world. But recent developments since the onset of the global financial crisis in the second half of 2008 show

Table 1 Data Description on Growth Rates of the Selected Developed and Developing Countries during 1970-2010

Country	Mean	Std. Deviation	Min	Max
United States	.0289717	.0222525	–.035	.0719482
Australia	.0323019	.0156302	–.0232003	.0587222
Brazil	.0407924	.0421096	–.0439336	.1397869
China	.091425	.034706	–.016	.152
Hong Kong	.0614203	.0480697	–.0602639	.1739835
India	.0545421	.0313279	–.0523759	.09817
Indonesia	.0598139	.037287	–.1312672	.0977616
Iran	.0325658	.0764545	–.158246	.177309
Japan	.0259539	.0275216	–.0628758	.0841355
S. Korea	.0659765	.036795	–.0685446	.1203432
Kuwait	.0180772	.1201974	–.2765882	.3399047
Malaysia	.0644707	.0388052	–.0735942	.117142
Mexico	.0348336	.0384939	–.062406	.0969817
The Philippines	.0384916	.0336351	–.0732368	.0892065
Saudi Arabia	.0481458	.0808813	–.1109816	.2749263
Singapore	.0744212	.040067	–.0210752	.1447127
Thailand	.0594527	.0416198	–.1050997	.1328811
Turkey	.0428076	.0424869	–.0569748	.1046118
UAE	.0871382	.127616	–.1495814	.4761671
UK	.0234228	.0231501	–.0437334	.0712789

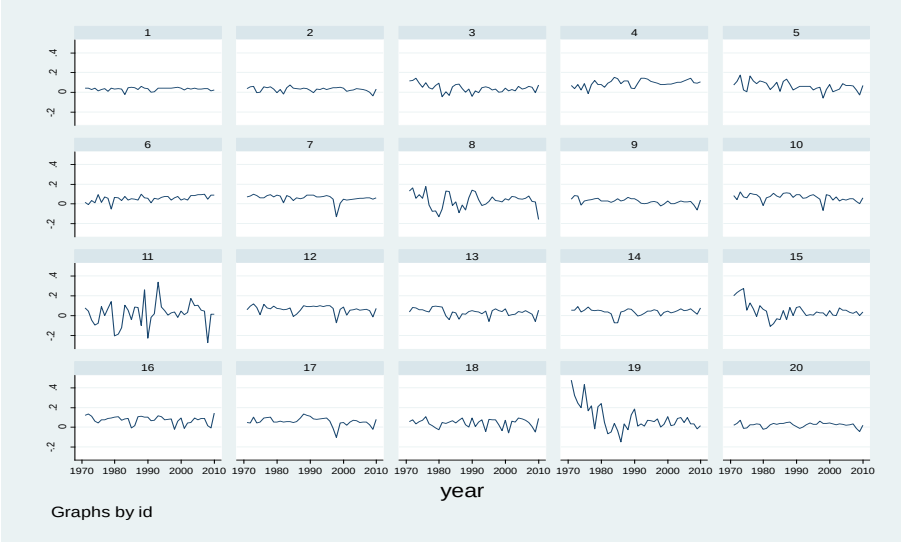
Source: Authors.

that also these countries are not autonomous and when a crisis occurs, it will spread to other countries (Fidrmuc and Korhonen, 2010).

The implication is that supply shocks tend to affect the economies along the production chain. Such supply-side shocks may lead to higher synchronization of business cycles among the economies that form the production network. He and Zhang (2010) argue, for example, that the effect on the supply side is more important than that on the demand side when considering the role of exports in promoting economic growth.

Correlation analysis is the most common approach for describing output synchronization between countries. However, the classical correlation has

Figure 1 Growth Rate Trend for the Selected Countries during 1970-2010



two main drawbacks: first, it does not allow separation of idiosyncratic components and common co-movements. Second, it is basically a static analysis that fails to capture any dynamics in the co-movement. An alternative measure of synchronization in the case of business cycles can be defined as dynamic correlation, which was proposed by Croux *et al*. (2001).

Following Croux *et al*. (2001), the dynamic correlation coefficient can be defined as a moving correlation between the US' GDP and GDPs of other 19 countries in the sampling. The dynamic correlation coefficient is defined to be between –1 and 1, as is the standard correlation coefficient. Moreover, the average value of dynamic correlation over all frequencies is approximately, although not exactly, equal to the static correlation. Therefore, we can interpret dynamic correlations as a decomposition of the aggregate correlation into co-movements at particular frequencies. Dynamic correlations show whether the global financial crisis influenced mainly short-term co-movements or also business cycle frequencies (Fidrmuc and Korhonen, 2010).

The relevant coefficient is defined as

$$\rho_{(US,\,i)_t} = \frac{\mathrm{Cor}(GDP_{US},\,GDP_i)_t}{(\sqrt{v(GDP_{US})v(GDP_i)})_t}, \tag{1}$$

Table 2 Moving Correlation Coefficients between the US' GDP and Other Selected Countries' GDP during 1997-2010

Year	$\rho_{US,AUS}$	$\rho_{US,BRA}$	$\rho_{US,CHI}$	$\rho_{US,HONG}$	$\rho_{US,IND}$	$\rho_{US,IND}$	$\rho_{US,IRN}$	$\rho_{US,JAP}$	$\rho_{US,KOR}$	
1997	0.977	0.9634	0.9985	0.9939	0.9913	0.9953	0.6306	0.9403	0.9895	
1998	0.998	0.988	0.998	0.990	0.994	0.997	0.731	0.944	0.995	
1999	0.997	0.980	0.996	0.998	0.987	0.986	0.948	0.984	0.984	
2000	0.997	0.933	0.992	0.647	0.983	0.383	0.977	0.750	0.698	
2001	1.000	0.888	0.997	0.403	0.996	–0.344	0.955	0.300	0.697	
2002	1.000	0.900	0.999	0.547	0.997	–0.562	0.986	0.264	0.761	
2003	0.999	0.868	0.973	0.619	0.988	–0.219	0.954	0.410	0.834	
2004	0.985	0.934	0.947	0.977	0.976	0.914	0.905	0.917	0.984	
2005	0.986	0.990	0.973	0.984	0.963	0.984	0.966	0.971	0.985	
2006	0.992	0.987	0.991	0.973	0.997	0.990	0.982	0.968	0.964	
2007	0.999	0.993	0.993	0.994	0.996	0.997	0.994	0.999	0.995	
2008	0.995	0.982	0.975	0.996	0.985	0.987	0.974	0.995	0.987	
2009	0.935	0.917	0.947	0.987	0.971	0.943	0.966	0.984	0.974	
2010	0.375	0.506	0.317	0.739	0.287	0.305	0.504	0.832	0.564	
Year	$\rho_{US,KUW}$	$\rho_{US,MAL}$	$\rho_{US,MEX}$	$\rho_{US,PHI}$	$\rho_{US,KSA}$	$\rho_{US,SING}$	$\rho_{US,THA}$	$\rho_{US,TUR}$	$\rho_{US,UAE}$	$\rho_{US,UK}$
1997	-	0.996	0.596	0.953	0.811	0.997	0.996	0.834	0.966	0.965
1998	0.879	0.997	0.461	0.989	0.858	0.997	0.995	0.858	0.985	0.998
1999	0.919	0.994	0.705	0.997	0.955	0.998	0.911	0.908	0.998	0.996
2000	0.964	0.777	0.862	0.936	0.992	0.920	0.094	0.972	0.959	0.997
2001	0.872	0.677	0.993	0.922	0.923	0.922	–0.559	0.809	0.939	0.994
2002	0.902	0.708	0.994	0.951	0.937	0.931	–0.419	0.801	0.935	0.995
2003	0.876	0.727	0.993	0.917	0.921	0.910	0.233	0.232	0.919	0.986
2004	0.831	0.989	0.980	0.967	0.887	0.987	0.969	0.365	0.973	0.979
2005	0.873	0.993	0.931	0.984	0.934	0.983	0.967	0.826	0.988	0.992
2006	0.977	0.996	0.959	0.999	0.967	0.979	0.996	0.925	0.989	0.981
2007	0.989	0.999	0.985	1.000	0.991	0.995	0.996	0.999	0.993	0.994
2008	0.997	0.991	0.991	0.989	0.996	0.989	0.995	1.000	0.993	0.985
2009	-	0.974	0.988	0.954	0.955	0.985	0.976	0.999	0.979	0.981
2010	-	0.596	0.987	0.473	0.421	0.667	0.720	0.927	0.684	0.980

Source: Authors.

where $\rho_{(US,\,i)_t}$ is the moving average of 5 years correlation between the US' GDP and *i*th country on the sample. $\mathrm{Cor}(GDP_{US}, GDP_i)_t$, $v(GDP_{US})$ and $v(GDP_i)$ denote the moving average of covariance between the US' *GDP*, the *i*th country's GDP, Variance of GDP_{US} and variance of the *i*th country' *GDP*, respectively.

The results obtained are expected to explain such co-movements especially when a country has a close trade relationship with the USA. They imply that increased trade simply increases the magnitude of the transmission of shocks between two countries and increased international trade may lead to a significant increase in output co-movement.

Table 2 shows moving correlation during 1997-2010 for the selected countries. It shows that, except for 2010, a strong moving correlation exists between the US' GDP and the other selected countries' GDP after 2005, particularly the recent financial crisis.

Eventually, it is found out that during the recent crisis all selected countries' GDP variations have had synchronized relationship with the US' GDP, implying the pattern of business cycles in selected economies generally displays a high degree of synchronization with the US business cycles.

4. MODEL SPECIFICATION AND EMPIRICAL FINDINGS

During the period of globalization, there has been a modest convergence of business cycles among industrial countries and, also among emerging market economies. That is global factors have been important in driving cyclical fluctuations in these two groups of countries. A question is now being raised whether the distinction between emerging markets and other developing economies is crucial or not. The issue may be more controversial if the global financial crisis affects co-movement of economies worldwide. Fidrmuc and Korhonen (2010) express that the pattern of international business cycles is much more volatile. The effects of structural changes can be found via analyses of correlations within moving windows (see e.g., Rana,

Table 3 Panel Estimation Results for the Selected Countries Based on Cross-sectional Time-series FGLS Regression

Variable	Coefficient	*z*	*P*>|*z*|
Cons	1. 10	8. 667	0.000
Trend	0.029	5.76	0.000
Openness	0.001	2.01	0.004
$Trade_{US}$	30.87	0.002	0.000
Wald chi2 (3) = 40.33		Prob. > chi2 = 0.0000	
LR chi2 (19) = 50.07		Prob. > chi2 = 0.0001	

Source: Authors.

2006). To describe the properties of international business cycles, they estimate the following panel regressions:

$$\frac{1}{2}\text{Log}\frac{1+\rho_{i,t}}{1-\rho_{i,t}} = \alpha_i + \beta_1 Trend_t + \beta_2 Trade_{US} + \gamma OPC + \varepsilon_{i,t}, \qquad (2)$$

where ρ_t is the moving correlation coefficient of output in selected countries versus USA. They note that the correlation coefficient is bounded between –1 and 1 and use the Fisher transformation to transpose its values to an unbounded variable. The explanatory variables include trend, which shows whether there is some convergence of international business cycles, the Trade with US, $Trend_{US}$ and Openness, OPC_t. The effects of trade with US are statistically meaningful. Using data of the selected countries the results of the panel regression are given in table 3.

With respect to the discussion of decoupling, the results confirm a strong positive trend of business cycle synchronization for all countries. The trend is statistically significant, besides openness has a significant effect on the selected economies. The later effect shows the higher degree of the openness, the greater business cycles synchronization in all selected countries. Trade with the US has also statistically significant and positive effect on business

cycles synchronization. It indicates that trade with the US causes business cycles with higher synchronization.

The reality is that financial crisis that has started in the US has transferred to other countries through trade channel and this fact would underline the inter-dependence of business cycles in the world economy. For instance, the global financial crisis started in 2008, has been highly specific to the US financial developments, but economic and financial integration worldwide has supported the transmission of effects to other countries. Eventually, it seems that the other economies may be affected by the financial crisis even harder than the USA, the origin of the shock (Bátorová, 2012). Due to the importance of crisis and transferring shocks to other countries that motivates business cycles in these economies, this study has used dynamic correlation coefficients to assess the degree of synchronization of the business cycle with the US. This has been of course a starting point of the research in this area. Additionally, both financial crisis and business cycles are supposed to be synchronized in different frequencies (low and /or high) within a time path, so that a spectral analysis can be applied to such movements, the task that will be done in the next section.

5. SPECTRAL ANALYSIS

Spectral analysis has been primary developed and used especially in scientific fields such as engineering, digital signal processing, geophysics, oceanography, atmospheric science, astronomy, and meteorology (Bátorová, 2012).

The last ten years have witnessed an increasing interest of the econometrics community in spectral theory. In fact, decomposing the series evolution in periodic contributions allows a more insightful view of its structure and on its cyclical behavior at different time scales. The first appearance of spectral analysis in the study of macroeconomic time series dates from the middle 1960s, motivated by the requirement of a more

insightful knowledge of the series structure and supported by the contemporaneous progress in spectral estimation and computation (Iacobucci, 2003).

While the spectral analysis provided a description of the main oscillatory components of time series, it has not been developed primarily for the economic purposes.

Nowadays it is highly attractive also for applied economic inquiries such as identifying trend of economic time series, analyzing the business cycles, seasonality and low frequency components, analyzing the co-movements among series and the study of international business cycles. Because of all reasons we use spectral analysis in this study.

Suppose time series, $\{Y_t\}_{t=-\infty}^{\infty}$ is the collection of observation indexed by the date of each observation. Its properties are generally analyzed in the time domain representation. It means, that the value of the variable Y_t at the date t is presented in the following form:

$$Y_t = \mu + \sum_{j=0}^{\infty} \psi_j \varepsilon_{t-j}, \tag{3}$$

where $\{\varepsilon_t\}_{t=-\infty}^{\infty}$ represents a sequence of innovations and μ is the mean of Y_t.

Spectral analysis is concerned with exploration of cyclical patterns of data and its main purpose is to decompose the original series into an infinite sum of periodic functions, each having a different frequency ω ranging between 0 and π. This fundamental of the spectral analysis is captured in spectral representation theorem which states that any covariance-stationarity process $\{Y_t\}_{t=-\infty}^{\infty}$ can be expressed as:

$$Y_t = \mu + \int_0^{\pi} \alpha(\omega) \cdot \cos(\omega t) d\omega + \int_0^{\pi} \beta(\omega) \cdot \sin(\omega t) d\omega, \tag{4}$$

where each frequency ω corresponds to a unique time horizon T, such $T = 2\pi / \omega$ and weights $\alpha(\omega)$ and $\beta(\omega)$ are random variables with zero mean. It means that the process Y_t is periodic function with frequency ω or with period T (Bátorová, 2012).

Applying spectral analysis, one may estimate a regression model by using time series of variables which are filtered by the Fourier approach.[1] In this condition variables are measured in low and high frequencies depending on the nature of the relevant data. According to Assenmacher and Gerlach (2005), we consider a low frequency band with less than 2 and a high frequency bound with greater than 2 for the annual data of the selected countries' *GDPs*.

Hence, it is expected that the US' *GDP* in low/high frequency affects directly the other countries' *GDPs* which are measured in low/high frequency. These variables are included in a regression model. In addition, a dummy variable (DUM_{08}) explains the effect of the global financial crisis onset in 2007-2008 on the selected economies. It takes 1 for years 2007 and 2008 and zero otherwise. Its coefficient is expected to be negative. Equation (5) shows a regression model for each country under consideration in time *t*:

$$GDP_{it} = \alpha_i + \beta_1 GDP_{USt} + \beta_2 DUM_{08} + u_{it}, \quad (5)$$

where GDP_{it} and GDP_{USt} denote the *i*th selected country's *GDP* (except for the US) and the US' GDP in time *t*, respectively. As explained, DUM_{08} is dummy variables for 2007-2008 crisis that takes 1 for 2007-2008 years and zero otherwise. U_{it} stands for the disturbance term of each equation, assuming white noise. We estimate the model for both low and high frequencies that referred to long term and short term.

To have a spectral analysis on empirical results, we use converted data based on the spectral domains in both low and high frequencies where the original time series data (1970-2010) come from the World Development Indicators (WDI) database of the World Bank.[2] These data, which are measured by the WinRATS (7.1), are used to estimate equation (5) by the least squares approach. Tables 3 and 4 summarize the estimation results for

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[1] The discrete Fourier transform is formulated if $h(t)$ is defined for integers *t*, the discrete Fourier transform of *h*is $H(\omega) = \sum_{t=-\infty}^{\infty} h(t) e^{-i\omega t}, \ -\pi \le \omega \le \pi.$

[2] http://data.worldbank.org/data-catalog/world-development-indicators

Table 4 Time Series Estimation Results for the Selected Countries in Low Frequency: Case 1

Variable	$LGDP_{US}$	DUM_{2008}	Cons
$LGDP_{AUS}$	1.05 (46.40)	0.04 (1.86)	–4.20 (–6.22)
$LGDP_{BRA}$	1.02 (21.57)	0.004 (0.06)	–2.77 (–1.98)
$LGDP_{CHI}$	2.96 (35.68)	0.13 (1.87)	–58.86 (–23.97)
$LGDP_{HONG}$	1.89 (26.69)	–0.95 (–2.11)	–29.17 (–13.79)
$LGDP_{IND}$	1.70 (24.02)	0.15 (2.93)	–20.40 (–9.70)
$LGDP_{IND}$	1.87 (34.14)	–0.87 (–1. 87)	–21.25 (–24.53)
$LGDP_{IRN}$	0.76 (9.43)	0.26 (4.89)	10.34 (4.28)
$LGDP_{JAP}$	0.86 (21.38)	–0.085 (–3.15)	7.73 (6.43)
$LGDP_{KOR}$	2.21 (4.53)	–0.11 (–3.47)	–32.40 (–28.92)
$LGDP_{KUW}$	0.44 (58.51)	0.12 (0.73)	9.67 (3.36)
$LGDP_{MAL}$	2.09 (62.40)	–0.03 (–0.88)	–36.20 (–36.46)
$LGDP_{MEX}$	1.03 (23.62)	0.0003 (0.02)	–1.52 (–1.17)
$LGDP_{PHIL}$	1.02 (21.44)	0.10 (2.99)	–1.85 (–1.31)
$LGDP_{KSA}$	0.94 (7.66)	0.01 (0.26)	–1.11 (–0.30)
$LGDP_{SIN}$	2.33 (53.32)	–0.04 (–0.59)	–44.18 (–34.04)
$LGDP_{THA}$	2.01 (43.91)	–0.04 (–2.58)	–31.72 (–23.45)
$LGDP_{TUR}$	1.32 (44.73)	0.60 (2.58)	–14.68 (–16.80)
$LGDP_{UAE}$	2.51 (3.42)	–0.22 (–0.99)	–48.004 (–2.19)
$LGDP_{UK}$	0.82 (47.33)	0.05 (4.84)	2.98 (5.77)

Note: The numbers in the parentheses are *t*-statistic values.
Source: Authors.

both low frequency (Case 1) and high frequency (Case 2), respectively.

The results reported in table 4 indicate that in low frequency the *US*' *GDP* has significantly positive effect on all other selected countries' *GDPs.* This reveals the fact that long-run movements of the US business cycles have been transferred to the most Asian countries during the period under consideration. Based on the results, the more economic relations with the US, the more

Table 5 Time Series Estimation Results for the Selected Countries in High Frequency: Case 2

Variable	$LGDP_{US}$	DUM_{2008}	Cons
$LGDP_{AUS}$	1.04 (15. 69)*	0.01 (3.16)	–3.71 (–18.98)
$LGDP_{BRA}$	0.99 (59. 60)	–0.003 (–3.15)	–1.87 (–1.96)
$LGDP_{CHI}$	1.86 (16.55)	0.22 (3.19)	–1.87 (–25.88)
$LGDP_{HONG}$	1.29 (31.39)	0.08 (3.17)	–11.13 (–9.13)
$LGDP_{INDI}$	1.38 (25.49)	0.10 (3.17)	–10.52 (–6.58)
$LGDP_{INDO}$	1.32 (29.65)	0.08 (3. 17)	–4.65 (–3.55)
$LGDP_{IRN}$	0.90 (64.30)	–0.02 (–3.16)	6.27 (15.13)
$LGDP_{JAP}$	0.91 (66.56)	–0.027 (–3.15)	6.36 (15.73)
$LGDP_{KOR}$	23.70 (4.53)	3.17 (3.47)	–5.13 (–28.92)
$LGDP_{KUW}$	0.65 (12.27)	–0.10 (–3.15)	3.03 (1.92)
$LGDP_{MAL}$	1.43 (23.89)	0.12 (3.17)	–16.51 (–9.31)
$LGDP_{MEX}$	1.0002 (46.01)	–0.0004 (–3.11)	–0.41 (–64.90)
$LGDP_{PHIL}$	1.03 (18. 71)	0.011 (3.15)	–2.06 (–12.65)
$LGDP_{KSA}$	0.94 (108.92)	–0.01 (–3.16)	–1.06 (–4.16)
$LGDP_{SIN}$	1.51 (21.61)	0.14 (3.18)	–19.64 (–9.49)
$LGDP_{THA}$	1.36 (27.13)	0.10 (3.17)	–12.17 (–8.20)
$LGDP_{TUR}$	1.14 (53.36)	0.049 (3.16)	–9.42 (–14.85)
$LGDP_{UAE}$	1.32 (29.47)	0.09 (3.17)	–12.52 (–9.44)
$LGDP_{KING}$	0.93 (47.33)	–0.01 (–3.16)	–0.43 (–1.66)

Note: The numbers in the parentheses are *t*-statistic values.
Source: Authors.

business cycles effects the counties have been faced with. The coefficient of the dummy variable for the 2008 financial crisis has been significant in all countries' equations, with expected and unexpected signs. DUM_{2008} has significant and expected negative effect on the *GDP* low frequencies of the East Asian countries: Thailand, Hong Kong, Indonesia, Japan and South Korea. However, the crisis effect has been significantly positive on low

frequencies of the GDPs for Australia, China, India, Iran, the Philippines, Turkey and the UK.

Table 5 reports the estimation results of equation (5) in high frequency of all selected countries' *GDPs* (Case 2), implying short-run movements of business cycles in the countries. Again, the *US*' *GDP* has significantly positive effect on all other selected countries' *GDPs*, implying that the short-run movements of the US business cycles have been also transferred to the most Asian countries during the period 1970-2010. Contrary to Case 1, different economies have been affected by the recent financial crisis. In high frequency of the period, the crisis has had negative effect on the *GDPs* of countries like Iran, Japan, Kuwait, the KSA, Mexico and the UK, some of which are oil producing countries. These results imply an indirect relationship between financial crisis and business cycles in the long-run. However, there is a direct relationship in other countries under consideration such as Australia, China, Korea, Turkey etc.

To investigate a cross effect of business cycles and the global financial crisis in 2007-2008, we define a new equation by inclusion a new variable, $DUM_{08} \cdot GDP_{US}$, where its coefficient (β_3) stands for a cross effect of the crisis and the US' business cycles on business cycles of all other sampling countries. The equation is thus shown in (6) as follows:

$$GDP_{it} = \alpha_i + \beta_1 GDP_{USt} + \beta_2 DUM_{08} + \beta_3 DUM_{08} \cdot GDP_{USt} + u_{it}. \qquad (6)$$

Using again time series data of *GDP* in low and high frequencies, standing respectively for the long-run and the short-run, we estimate the model, appearing in Case 3 and Case 4, by the least squares spectral-based and summarize the results in table 6 and table 7. The main result is that the cross effect of the financial crisis and the US business cycles on the GDPs is highly significant and negative, which seems to be expected to the most selected countries (with few exceptions). The result is reliable for both low and high frequencies of data, standing respectively for the long-run and the short-run.

Table 6 Time Series Estimation Results for the Selected Countries in Low Frequency: Case 3

Variable	$LGDP_{US}$	DUM_{2008}	$LGDP \cdot DUM_{2008}$	Cons
$LGDP_{AUS}$	1.05 (45.79)	12.93 (18. 90)	–4.28 (–18.51)	–4.20 (–6.14)
$LGDP_{BRA}$	1.02 (15.60)	16.36 (83.90)	–5.41 (–82.81)	–1.87 (–2.77)
$LGDP_{CHI}$	2.96 (35.21)	32.47 (13. 04)	–10.74 (–12. 78)	–58.87 (–23.65)
$LGDP_{HONG}$	1.90 (26.34)	11.35 (52.98)	–3.76 (–52.16)	–29.17 (–13.61)
$LGDP_{INDI}$	1.71 (23.70)	17.26 (80.96)	–5.70 (–79.14)	–20.41 (–9.57)
$LGDP_{INDO}$	1.87 (33.68)	21.18 (12. 88)	–7.01 (–12.63)	–21.25 (–12.93)
$LGDP_{IRA}$	0.76 (9.30)	10.23 (41.78)	–3.37 (–40.90)	10.34 (4.22)
$LGDP_{JAP}$	0.86 (21.09)	–4.35 (–3.57)	–0.027 (–0.14)	7.73 (6.34)
$LGDP_{KOR}$	2.21 (57.74)	12.36 (10.88)	–4.09 (–10.65)	–32.40 (–28.54)
$LGDP_{KUW}$	0.43 (4.22)	–16.35 (–52.96)	54.15 (52.01)	9.69 (3.14)
$LGDP_{MAL}$	2.09 (23.89)	18.33 (18.22)	–6.06 (–17.86)	–36.20 (–35.98)
$LGDP_{MEX}$	1.03 (23.31)	58.42 (43.86)	–1.93 (–43.44)	–1.53 (–1.15)
$LGDP_{PHIL}$	1.02 (21.16)	13.59 (94.39)	–4.49 (–92.64)	–1.85 (–1.29)
$LGDP_{KSA}$	0.94 (7.56)	13.89 (37.21)	–4.59 (–36.81)	–1.11 (–0.30)
$LGDP_{SIN}$	2.33 (51.74)	81.52 (61.04)	–2.70 (–59.89)	–44.18 (–33.08)
$LGDP_{THA}$	2.01 (43.33)	26.53 (74.03)	–0.87 (–72.25)	–14.69 (–23.14)
$LGDP_{TUR}$	1.32 (44.14)	26.53 (29.95)	–0.87 (–29.24)	–14.69 (–16.58)
$LGDP_{UAE}$	2.51 (3.37)	14.45 (6.49)	–4.79 (–6.43)	–48.006 (–2.16)
$LGDP_{KK}$	0.82 (46.70)	–34.42 (–65.77)	1.14 (64.74)	2.98 (5.70)

Note: The numbers in the parentheses are *t*-statistic values.
Source: Authors.

Table 7 Time Series Estimation Results for the Selected Countries in High Frequency: Case 4

Variable	$LGDP_{US}$	DUM_{2008}	$LGDP \cdot DUM_{2008}$	Cons
$LGDP_{AUS}$	1.04 (31.38)	2.36 (24.09)	–0.07 (–23.98)	–3.71 (–37.93)
$LGDP_{BRA}$	0.99 (11.87)	–0.58 (–23.75)	0.01 (–23.65)	–1.86 (–76.02)
$LGDP_{CHI}$	1.86 (35.21)	41.34 (24.88)	–1.39 (–24.77)	–25.89 (–11.13)
$LGDP_{HON}$	1.29 (62.92)	14.86 (24.41)	–0.50 (–24.30)	–29.17 (–18.29)
$LGDP_{INDI}$	1.38 (51.09)	19.49 (24.39)	–0.65 (–24.28)	–10.53 (–13.18)
$LGDP_{INDO}$	1.32 (89.44)	16.02 (24. 4 5)	–0.54 (–24. 34)	–4.66 (–7.11)
$LGDP_{IRA}$	0.90 (9.30)	–5.01 (–24.16)	0.16 (24.05)	6.27 (30.24)
$LGDP_{JAP}$	0.91 (21.09)	–4.88 (–3.57)	0.16 (23.98)	6.36 (31.40)
$LGDP_{KOR}$	1.44 (47.52)	22.05 (24.54)	–0.74 (–24.43)	–9.24 (–10.28)
$LGDP_{KUW}$	0.65 (24.49)	–19.02 (–24.06)	0.64 (23.96)	3.04 (3.85)
$LGDP_{MAL}$	1.43 (47.91)	–0.73 (–24.39)	21.70 (24.50)	–16.52 (–18.65)
$LGDP_{MEX}$	86.10 (23.31)	–0.07 (–22.49)	0.002 (22.40)	–0.41 (–121.34)
$LGDP_{PHIL}$	1.03 (37. 37)	1.96 (24.03)	–0.06 (–23.92)	–2.06 (–25. 96)
$LGDP_{KSA}$	0.94 (21.77)	–3.07 (–24.07)	0.10 (23.96)	–1.06 (–8.31)
$LGDP_{SING}$	1.51 (43.35)	25.38 (24.58)	–0.85 (–24.47)	–19.65 (–19.03)
$LGDP_{THA}$	1.36 (54.39)	18.11 (24.45)	–0.61 (–24.34)	–12.18 (–16.44)
$LGDP_{TUR}$	1.14 (10. 68)	7.69 (24.27)	–0.25 (–24.16)	–9.42 (–9.42)
$LGDP_{UAE}$	1.32 (59.07)	16.17 (24.43)	–0.54 (–24.32)	–12.52 (–18.91)
$LGDP_{UK}$	0.93 (208.53)	–3.20 (–24.17)	0.10 (24.06)	–0.43 (–3.30)

Note: The numbers in the parentheses are *t*-statistic values.
Source: Authors.

5. CONCLUSION

The objective of this paper was to examine whether a synchronized relationship exists between financial crisis and business cycles in the selected Asian and developed countries. The hypothesis was that the deeper economic integration should lead to the higher synchronization of international business cycles, which can be observed in GDP, consumption, investment and trade. To test this hypothesis, we analyzed the trends of the selected countries' (mostly from Asia) GDPs during 1980-2010, by computing moving correlation coefficients. We also used the spectral regression to explore the dynamic effects of the GDP determinants. Our findings concluded such co-movements for the GDP business cycles of the selected countries. In addition, the empirical results arising from the spectral method showed a significant effect of the financial crisis on business cycles of the sampling economies. The results also confirmed the closer economic relations with the US the higher effect on business cycles the countries confront.

The implication of our findings is that there is a complementary relationship between the recent global financial crisis and the US business cycles that influences significantly the real business cycles in other countries, which have economic relations with that country. Such findings are pertinent to both low and high frequencies of data, standing respectively for the long-run and the short-run. A policy recommendation is that the sampling countries can conduct an integrated economic policy during a crisis in order to modify its harmful effect.

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