The Singapore Economic Review, Vol. 60, No. 1 (2015) 1550009 (20 pages)

DOI: 10.1142/S0217590815500095

THE IMPACT OF WORLD ENERGY PRICE VOLATILITY ON AGGREGATE ECONOMIC ACTIVITY IN DEVELOPING ASIAN ECONOMIES

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Published 10 February 2015

This paper analyzes the impact of volatility in the world energy price on aggregate economic activity in an unbalanced panel data framework for 10 developing Asian countries: Bangladesh, PR China, India, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Turkey and Vietnam. We use both the realized volatility and the generalized autoregressive conditional heteroskedasticity models to measure the volatility in the world energy price. Empirical findings from dynamic panel data estimations show that the volatility in world energy price is negatively associated with the aggregate economic activity. Using the common correlated effects panel estimation techniques, we also systematically examine uncertain transmission channel of the world energy price volatility on the aggregate economic activity in each economy and obtain the most impressive negative effects in Turkey, PR China and India, respectively.

Keywords: Developing asian economies; world energy price; volatility models; aggregate economic activity; panel data estimation techniques.

JEL Classification: Q43, C33, O53

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1. Introduction

The world economy is afflicted with highly volatile nature of energy prices. There is a consensus among economists that high and persistent prices in energy markets decrease economic activity and increase inflation, simultaneously. Many studies therefore have focused on the relationship between the energy price shocks or their volatility and economic activity. For instance, Bruno and Sachs (1982), Hamilton (1983, 1985, 1996), Burbidge and Harrison (1984), Gisser and Goodwin (1986), Mork (1989, 1994), Mork *et al.* (1994), Lee *et al.* (1995), Lee and Ni (2002), Huang *et al.* (2005), Lardic and Mignon (2006, 2008), Cologni and Manera (2008), Tang *et al.* (2010), and Peersman and Van Robays (2012), found that there is a negative relationship between energy prices and aggregate economic activity. Moreover, energy price (particularly oil price) fluctuations caused eight of the nine post-World War II economic recessions (Brown and Yucel, 2002). However, Hooker (1996) and Doroodian and Boyd (2002) indicated that the relationship ended up in the early 1990s.

In fact, studies to examine the nexus between the energy price or its volatility and aggregate economic activity were classified in three main categories (Tang *et al.*, 2010). First category studies have explained the theoretical mechanisms of increasing energy prices and slowing-down economic activity (Bruno and Sachs, 1982; Hooker, 1996; Hamilton, 1996; Brown and Yucel, 2002). Studies in second group have focused on the relationship between the change in energy prices or their volatility and the aggregate economic activity. Symmetric or asymmetric effects in linear or non-linear models showed that the relationship is valid in most developed economics (Lee and Ni, 2002; Lardic and Mignon, 2006, 2008). Finally, some papers have pointed out the role of macro-economic policies in order to deal with macro-economic effects of the energy price shocks. Studies in this group have also examined the possible relationship between the energy price fluctuations and aggregate economic activity (Huang *et al.*, 2005; Cologni and Manera, 2008).

As seen, there is a vast amount of evidence on the relationship between energy prices and or their volatility and aggregate economic activity, particularly in developed economies. However, volatility in energy prices can also severely affect the economic activity in developing economies with several spillover channels.[1] Within this context, this paper aims to examine the impact of volatility in the world energy price on the aggregate economic activity in 10 developing Asian countries: Bangladesh, PR China, India, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Turkey and Vietnam within an unbalanced panel data framework. Indeed, the world price of energy is an important input in industrial production process — which is the engine of economic growth in these developing Asian countries (Dosi and Nelson, 2013). In addition, most of these economies have provided stable and strong economic growth, particularly during last decade. Thus, it is important to know how volatility of the world energy prices affects the aggregate economic activity in developing Asian countries.

In this paper, along with the standard deviation, we use both the realized volatility (RV) and the generalized autoregressive conditional heteroskedasticity (GARCH) models to

[1] For instance, Baskaya *et al.* (2013) recently calibrated a model to explain how shocks to the level and volatility of energy (particularly oil) prices affect aggregate economic activity in a small open economy.

calculate volatility in the world energy price. We then employ, the System Generalized Methods of Moments (sys-GMM), the common correlated effects pooled (CCEP) and the common correlated effects mean group (CCEMG) panel data estimations. We find that the world energy price volatility is negatively associated with the aggregate economic activity in our panel data framework. Using the CCEP and the CCEMG estimators, we also systematically examine the uncertain transmission channel of the world energy price and its volatility on the aggregate economic activity in each economy and obtain different dynamics in 10 developing Asian economies over the period under concern.

This paper makes two main contributions to the existing literature. First, to the best of our knowledge, the effects of the world energy price volatility on the aggregate economic activity have not systematically investigated in developing Asian economies within such a large dimension panel data set. Using robust and efficient panel data estimators, this paper seeks to fill this gap in the literature. Second, this paper includes the periods of the global commodity crisis and the great global recession of 2008–2009. In other words, over the period under concern, both the aggregate economic activity in the world and the energy prices in global markets were in the boom and bust cycle, and this introduced a remarkable volatility in both economic activity and energy prices. But during and beyond the global recession, developing Asian economies are relatively solid — when they compare to advanced economies and developing economies in other regions, i.e., the Central and Eastern European economies. We therefore suggest that our aim, the data and the methodology can generate additional and valuable empirical results on the relationship between the aggregate economic activity and the world energy price volatility in developing 10 Asian economies.

The remainder of this paper is organized as follows. Section 2 provides a summary of the related literature. Section 3 explains the data and the methodology. Section 4 reports and discusses the empirical findings, and Section 5 presents our concluding remarks.

2. Literature Review

2.1. *Volatile nature of energy and commodity markets and volatility models*

Volatile price movements have marked on global energy markets during recent years.[2] The accrual factor of energy price movements for the period from 2003 to 2010 has typically considered as a motivator and a consequence of the great global recession of 2008–2009. Indeed, the great global recession, global energy prices at major international exchanges jumped and reached record–high prices for both oil and natural gas (Ali Ahmed and Wadud, 2011). However, the great global recession of 2008–2009 destroyed the demand for energy and triggered off a deep decline in the world energy prices, and this led to a remarkable increase in the world energy price volatility. Previous findings showed not only the level of energy prices, but also their volatility could economically be destructive (Ferderer, 1996).

In fact, the price level or the volatility in all commodities can hurt aggregate economic activity in accordance with the structure of exports and imports in a small-open economy.

[2] Note that Figure 1 illustrates the nominal world energy price over the period 1960–2010.

However, not only the level of energy prices, but also their volatility in energy markets is relatively higher than the volatility in other types of commodities (Regnier, 2007). Indeed, whether energy prices are more volatile than other commodities is a noteworthy phenomenon in literature and propositions of the topic have empirically been tested. For instance, Plourde and Watkins (1998) concluded that crude oil price volatility was higher than the volatilities of nine other commodities and the volatility differences were significant in six of nine commodities during the period from 1985 to 1994. Pindyck (1999) analyzed the changes of oil, coal and natural gas price from 1870 to 1996 without comparing their volatilities. He simply calculated the constant volatility measure for very long period and showed that the energy volatility is on the upward movement. In a relatively recent study, Regnier (2007) used the monthly producer price index commodity series over the period January 1945–August 2000 and provided a heterogeneous set of product-prices for the long-time horizon. He also examined the relationship between the energy prices volatility and the prices of other products, including some crude commodities. Regnier's findings were generally consistent with the previous studies but they were more detailed. In other words, he showed the volatile nature of oil and energy markets for a longer period by using several modeling techniques. Furthermore, Narayan and Narayan (2007), who followed Plourde and Watkins (1998), Pindyck (1999), Regnier (2007),[3] looked into the volatility dynamics in energy prices. Using daily data, they modeled the crude oil price volatility for the period from 13th September 1991 to 15th September 2006. Their study was the first, to model the crude oil prices by using daily data. Their results indicated two features of the crude oil price volatility: "asymmetry" and "persistence into shocks". They also showed that oil price shocks had both permanent and asymmetric effects on the volatility. Asymmetric impacts of the crude oil price on volatility mean that negative and positive shocks would have different effects on the crude oil price volatility. In short, studies suggested that in terms of an examination on nexus between the energy price volatility and the aggregate economic activity, energy price volatility has a greater volatile nature compare to any other commodities. Following this, our paper focuses on the impacts of the world energy price on the aggregate economic activity in developing Asian economies.

Indeed, many volatility models both in continuous-time and discrete-time have originally developed for assets of financial markets. These volatility models have successfully applied into energy markets without requiring any adjustment for the characteristics of energy assets. Based on the nature of data, various volatility measures — which have parametric or non-parametric backgrounds — has been implemented in literature.[4] Furthermore, the continuous-time[5] and the discrete-time[6] models have also been successfully used in energy markets.[7] For instance, Oberndorfer (2009) followed similar methodology

[3] Note that they have comparatively examined the volatility in crude oil, refined petroleum and natural gas prices.

[4] These are the historical volatility (HS), the stochastic volatility (SV), the implied volatility (IV), the realized volatility (RV) and the conditional volatility (CV) models.

[5] For instance, see the stochastic volatility model of Heston and the constant elasticity of variance (CEV) models.

[6] For instance, see the Autoregressive Conditional Heteroskedasticity (ARCH), the Generalized ARCH (GARCH), the ARCH in Mean (ARCH-M) and the Exponential GARCH (EGARCH) models.

[7] See Eydeland and Wolyniec (2003) and Duffie *et al.* (2004) for details in the usage of volatility models in energy markets.

with the recent studies and used the GARCH model to measure volatility in natural gas, coal and oil prices in monthly data set. Geman and Ohana (2009) analyzed the volatility structure in the United States (US) oil and natural gas markets. In their paper, monthly values of the volatility were computed as the annualized standard deviations of the daily returns for the front-month futures prices over the corresponding month. However, there may still be a lack of understanding on the volatility of energy prices (Sadorsky, 2006).

2.2. *The relationship between macroeconomic indicators and volatility in energy markets*

Lee *et al.* (1995), Ferderer (1996), Amano and Norden (1998), Guo and Kliesen (2005), Huang *et al.* (2005), Chen and Chen (2007), and Elder and Serletis (2010), examined the relationship between the energy price volatility and macroeconomic indicators. These studies showed that there is an asymmetry of the impact of oil price shocks on economic activities. In addition, Cologni and Manera (2008) investigated the impact of oil prices on inflation and interest rates by the co-integrated vector auto-regression (VAR) framework for G7 countries. They used quarterly data from 1980Q1 to 2003Q4 and found that oil prices significantly affect inflation and it transmitted to the real economy by increasing interest rates, except for Japan and the United Kingdom (UK). Their impulse response function analysis also suggested that there are instantaneous and temporary effects of oil price and these significantly affect inflation. Moreover, Lardic and Mignon (2006, 2008) emphasized that the oil price is an important source of economic fluctuations but they suggested that macroeconomic effects of oil price shocks have become less clear in 2000s. On the contrary, Blanchard and Gali (2009) indicated that events in the last decade clearly show that oil prices are not a significant source of economic fluctuations in developed economies.

On the other hand, studies on the impacts of energy price volatility on aggregate economic activity in developing economies are limited in literature. The more volatile energy prices pioneer more uncertainty and this leads to a macro-economic instability for both energy-exporting and energy-importing developing countries. Higher energy prices also contribute to rise in inflation in the result of recession in energy-dependent countries. One branch of this literature demonstrated that energy prices have a negative impact on economic growth and mixed effects on real exchange rates. For instance, Rafiq *et al.* (2009) empirically examined the impact of oil price volatility on some key macroeconomic indicators in Thailand. Following evaluation of the volatility forecasts of Andersen *et al.* (2004), they used quarterly data series from 1993Q1 to 2006Q4 for oil price volatility and the volatility was measured by RV. In addition, the impacts of the oil price volatility were examined by the VAR system. The results of the Granger causality test, the impulse response functions and the variance decomposition showed that oil price volatility have a significant impact on macroeconomic indicators, particularly on unemployment and investment. Jbir and Zouari-Ghorbel (2009) analyzed the oil prices-macro-economy nexus with considering the impacts of oil prices fluctuations on the Tunisian economic activity. They applied the VAR model in quarterly data from 1993Q1 to 2007Q3. The results of the linear and the non-linear model specifications indicated that there is no direct impact of the oil price shock on the economic activity. In other words, oil price shocks indirectly affected the Tunisian economic activity. Tang *et al.* (2010) emphasized the price transmission mechanisms and investigated how oil price shocks impact the Chinese economy. For this purpose, they developed the SVAR model. Their findings showed that an increase in oil price negatively affects output and investments and also positively affects inflation rate and interest rate. Using the VAR methodology, Du *et al.* (2010) also investigated the relationship between the world oil price and macro-economic indicators in PR China for the period from January 1995 to December 2008. Their findings showed that the world oil price negatively affected the economic growth and soaring inflation in PR China and their impacts were found as non-linear. Malik (2010) investigated the relationship between oil prices and the macro-economic variables (including output) in Pakistan over the period 1979Q1–2008Q2. The empirical results were in line with Du *et al.* (2010) — where oil prices and output were negatively related — and the relationship was non-linear. Salim and Rafiq (2011) examined the effects of oil price volatility on six emerging Asia economies: PR China, India, Indonesia, Malaysia, the Philippines and Thailand. They used RV measure of Andersen *et al.* (2004) as well as the VAR analysis, the Granger causality test, the generalized impulse response functions, and the generalized variance decompositions. Their results indicated that oil price volatility negatively affects output growth in PR China but only in the short run. In addition, oil price volatility had negative long-run effects on output growth in India, Indonesia, Malaysia and Thailand. There was also no significant relationship between oil price volatility and output in the Philippines. Ng (2012) recently considered the realized volatility measure of daily crude oil price and applied the multivariate co-integrated VAR model on the relationship between oil price volatility and investments and aggregate output in Singapore. His findings indicated that a spike in oil price volatility negatively affects investments and aggregate output in Singapore for the period from 1983Q2 to 2009Q2 in quarterly data set.

3. Data and Methodology

3.1. *Data*

In this study, we empirically examine the impact of volatility in the world energy price on aggregate economic activity in Bangladesh, PR China, India, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Turkey and Vietnam. Our panel data framework is based on the period from 1970 to 2010 in Vietnam and for remaining nine developing economies, we consider over the period 1960–2010. The frequency of the data is annual. Our definition of developing countries is based on the classifications of the International Monetary Fund (IMF) and the World Bank Group.

Data of the world energy price in monthly frequency are available from 1960 to present at the database of the Global Economic Monitor (GEM) Commodities of the World Bank Group. We obtain the world energy price data from the World Bank and that is why the beginning date of the empirical analysis is 1960. We also use the data of the Penn World Tables (version 7.1) to measure and define the aggregate economic activity in developing 10 Asian economies. We report a summary of the descriptive statistics and the data source

Table 1. Source of the Data and a Summary of the Descriptive Statistics

Variables	Source	Definition	Mean	Std. Dev.	Obs.
Real GDP per Capita (RGDPC)	Penn World Tables	In logarithmic form	7.52	0.85	500
Government Consumption	Penn World Tables	% of GDP	8.07	4.08	500
Investments	Penn World Tables	% of GDP	23.1	9.61	500
Inflation Rate	The World Bank	%	0.50	17.2	490
Real Openness	Penn World Tables	%	52.9	42.4	500
Population	Penn World Tables	In logarithmic form	11.5	1.26	500
Nominal Exchange Rate	Penn World Tables	Exchange rate to USD	905	1324	500
World Energy Price	The World Bank	In logarithmic form	3.14	1.29	500
World Energy Price Volatility	Authors' Calculations	Standard deviation	0.18	0.16	491
World Energy Price Volatility	Authors' Calculations	Realized volatility	0.19	0.17	491
World Energy Price Volatility	Authors' Calculations	GARCH (1,1)	0.23	0.16	491

in Table 1. We also illustrate the world energy price in logarithmic form over the period 1960–2010 in Figure 1.

3.2. *Methodology*

3.2.1. *Measuring volatility in the world energy price*

We use monthly world energy price data (ep_t) to compute annual energy price volatility (epv_t). Given that $r_t = \ln(epv_t) - \ln(epv_{t-1})$ is the return of the world energy price, this paper uses three volatility calculation methods: The Standard Deviation (SD_t), the Realized

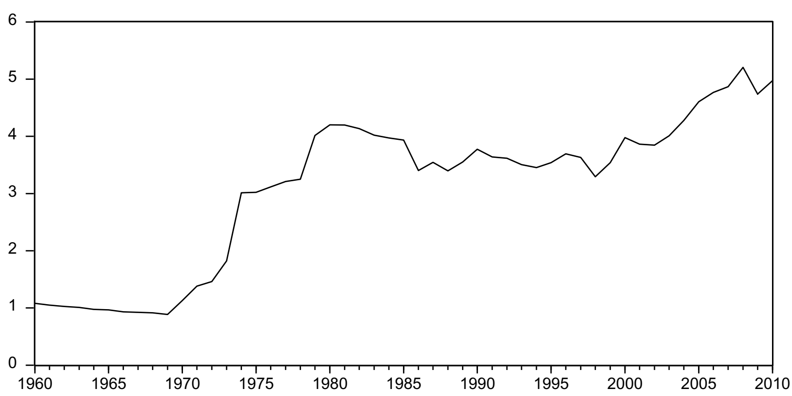

Figure 1. Nominal World Energy Price, USD (2005 = 100)

Volatility (RV_t), and the GARCH (1,1) (GARCH_t) models. We simply write down the volatility measures as follows (Oberndorfer, 2009; Geman and Ohana, 2009):

$$epv_t = SD_t = \sqrt{\frac{1}{12-1}\sum_{t=1}^{12}\left(r_t - \frac{1}{12}\sum_{t=1}^{12} r_t\right)^2}, \tag{1}$$

$$epv_t = RV_t = \sum_{t=1}^{12} r_t^2, \tag{2}$$

$$\begin{aligned} r_t &= \mu + \varepsilon_t, \quad \varepsilon_t = \varphi_t \sigma_t, \quad \sigma_t \sim N(0,1), \\ \sigma_t^2 &= c + a\varepsilon_{t-1}^2 + b\sigma_{t-1}^2. \end{aligned} \tag{3}$$

We then compute the annual world energy price volatility as the average of the monthly conditional variance as follows:

$$epv_t = \mathrm{GARCH}_t = \frac{1}{12}\sum_{t=1}^{12}\sigma_t^2. \tag{4}$$

The GARCH model was first proposed by Bollerslev (1986). Using GARCH (1,1) model for the conditional variance of the mean-equation error term will be explained the systematic variation of the world energy price. We consider the GARCH (1,1) model is due to the evidence that it responds more quickly to the shocks than alternative volatility models (Oberndorfer, 2009). Before the GARCH (1,1) estimations and calculations, we investigate possible Autoregressive Conditional Heteroskedasticity (ARCH) effects and determine appropriate AR (p) and MA (q) specifications that are based on the Akaike Information Criteria (AIC). We find that the ARCH effects exist in the returns of the world oil price. Furthermore, we analyze possible presence of autocorrelation in the GARCH (1,1) model. We select the maximum number of lag as 15 for the autocorrelation analysis as suggested by Engle (2001). We also apply the appropriate ARCH test statistics to investigate remaining autocorrelation in order to test the existence of remaining ARCH effect in selected lag of the variance equation. The results indicate that variance equations are correctly specified. However, we do not report the results of the GARCH estimation and the diagnostic tests to save the space.[8] We report measures of the standard deviation, the RV and the GARCH (1,1) for the world energy price in Figure 2.

3.2.2. *Preliminary tests and panel data estimation procedure*

We apply panel unit root (PUR) tests to examine whether the dependent variable is stationary or not. However, the recent literature has criticized the reliability of the "first generation" PUR tests that assume cross-sectional independence of both heterogeneous and homogenous unit roots by default. To address the issue, we initially perform a relatively efficient and formal test of the cross-sectional independence of Pesaran (2004) to

[8] The results are available upon request.

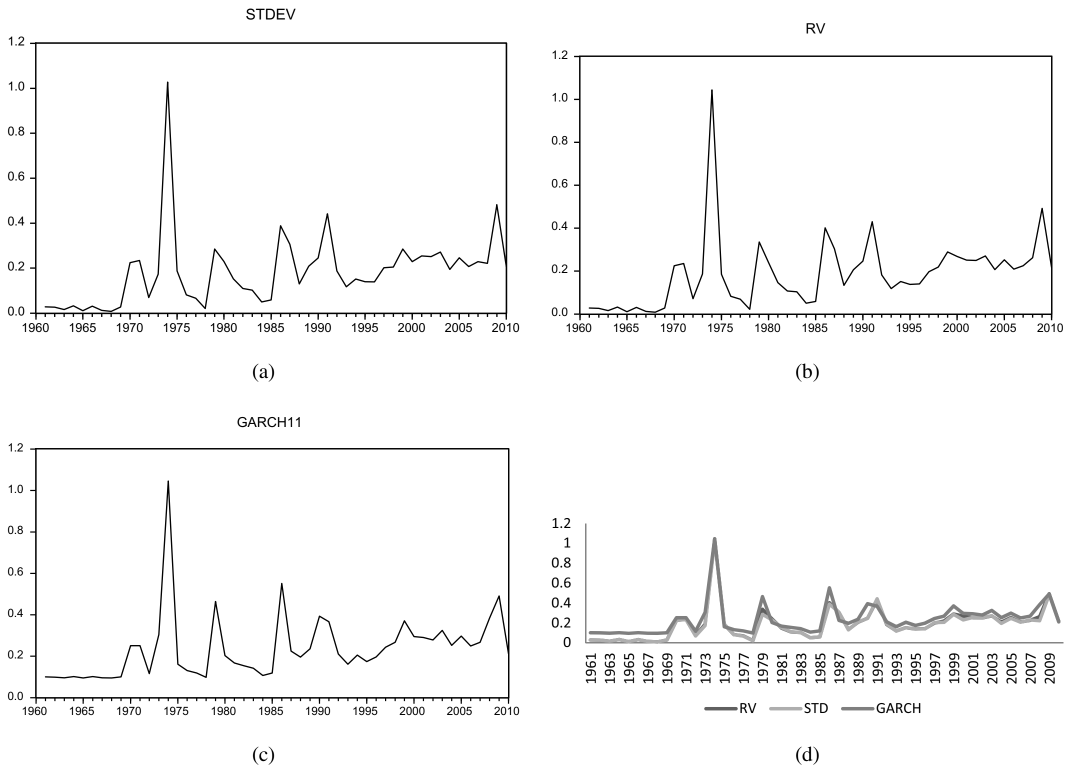

Figure 2. Volatility Measures for the World Energy Price

determine whether there is cross-sectional dependence, so "second generation" PUR tests are necessary or not. Following the results of the CD test of Pesaran (2004) and given the unbalanced structure of the panel data, we apply the second generation cross-sectionally augmented PUR test (CIPS) of Pesaran (2007) which overcomes short-comings of the homogenous "first generation" PUR tests (Gozgor, 2014a).

We then specify and estimate our benchmark model within the sys-GMM techniques of Blundell and Bond (1998). We do not, however, consider the pooled ordinary least square and the fixed (or random) effects panel data estimations because of the significant and highly-persistent characteristics of the aggregate economic activity in developing Asian economies — a contingent not fully captured by the fixed (or random) effects estimations. We control for the country fixed effects in the panel data estimations because there could be other heterogeneities across countries that affect the aggregate economic activity. In addition, we use dummies for the time fixed effects to control for potential cyclical effects not captured by variables in our estimations. Furthermore, we address controlling potential endogeneity of the explanatory variables and of the lagged aggregate economic activity (Gozgor, 2014b). The panel sys-GMM estimation technique of Blundell and Bond (1998) adds level equations to the differenced ones and this leads to a system of two different sets of moment conditions, namely differences and levels (Felbermayr *et al.*, 2011). To compute this dynamic panel GMM estimation technique, two assumptions must hold. First, instruments must be uncorrelated with error terms. Second, instruments must be correlated with the instrumented variables. Thus, we must obtain empirical evidence in favor of first-order autocorrelation but against second-order autocorrelation in the residuals (Gozgor, 2014a, 2014b).

On the other hand, we systematically examine uncertain transmission channel of the world energy price volatility on the aggregate economic activity in each developing Asian economy. For this purpose, we consider the CCEP and the CCEMG estimators of Pesaran (2006), and thus take cross-sectional dependence into account among panel units. The CCEP estimation is the suitable and the efficient approach for the panel structure of this paper in which allowing for homogenous technology parameters but heterogeneous factor loadings in the regressions (Pesaran, 2006). Indeed, the common correlated effects (CCE) estimations technique allows for homogenous (or heterogeneous) slope coefficients across panel units and this method can successfully eliminate time-variant and unobservable impacts across panel units as well as the problems of identification — related to correlation across cross-sectionally dependent panel units (Pesaran and Tosetti, 2011). We report and discuss all empirical findings from these estimation techniques in Section 4.

3.3. *Empirical model and definition of variables*

Following Barro (1998, 2003), we estimate the following empirical model to measure the impacts of the world energy price and its volatility on the aggregate economic activity in 10 developing Asian economies as follows:

$$\begin{aligned}\mathrm{RGDPC}_{i,t} = {} & \alpha_0 + \alpha_1 \mathrm{RGDPC}_{i,t-1} + \alpha_2 \mathrm{GOVCON}_{i,t} + \alpha_3 \mathrm{INVS}_{i,t} + \alpha_4 \mathrm{CONTROL}_{i,t} \\ & - \alpha_5 epv_{i,t} + v_i + v_t + \varepsilon_{i,t},\end{aligned} \tag{5}$$

where, $\mathrm{RGDPC}_{i,t}$ and $\mathrm{RGDPC}_{i,t-1}$ are the current and the lagged purchasing power parity (PPP) converted gross domestic product (GDP) per capita at 2005 constant prices in country i at times t and $t-1$; $\mathrm{GOVCON}_{i,t}$ is the government consumption share of the PPP converted GDP at 2005 constant prices in country i at time t; $\mathrm{INVS}_{i,t}$ is the investment share of the PPP converted GDP at 2005 constant prices in country i at time t; $epv_{i,t}$ is the annualized volatility of the monthly world energy price in the USD at 2005 current price. Along with the world price of energy, we consider three measures of the volatility: the SD_t, the RV_t and the GARCH (1,1) for the empirical model in Equation (5). In addition, the country effects, the period effects, and the error term are denoted as v_i, v_t and $\varepsilon_{i,t}$, respectively. On the other hand, we consider four control variables, $\mathrm{CONTROL}_{i,t}$, in the empirical model for the aggregate economic activity: $\mathrm{NER}_{i,t}$ is the nominal exchange rate in units of local currency per USD for country i at time t; $\mathrm{INF}_{i,t}$ is the price level of GDP (US $=100$) (%) in country i at time t, ln $\mathrm{POP}_{i,t}$ is the population in thousands in logarithmic form in country i at time t, $\mathrm{ROPN}_{i,t}$ is the measure of trade openness at 2005 constant prices (%).

We define the aggregate economic activity as the PPP converted real GDP per capita. We thus adjust the real GDP for population and the difference between domestic and international prices. Indeed, the developing Asian countries demonstrate a rapid population growth over the period 1960–2010. At this point, the real GDP is considered as one of the best measure for economic activity in literature. For instance, we put following in Hall *et al*. (2003a):

> "*The National Bureau of Economic Research (NBER) defines expansions and recessions in terms of whether aggregate economic activity is rising or falling, and it views real GDP as the single best measure of economic activity*."

In addition, following Hall *et al.* (2003b), we put it as follows:

> "*The (business cycle dating) committee views real GDP as the single best measure of aggregate economic activity*."

On the other hand, we expect that the government consumption and the investment level positively affect the aggregate economic activity. We also separately control the country size (population in logarithmic form), the domestic inflation, and the nominal exchange rates in the empirical model. So doing, in a way we check the robustness of effects of both domestic and international prices and population on the measure of aggregate economic activity — i.e., whether measure of the aggregate economic activity is able to capture these effects or not. Following Sadorsky (2011), we control for the real (trade) openness in our empirical model. In fact, Alcala and Ciccone (2004) proposed the real measure for openness to trade and they suggested that this measure of trade openness take productivity differences among countries into account to remove a bias that arise from the prices of non-tradable goods.

4. Empirical Results

4.1. *Results of the preliminary tests*

As a preliminary, we report results of the CD test of Pesaran (2004) in Table 2.

The results of the CD test of Pesaran (2004) in Table 2 strongly reject the null hypothesis of no cross-sectional independence among the aggregate economic activity in developing Asian countries. Second, we employ the CIPS tests of Pesaran (2007), namely the "second generation" PUR test that is to take the cross-sectional dependence into account in 10 developing Asian economies. We report the CIPS tests results of Pesaran (2007) in Table 3.

Table 2. Results of the CD Test of Pesaran (2004) for the Aggregate Economic Activity

The CD Test of Pesaran (2004)	RGDPC
Pesaran's (2004) the CD-stat	9.745 (0.000)
The Average Absolute Value of the Off-diagonal Elements	0.232

Notes: The CD test of Pesaran (2004) is defined under the null hypothesis of cross-sectional independence in the RGDPC (in logarithmic form) in 10 developing Asian countries. The *p*-value is in parenthesis.

Table 3. Results of the CIPS PUR Tests of Pesaran (2007)

Heterogeneous Unit Root (The CIPS)	Constant (RGDPC)	Constant and Trend (RGDPC)
Zt-bar Statistic	1.712 (0.947)	1.536 (0.815)

Notes: The CIPS test assumes the cross-sectional dependence as in form of a single unobserved common factor. The test is defined under the null hypothesis of the RGDPC series have a unit root. The optimal number of lag is selected by the AIC. The *p*-values are in parentheses.

As seen in Table 3, the PUR tests of Pesaran (2007) cannot reject the null hypothesis of the real GDP per capita (RGDPC) has a unit root. Thus, the RGDPC has persistence in significant degree. We then compute the system GMM panel estimation — which performs well with the highly persistent panel data (Blundell and Bond, 1998).

4.2. *Results of the panel data estimations and discussions on policy implications*

We report the results of the sys-GMM panel estimation technique of Blundell and Bond (1998) in Tables 4 and 5. All results of the Hansen test indicate no over-identification problem in the panel estimation specifications. In addition, results of the LM tests for AR(1) and AR(2) indicate first-order but no second-order autocorrelation. Thus the empirical results satisfy the necessary conditions for validation of the sys-GMM panel estimation technique of Blundell and Bond (1998).

The empirical findings in Tables 4 and 5 show statistically significant persistence of the lagged RGDPC in natural logarithm in the developing Asian economies, with an average coefficient 0.994. The result signals very high-level persistence of aggregate economic activity in developing Asian countries.

The results in Table 4 report estimates using various fundamental framework specifications of factors as determinants of the aggregate economic activity in developing economies. In Column I, we consider a relatively basic framework in literature. We then control for inflation, real openness, and population in logarithmic form and nominal exchange rate in Columns II, III, IV and V. The empirical results in Table 4 indicate that the government consumption and the investments positively affect the aggregate economic activity in developing Asian economies. Among all variables considered, these are the only ones whose coefficients are statistically significant in all frameworks. We therefore deal with the model in Column I as the benchmark estimation and examine the impacts of the world energy price and its volatility on the aggregate economic activity in the developing Asian economies. We report the results of the system-GMM estimation of Blundell and Bond (1998) in Table 5.

Table 5 reports on the explanatory variables used in the benchmark model of Column I in Table 4, the world energy price and various measures of volatility in the world energy price. The results in Table 5 indicate that the government consumption and the domestic investments positively contribute to the aggregate economic activity. Thus, they are robust explanatory variables. The coefficient of the world energy price is not found as statistically

Table 4. Results of the System-GMM Panel Estimation of Blundell and Bond (1998)

Regressors	(Sys-GMM) (I)	(Sys-GMM) (II)	(Sys-GMM) (III)	(Sys-GMM) (IV)	(Sys-GMM) (V)
Lagged Real GDPC (ln)	0.993 (0.0006)***	0.993 (0.0006)***	0.994 (0.0079)***	0.994 (0.0006)***	0.994 (0.0006)***
Government Consumption	0.0053 (0.0021)**	0.0048 (0.0021)**	0.0052 (0.0023)**	0.0053 (0.0021)**	0.0052 (0.0021)***
Investments	0.0021 (0.0003)***	0.0020 (0.0003)***	0.0021 (0.0003)***	0.0021 (0.0003)***	0.0021 (0.0003)***
Inflation	–	0.0003 (0.006)	–	–	–
Real Openness	–	–	0.0001 (0.001)	–	–
Population (ln)	–	–	–	−0.0008 (0.0087)	–
Nominal Exchange Rate	–	–	–	–	−0.0001 (0.001)
Observations	490	480	490	490	490
R^2 (overall)	0.997	0.997	0.997	0.997	0.997
Hansen Test	[0.73]	[0.67]	[0.80]	[0.74]	[0.78]
AR(1)	[0.01]	[0.00]	[0.00]	[0.00]	[0.01]
AR(2)	[0.36]	[0.72]	[0.51]	[0.47]	[0.81]

Notes: The dependent variable is the real GDP per capita (RGDPC) in logarithmic form. The constant term is also estimated but not reported. The Hansen test shows the results of the over-identifying restrictions (null hypothesis: there is over-identification in the estimation specification). AR(1) and AR(2) show results of the LM statistics for autocorrelation (null hypothesis: no first-order autocorrelation and no second-order autocorrelation, respectively). We report robust standard errors. Standard errors are in parentheses, and the *p*-values are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5. Results of the System-GMM Panel Estimation of Blundell and Bond (1998)

Regressors	(Sys-GMM) (I)	(Sys-GMM) (II)	(Sys-GMM) (III)	(Sys-GMM) (IV)	(Sys-GMM) (V)
Lagged RGDPC (ln)	0.993 (0.0006)***	0.995 (0.0076)***	0.995 (0.0062)***	0.995 (0.0062)***	0.995 (0.0062)***
Government Consumption	0.0053 (0.0021)**	0.0056 (0.0019)***	0.0053 (0.0021)**	0.0053 (0.0021)**	0.0053 (0.0021)***
Investments	0.0021 (0.0003)***	0.0021 (0.0003)***	0.0021 (0.0003)***	0.0021 (0.0003)***	0.0021 (0.0003)***
World Energy Price (ln)	–	−0.001 (0.002)	–	–	–
Standard Deviation	–	–	−0.0013 (0.0061)**	–	–
Realized Volatility	–	–	–	–0.0014 (0.0066)**	–
GARCH (1,1)	–	–	–	–	−0.0014 (0.0063)**
Observations	490	480	490	490	490
R^2 (overall)	0.997	0.997	0.997	0.997	0.997
Hansen Test	[0.87]	[0.93]	[0.91]	[0.99]	[0.99]
AR(1)	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]
AR(2)	[0.61]	[0.33]	[0.44]	[0.39]	[0.56]

Notes: The dependent variable is the real GDP per capita (RGDPC) in logarithmic form. The constant term is also estimated but not reported. The Hansen test shows the results of the over-identifying restrictions (null hypothesis: there is over-identification in the estimation specification). AR(1) and AR(2) show results of the LM statistics for autocorrelation (null hypothesis: no first-order autocorrelation and no second-order autocorrelation, respectively). We report robust standard errors. Standard errors are in parentheses, and the *p*-values are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

significant. In addition, different measures of volatility in the world energy price negatively affect the aggregate economic activity in developing Asian economies.

On the other hand, the average short run coefficients of the government consumption and the investments are 0.0053 and 0.0021, respectively. The long run impact, namely, the short run effect together with the effect through the lagged aggregate economic activity, is found to be 0.883[9] for the government consumption and 0.35[10] for the investments. Furthermore, the empirical evidence shows that a 1% increase in volatility in the world energy price reduces the aggregate economic activity by approximately 0.0014% (on average) in the short run and by approximately 0.233%[11] (on average) in the long run. Moreover, we systematically examine uncertain transmission channel of the world energy price and its volatility on the aggregate economic activity in each developing Asian economy. For this purpose, we report the results of the CCEP and the CCEMG estimations of Pesaran (2006) in Table 6.

The empirical results of the CCEP estimation in Table 6 indicate that the world energy price positively affect the aggregate economic activity only in Malaysia. We suggest that this result may come from the fact that Malaysia is one of the leading natural-gas exporters (Ali Ahmed and Wadud, 2011). The long-run coefficients of the CCEP show that the impact of volatility in world energy price is significant in PR China, India and Turkey. In addition, the empirical findings indicate that a 10% increase in the volatility in the world energy price reduces the aggregate economic activity in the long run by approximately 0.97%, 0.64% and 0.52% (on average) in Turkey, PR China and India, respectively. On the other hand, results of the CCEMG estimation of Pesaran (2006) confirm the negative impact of the world energy price volatility on the aggregate economic activity within the panel framework and the average long run coefficient is found as −0.15.

The findings indicate that the most impressive negative effects of the world energy price volatility on the aggregate economic activity in Turkey, PR China and India, respectively. PR China and India are among top five largest net-energy consumers in the world and they depend heavily on imported energy, particularly on crude oil. Turkey, the rapid thriving economy during the last decade, is not only a growing energy consumer, but also she is a regional energy transit hub (Nenem and Ozkan-Gunay, 2012). Therefore, several policy implications can be issued from our findings. First, policy-makers in PR China, India and Turkey should maintain their policy to stabilize the world energy price through subsidization and hence help to retain aggregate economic activity. Second, they should focus more on non-energy taxes, and should constitute a broader tax base. This kind of policy implication would automatically delimitate a volatility spillover from world price to domestic price in energy products. Third, they can boost the infrastructure investments to control costs and volumes of energy imports to provide sustainable economic activity. Fourth, they may turn toward renewable and alternative energy sources in their production processes. However, these developing economies are still net energy-importers and

[9] Note that $0.0053/(1-0.994)$.
[10] Note that $0.0021/(1-0.994)$.
[11] Note that $0.0014/(1-0.994)$.

Table 6. Results of the CCEP and the CCEMG Estimations of Pesaran (2006) for Individuals

Real GDP per Capita (ln)	World Energy Price (ln) (I)	Standard Deviation (II)	Realized Volatility (III)	GARCH (1,1) (IV)
Bangladesh	−0.005 (0.014)	−0.043 (0.031)	−0.042 (0.032)	−0.049 (0.033)
PR China	−0.006 (0.012)	−0.065 (0.024)**	−0.065 (0.023)***	−0.063 (0.023)***
India	−0.001 (0.011)	−0.047 (0.017)***	−0.051 (0.018)***	−0.057 (0.021)***
Indonesia	0.011 (0.014)	0.034 (0.024)	0.032 (0.023)	0.031 (0.024)
Malaysia	0.022 (0.013)**	0.026 (0.026)	0.028 (0.026)	0.025 (0.028)
Pakistan	−0.007 (0.008)	−0.008 (0.014)	−0.009 (0.015)	−0.015 (0.014)
The Philippines	0.012 (0.014)	0.037 (0.042)	0.037 (0.041)	0.041 (0.040)
Thailand	−0.024 (0.015)	−0.017 (0.016)	−0.021 (0.016)	−0.023 (0.021)
Turkey	−0.021 (0.086)	−0.101 (0.023)***	−0.098 (0.022)***	−0.092 (0.032)***
Vietnam	0.012 (0.009)	−0.042 (0.033)	−0.042 (0.032)	−0.037 (0.029)
Panel: the CCEMG	−0.001 (0.002)	−0.137 (0.006)**	−0.153 (0.008)**	−0.159 (0.007)**
RMSE of the CCEMG	0.012	0.005	0.003	0.004
I(1) in the CCEMG	[0.00]	[0.00]	[0.00]	[0.00]

Notes: The dependent variable is the real GDP per capita (RGDPC) in logarithmic form. We estimate the benchmark model including the constant term for the CCEP but report only the parameters for the world oil price and the world oil price volatility for reasons of parsimony. The optimal number of lag length is selected by the AIC. We include the sets of cross-section period averages in the CCEP estimator. RMSE is the root square mean error. I(1) indicates the results of the CIPS test of Pesaran (2007) under the null hypothesis of non-stationarity with maximum number of lag is two. See Pesaran (2006) for details. Standard errors are in parentheses and the p-values are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

therefore policy-makers are not able to fully eliminate the negative impacts of the world energy price volatility on the aggregate economic activity but suitable policy implications would minimize them.

5. Concluding Remarks

High and persistent prices in global energy markets decrease economic activity and increase inflation, simultaneously. Particularly following the deep boom and bust cycles in both commodity and oil prices through and beyond the great global recession 2008–2009, it is observed that possible effects of persistent and volatile characteristics in energy prices can be severe on developing economies. Within this context, this paper empirically analyses the impact of volatility in the world energy price on the aggregate economic activity in an unbalanced panel data framework for 10 developing Asian countries: Bangladesh, PR China, India, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Turkey and Vietnam. Along with the standard deviation, we use both the RV and the GARCH models in order to measure the volatility in the world energy price.

The empirical results from dynamic panel data estimations show that the world energy price volatility is negatively associated with the aggregate economic activity in our panel data framework. Using the common correlated effects estimators, we also systematically examine uncertain transmission channel of the world energy price volatility on the aggregate economic activity in each economy. Our findings show negative effects of the world energy price volatility on the aggregate economic activity. These statistically significant findings indicate that volatility in the world energy price has economically retarding effects on the long run growth pattern in Turkey, PR China and India. These empirical results are in line with the previous studies of Du *et al.* (2010) and Tang *et al.* (2010) for the Chinese economy.

Future researches about the topic can implement different time series or panel estimation techniques and volatility models in order to examine the effects of world or domestic energy prices volatility on other macro-economic indicators in developing economies — i.e., inflation, investments and unemployment — within larger panel data set frameworks.

Acknowledgments

This work was supported by Research Fund of the Istanbul Medeniyet University. Project Number: SUY-2013-405.

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