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Exchange Rate Volatility and its Impact on Industrial Production, Before and After the Introduction of Common Currency in Europe

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ABSTRACT: We explored the impact of exchange rate volatility on industrial production before and after the introduction of common currency for eleven European countries included in European Monetary Union and for four European countries that did not adopt 'Euro' as common currency. Study employed monthly data of exchange rate and macroeconomic variables from January 1980 to April 2009 for the analysis. We employed AR(k)-EGARCH(p,q) models for calculation of volatility in growth rate of nominal and real exchange rates for all countries before and after the introduction of common currency separately. In this paper, we used Pooled IV/TSLS. We can conclude that all the countries enjoyed benefits after the introduction of common currency by reduction in negative impacts of real exchange rate volatility even some countries also faced increase in real exchange rate volatility. More than this, it can also be concluded that basket of fruits is not same for every country that joined common currency.

Keywords: Common Currency; Euro; AR-EGARCH; Exchange Rate
JEL Classifications: F31; F36; F55; G31

1. Introduction

The volatility is defined as "instability, fickleness, or uncertainty" whether appearing in asset pricing, option pricing, portfolio optimization, or risk management. This volatility provides huge base for economic decisions. The exchange rate (price of one currency in relation to another) is believed to be the fastest moving price in the economy, if it's allowed to move freely. The volatility of exchange rate describes uncertainty in international transactions both in goods and in financial assets. Exchange rates are modeled as forward-looking relative asset prices that reflect unanticipated changes in relative demand and supply of domestic and foreign currencies. Hence, exchange rate volatility reflects agent's expectations regarding changes in determinants of money supplies, interest rates and incomes. The impacts of volatility in exchange rate remained in discussion for a long time.

Over the last few decades, many developing countries/regions have or are considering implementing changes in their development strategies. After an effort of more than fifty years, introduction of "Euro" as the common currency on January 1, 1999, was a great success in monetary history. At that time, eleven countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Portugal, and Spain) replaced their own national currencies with Euro. Removal of the exchange rate volatility among the European countries is supposed to be one of the major benefits out of many expected benefits of Euro as common currency. Now after more than a decade, it's an opportune time to investigate the issue whether alterations in exchange rate arrangements have an effect on the exchange rate volatility. The case of European countries provides a

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particularly rich tested for the theoretical predictions. It also provides an opportunity to investigate, if changes in exchange rate volatility after the introduction of Euro have similar effects on real economy or not? The European countries also provide an opportunity to check if changes in exchange rate volatility have a similar impact on real economic variables of all the countries or if their responses differ. It also provides an opportunity to check how real economic variables have responded to variations in exchange rates for the countries that have not adopted the common currency. The present study tries to answer the above mentioned questions using data for 15 European countries from Jan. 1980 to Feb. 2009.

The rest of the paper is arranged as follows: Section 2 provides discussion about the historical background of the Euro, theoretical channels through which exchange rate volatility can affect real economy, and the empirical studies regarding the issue. The construction and utilization of variables along with empirical methodology is presented in section 3. Results and their discussion are presented in section 4. The last section contains conclusions.

2. Literature Review

For detail review of literature, the present section is further divided into four sub-sections: First, we will discuss historical background about the introduction of the Euro as common currency; second, we will highlight pros and Cons of adopting common currency; third, the literature regarding sources through which exchange rate volatility can affect real economic variables will be presented; In the last subsection, empirical studies regarding the issue will be presented.

2.1 Historical Background of Euro

Introduction of the Euro as the common currency is one of the steps for establishing European integration. This is the process of political, legal, economic, and in some cases social and cultural integration of states, wholly or partially in Europe. Recently, Jadresic (2002) analyzing common currency for the countries of Gulf Cooperation Council (GCC), states that a currency union should be seen as only one component of a much broader integration effort. This would have to include the removal of domestic and cross-border distortions that inhibit intra-regional trade and investment. For this reason, at various points in time numbers of institutions have been established among countries of Europe. The Council of Europe (founded in 1949) is one of the oldest international organizations working towards European integration. It has 47 member states with more than 800 million citizens. Other than this, European Union Customs Union (EUCU-1958), European Free Trade Association (EFTA-1960), European Monetary System (EMS-1979), Schengen Agreement (1985), European Union (EU-1993), European Economic Area (EEA-1994) etc., have been established to contribute in the efforts to achieve the goal of European integration.[2] Each institution has been contributing significantly to the integration process among the European countries after its establishment.

The European Monetary system (EMS) introduced in 1979, as the reaction to the large exchange rate variability of currencies during the 1970s.[3] The EMS ceased to exist on January 1, 1999. The Exchange Rate Mechanism (ERM) and the European currency Unit (ECU) were the two elements of EMS.

Exchange Rate Mechanism (ERM) is an 'adjustable peg' system. Countries that were participating in the ERM determined an official exchange rate for all their currencies, and a band around these central rates within which the exchange rates could fluctuate freely. The band was set at 2.25% and -2.25% around the central rates for most of the member countries (Belgium, Denmark, France, Germany, Ireland, and the Netherlands). However, Italy was allowed to use a larger band of fluctuations (6% and -6%) until 1990. The three newcomers to the system, Spain (1989), the United-Kingdom (1990), and Portugal (1992) also used the wider bands of fluctuations. In September 1992, UK dropped out of the system.

The central banks of the countries were committed to intervene so as to maintain the exchange rate within the band. These interventions were very frequent during the first half of the 1980s. They became much less frequent after the mid of 1980s. During the years 1987-1992 no realignment took

[2] For detail review of European history see; http://www.ena.lu/

[3] For details regarding the procedures of introduction of Euro see, Ludlow (1982), Emerson et al. (1992), Grauwe (2007).

place. However, due to crises in 1992-93 much realignment took place. The nature of the ERM was changed drastically by the increase of the band of fluctuations to 15% and -15% in August 1993.

European Currency Unit (ECU) defined as the basket of currencies of the member countries, was the second feature of EMS.[4] It included all the EU countries except Austria, Finland and Sweden. On January 1, 1999, the ECU was transformed into the Euro at the rate 1 ECU equivalent to 1 Euro.

The Euro came into existence after coordinating economic policies and achieving economic convergence among the European countries. Economic and monetary union (EMU) of the European Union (EU) members was established to look after issues regarding adoption of single currency. According to 'Maastricht Treaty', signed in 1991, before joining the common currency countries have to fulfill the following convergence criteria:

i. Country's rate of inflation must not be more than 1.5 percent above the average of the three countries of European Union (EU) with the lowest inflation.
ii. Country's nominal interest rate on long run government bonds (usually 10-years maturity) must not be more than 2 percent above the average of the three countries of EU with the lowest inflation.
iii. Country's government budget deficits must not be more than 3 percent of their Gross Domestic Product (GDP)
iv. Country's total government debt must not be more than 60 percent of their GDP
v. Country's national currency has to join Exchange Rate Mechanism (ERM) for two years period and exchange rate has to fluctuate between (plus minus] 15 percent band and short term high changes of the exchange rate are not acceptable.
vi. Country's national government cannot influence central bank's decisions.

It was decided in May 1998 that 11 EU countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxemburg, the Netherlands, Portugal, and Spain) satisfied this convergence criteria. On the other hand, Greece did not satisfy these criteria at that time. However, it thought to satisfy the conditions afterwards and was ready to introduce the Euro on January 1, 2002. Technically, monetary union started on January 1, 1999; however, the Euro did not exist in physical form until December 31, 2001. The national currencies continued to circulate in each country, and the exchange rates between them were irrevocably fixed. Full monetary union came into existence on January 1, 2002, when the Euro was introduced in physical form (banknotes and coins) and the national currencies were taken out of circulation.

On January 1, 2007, Slovenia became the 13th member of the Eurozone. Moreover, Cyprus and Malta joined currency union on 1st January, 2008 and Slovakia adopted common currency on 1st January, 2008. Estonia became the member of EMU on 1st January, 2011. In total, currently Euro is used as national currency in seventeen countries. Lithuania and Latvia are expected to join the Eurozone in the next few years and thus become countries using the euro. Euro is the second largest reserve currency as well as the second most traded currency in the world after the U.S. dollar.[5] According to IMF estimates, based on Gross Domestic Product (GDP) and purchasing power parity among the various currencies of 2008, the Eurozone is the second largest economy in the world.

Pros and Cons of Euro

Obviously, every project has its pros and cons; the Euro-project is no exception. There are number of pros and cons related to the introduction of Euro. The costs of common currency through common monetary union derive from the fact that when a country relinquishes its national currency, it also relinquishes an instrument of economic policy. In a monetary union, common central bank can perform well in the case of symmetric shocks while common central bank has no solution to the problem of asymmetric shocks. The reason behind this is that common central bank cannot stabilize output at the county level; it can only do this at the union level.

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[4] The ECU rate of currency i was defined as: $ECU_i = \sum_j a_j S_{ji}$, Where a_j is the amount of currency j in the basket; S_{ji} is the bilateral exchange rate.

[5] For detail, see Bank for International Settlements (2007)

On the other hand, the single currency should end currency instability in the participating countries. Because Euro would have the enhanced credibility of being used in a large currency zone, it would be more stable against speculation than individual currencies has been. An end to internal currency instability and a reduction of external currency instability would enable exporters to project future markets with greater certainty. This would unleash a greater potential for growth. Similarly, consumers would not have to change money when travelling and would encounter less red tape when transferring large sums of money across borders. A single currency would help that transactions pass smoothly without transaction costs. Likewise, businesses would no longer have to pay hedging costs, which they did in order to insure themselves against the threat of currency fluctuations. Businesses, which are involved in commercial transactions in different member states, would no longer have to face administrative costs of accounting for the changes of currencies, plus the time involved. Other than the economic reasons to join common monetary union, countries might adopt a common currency for political reasons.

2.2 Theoretical links between exchange rate volatility and Real Economy

An introduction of the common currency in the European region imposes the question of its contributions to stabilize exchange rates and their impacts on real economy. The argument that the elimination of the exchange risk will lead to an increase in economic growth can be made using the neoclassical growth model, and its extension to situations of dynamic economies of scale. This analysis featured prominently in the European Commission report 'One Market, One Money' (1990). According to this model, elimination of exchange risk reduces the systemic risk. This would have the effect of lowering the real interest rate. The reason is that in a less risky environment, investors would require a lower risk premium to make the same investment. In addition, when agents discount the future they are willing to use a lower discount rate. Due to this, there will be an accumulation of capital and an increase in the growth rate of GDP. Some of the various channels through which exchange rate volatility transmit to more economic growth are described below.

2.3.1 Trade

The relationship between the exchange rate volatility and international trade is highly explored and well established. According to Brodsky (1984), due to risk averse (or even risk neutral) behavior of commodity traders, higher exchange rate uncertainty may lead to a reduction in the volume of trade. The main idea is the demand of higher price by economic agents to cover their exposure to current risk. In turn, it would decrease the volume of trade. Other than the direct effect of exchange rate volatility on trade, there may be a more or less important indirect effect of exchange rate volatility on trade and hence on economic growth.

2.3.2 Foreign Direct Investment

Exchange rate volatility may also affect level of development of the country through its effects on foreign direct investment inflows. The main idea is that the higher exchange rate volatility increases uncertainty over the return of the investment. A potential investor will invest in foreign location only if the expected returns are high enough to cover for the currency risks. Thus, under high exchange rate volatility foreign direct investment will be lower. This can be counted as another channel through which negative impact of exchange rate volatility on economic growth can be traced out.

2.3.3 Currency Crises

It is argued that instability in big currencies can contribute to currency crises in small countries. The idea behind this is if big currency (dollar) had large and relatively rapid appreciation vis-à-vis other big currencies (i.e. Euro, Yen) then all the currencies that were pegged to the dollar also appreciated with respect to Euro and Yen. The result is the weakening of relative price competiveness of these currencies, thus contributing to a deterioration of their external accounts and may have eventually led to the currency crises. Thus exchange rate volatility is not the volatility itself, but a continuous change of one currency in certain direction adversely affecting the real economy.

2.3.4 Debt Servicing Costs

One of the main effects of exchange rate movements for developing countries refers to the external debt burden. As most of the developing countries are net debtors, hence changes in exchange rates may affect the real cost of servicing their debts. A strong appreciation of the dollar, for example, implies a higher cost of servicing an external debt. Thus high exchange rate fluctuations affect allocation of funds for development purpose. On the other hand, Frankel and Roubini (2001) find ambiguous impact of exchange rate variations because changes in all big currencies for developing countries are not in the same direction.

Summarizing, exchange rate changes may affect economic growth differently for different countries depending upon the channels through which the effects take place. Impact might also change when national currency is backed up with more than one country. Other than this, trade and foreign direct investment channels suggest that exchange rate volatility may decrease economic growth in the country. Moreover, the impact of exchange rate volatility through channels of currency crises and debt servicing costs is ambiguous depending upon the parity conditions. A detailed review of empirical studies regarding these relationships is presented in the next sub-section.

2.4 Empirical Studies regarding exchange rate volatility

A vast number of empirical studies are conducted to determine and evaluate the impacts of exchange rate volatility to various indicators of real economy. Empirical studies are concentrated most of the time on the selection of exchange rate systems i.e. fixed or flexible. Studies demonstrate a discrepancy in terms of their findings regarding the impacts of exchange rate volatility on indicators of real economy. Differences in studies take place because of differences in types of exchange rates, the time of analysis, the place of analysis, and the methodology used for analysis. The main intuition behind the difference in findings is that the increase in exchange rate volatility leads to uncertainty, which might have different impacts for different countries on both domestic and foreign investment decisions, trade, and other sources of economic growth. The studies have explored various channels through which exchange rate volatility linked (positively/negatively) with real economy.

Mainly, Kormendi and Meguire (1985), and Grier and Tullock (1989) are among the first who explore the relationship between volatility and growth empirically. Both report positive impact of standard deviation of GDP growth on its mean. Nevertheless, Ahmed (2009), being one of the last in literature so far investigates impact of exchange rate volatility on growth using quarterly data for Bangladesh trade with North America, Western Europe, Eastern Europe, SAARC, ASEAN, and Asia-Pecific regions. The study points out that the volatility of exchange rate has a negative and significant effect in the long run as well as in the short run. On the other hand, Ghosh et al. (2003) find weak evidence that exchange rate affects growth in a positive or negative way.

In the literature, Hooper and Kohlhagen (1978) are among the first ones who analyzed systematically the effects of exchange rate volatility on trade. In this study, exchange rate risk is measured by standard error of nominal exchange rate fluctuations. Any significant link could not be established by them, and inconsistent results regarding the impact of exchange rate volatility on international trade are being observed. Frankel and Rose (2002) using data for more than 200 countries suggest that belonging to a currency union triples trade with other currency union members. They also report that every one percent increase in a country's overall trade relative to GDP raises income per capita by at least one third of the percent. The hypothesis that the volatility of exchange rate decreases the volume of international trade is supported by Akhtar and Hilton (1984), Kenen and Rodrick (1986), Thursby and Thursby (1987), De Grauwe (1988), Pere and Steinherr (1989), Koray and Lastrapes (1989), and Arize (1995). No impact of the exchange rate volatility on trade is reported by Hooper and Kohlhagen (1978), Gotur (1985), Bailey et al.(1987), Asseery and Peel (1991), and Bacchetta and Wincoop (2000).

Another way to analyze the impact of real exchange rate volatility on the real economy is to check its impact on investment. The literature provides evidence that uncertainty decreases investment in the presence of adjustment costs. If the investment projects are irreversible then uncertain environment leads to delay in investment decisions by investors to obtain more information about the real exchange rates. This exerts negatively on economic performance. Campa and Goldberg (1993) report a negative impact of exchange rate volatility on investment. Similarly, Barlevy (2004) using AK models with concave investment function show that volatility of the exchange rate lowers growth through the volatility of investment.[6] On the other hand, using AK models Mendoza (1994), and Jones and Wilson (1989) show that high risk will increase growth for individuals having high degree of

[6] AK models are special form of the Solow growth model (α = 1), first time discussed by King and Rebelo (1990).

relative risk aversion. Aizenman (1992) also reports a positive relationship, whereas Campa and Goldberg (1995) find almost no impact between these variables.

Despite the existence of huge literature regarding exchange rate volatility few studies have investigated impact of exchange rate volatility on the real economy after the introduction of Euro in Eurozone. De Grauwe and Schnabl (2004) using a panel estimation for the period 1994-2002 find a significant impact of the exchange rate stability on low inflation as well as a highly significant impact of the exchange rate stability on real growth. Micco et al. (2003) reports that in its early years, the European Monetary Union has increased intra-EMU trade by up to 16%. Schnabl (2007) analyzes the impact of exchange rate stability at the periphery of the euro area. It identifies international trade, international capital flows, and macroeconomic stability as important transmission channels from exchange rate stability to more growth. By panel estimation, Schnabl (2007) establishes a negative relationship between the exchange rate volatility and economic growth for the countries in the economic catch-up process with open capital accounts. A clear gap between the impacts of exchange rate volatility on economic growth within new system can be observed in literature.

Other than these, there are various other channels that have been explored theoretically and empirically as the possible sources of building relationship between exchange rate volatility and economic growth. Keeping such relationships in mind a hypothesis is developed relating to the link between exchange rate volatility and economic growth after the introduction of common currency Euro. It is considered to be an appropriate time for such analysis because more and more countries are joining the group. In such state of affairs, the aim of the study is to find out:

1. Has the introduction of the common currency Euro decreased volatility in exchange rate for each European country as compared to the volatility they were facing before the introduction of Euro?
2. Has introduction of the Euro any effect on the relationship between exchange rate volatility and the real economic variables?
3. How does exchange rate volatility affect the real economy of the countries that are part of European Union but not the part of Eurozone?

3. Methodology and Data Description

This section provides detailed description of the methodology, which is employed to measure volatility in the exchange rates. Techniques to capture the effects of volatility on economic performance are presented in later subsections.

3.1.1 Unit Root Tests

One of the initial steps of the empirical analysis is to test for unit roots. For this reason, we employ Augmented Dickey Fuller (ADF) test, presented by Dickey and Fuller (1979), to check the stationarity of the growth rate of exchange rate. The current study also employs methods that are developed by Maddala and Wu (1999), and Choi (2005) to determine the level of integration of the macroeconomic variables of each group. Along with this Fisher-type test, we also use the IPS test developed by Im, Pesaran, and Shin (1997). However, both of these tests are based on the null hypothesis of unit root. The IPS test, the Fisher-ADF, and PP tests allow for individual unit root processes. These tests combine individual unit root tests to derive a panel-specific result.

3.1.2 Measurement of Volatility

In past, studies have used naive measures of volatility i.e. rolling variance of the series for the analysis of volatility structure of financial variables. However, Campbell et al. (1997, p.481) have argued that:

> "*it is both logically inconsistent and statistically inefficient to use volatility measures that are based on the assumption of constant volatility over some period when the resulting series moves through time*."

During the last more than two decades, another class of model, *Autoregressive Conditional Heteroscedasticity* (ARCH) and *Generalized Autoregressive Conditional Heteroscedastic*y (GARCH), has proved to be very successful in predicting the volatility changes. These kinds of the volatility models are more acceptable because of their capability to capture most stylized facts of volatility, i.e. leptokurtosis (fat tails) and volatility clustering (the tendency of large observations to be followed by other large observations and of small observations to be followed by other small observations).

In ARCH model, the conditional variance changes over time as a function of past squared deviations from the mean. As the extension of ARCH model, GARCH processes take changes in variance over time as a function of past squared deviations from the mean and past variances. Generalized Autoregressive Conditional Heteroscedasticity (GARCH) is another most popular class of models for volatility that was first time suggested by Engle (1982) and Bollerslev (1986).

In detail, standard GARCH models assume that positive and negative error terms have a systematic effect on the volatility. In other words, good and bad news have the same effect on the volatility of the model. In practice this assumption is frequently violated and it is observed that volatility increases more after bad news than after good news. This so called leverage effect is first time introduced by Black (1976). Precisely, *Exponential GARCH* (EGARCH) model that is proposed by Nelson (1991) incorporates the leverage effects while calculating volatility. Berument et al. (2001) and Kontonikas (2004) indicated that the EGARCH method is more powerful and more advantageous than other models for quantifying volatility. The EGARCH is preferred over other models because of the following reasons: First, as discussed above the EGARCH models capture asymmetry in the responsiveness of uncertainty to good and bad news; second, unlike GARCH, an EGARCH does not impose the non-negativity constraints on the parameters; Third, modeling uncertainty in logarithms form, reduces the effects of outliers on the estimation results.

Let, RER_{it} with $t = 1,2,3,\dots,T$, $i = 1,2,3,\dots,N$ denote the real bilateral exchange rate of country "i" in period "t".[7] This is the relative inflation adjusted exchange rate and is constructed by multiplying the nominal exchange rate with the ratio of consumer price indexes, e.g. real exchange rate of Germany can be calculated as:

$$RER_t^{GER} = \left[\frac{DM_t}{USD_t}\right] * \left[\frac{CPI_t^{US}}{CPI_t^{GER}}\right] \qquad \text{...(1)}$$

Where, DM_t / USD_t represents Deutsche-Mark per unit of US-Dollar, CPI_t^{US} / CPI_t^{GER} represents relative CPI in period "t". Moreover, monthly exchange rate returns R_{it}, for country i in period t, is calculated by the log-differences of the real exchange rates.

$$R_{it} = \ln\left(\frac{ER_{it}}{ER_{it-1}}\right) \qquad \text{... (2)}$$

Formally, *AR(k)-EGARCH(p,q)* model for returns of exchange rate can be expressed, like expressed by Wang (2010), as follows:

$$R_t = \alpha_o + \sum_{i=1}^{k} \alpha_i R_{t-i} + \varepsilon_t h_t^{1/2} \qquad \text{... (3)}$$

$$\varepsilon_t / \psi_{t-1} \sim N(0, h_t)$$

$$h_t = \exp\left[\omega + \sum_{i=1}^{p} \gamma_j \log h_{t-j} + \sum_{j=1}^{q} \rho_j \left|\frac{u_{t-j}}{\sqrt{h_{t-j}}}\right| + \sum_{m=1}^{r} \theta_m \frac{u_{t-m}}{\sqrt{h_{t-m}}}\right]$$

OR

$$\log(h_t) = \omega + \sum_{i=1}^{p} \gamma_j \log h_{t-j} + \sum_{j=1}^{q} \rho_j \left|\frac{u_{t-j}}{\sqrt{h_{t-j}}}\right| + \sum_{m=1}^{r} \theta_m \frac{u_{t-m}}{\sqrt{h_{t-m}}} \qquad \text{... (4)}$$

Where R_t is the exchange rate return, α_o is the mean exchange rate return conditional on information set at time $t-1(\psi_{t-1})$. Similar to original Nelson model, we assume that the ε_t follows a

[7] We used same methodology for the calculation of volatility in the nominal exchange rate. From onward in methodology section, exchange rate is used for both real exchange rate and nominal exchange rate unless it is mentioned.

Generalized Error Distribution (GED). Logarithm of the conditional variance (h_t) on the right hand side imply that the leverage effect is exponential, rather than quadratic, and that forecasts of the conditional variance are guaranteed to be nonnegative without imposing any restriction on the coefficients. The presence of leverage effects can be tested by the hypothesis $\theta_m < 0$. The impact is asymmetric if $\theta_m \neq 0$.

Modeling volatility of financial time series has been enriched by various types of ARCH-GARCH models. We employ *AR(k)-EGARCH(p,q)* model to describe the dynamics of the exchange rate volatility of each European country in the analysis separately. With the availability of more sophisticated measures of volatility, choice of order of autoregression in mean and variance equation becomes a more complicated part. In this paper we employ Schwarz Bayesian Information Criteria (SBIC) for the selection of the orders k, p , and q.

3.1.3 Real Exchange Rate volatility and Industrial Production

At the first step, a detailed graphical analysis of the real exchange rate volatility has been conducted to compare its movements across countries. Later to analyze the impact of real exchange rate volatility on the indicators of real economy of Eurozone before and after the introduction of Euro, present study takes the help from two-stage least squares (instrumental variable) regression using pooled data (Pooled IV/TSLS).

$$Y_{it} = \sum_{j=1}^{n} \beta_j X_{j,it} + \lambda_i VOLER_{it} + \nu_{it} \qquad \text{...} \quad (5)$$

Where Y_{it} represents growth rate of real economy, $X_{j,it}$ represents the list of " n " control variables, and $VOLER_{it}$ is the indicator of exchange rate volatility obtained from conditional variance by using *AR(k)-EGARCH(p,q)* models for each country. Here, λ_i indicates separate coefficients of the impact of exchange rate volatility on real economy for each country. Separate pooled regressions for two groups of countries before and after the introduction of Euro have been regressed.

3.2. Data Sources and Construction of Variables

Mainly, we have divided the analysis with respect to region and time. Countries are divided into two groups: Group A consists of countries that have adopted Euro as common currency on January 1999, while Group B consists of countries that have not adopted Euro as common currency on January 1999. In our sample, Group-A consist of Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherland, Portugal and Spain. On the other hand, Group-B consists of Denmark, Norway, Sweden and the United Kingdom. The impact of exchange rate volatility on the real economy is analyzed across two groups before and after the introduction of Euro.

To analyze the impact of exchange rate volatility on the real economy, before and after the introduction of Euro, study employs logarithm of industrial production index (LIPI) as an indicator of economic growth. Data of exchange rates of the European national currencies with US dollar before 1998 and exchange rate of the Euro with US dollar after 1998 is calculated using *AR(k)-EGARCH(p,q)* models separately. Both real and nominal exchange rates are used for the calculation of exchange rate volatility. Values of real and nominal exchange rate volatility for the countries that did not adopt common currency are also calculated using *AR(k)-EGARCH(p,q)* models in the similar way. Other explanatory variables (control variables), include indicator of inflation (consumer price index-CPI), indicator of government interest rates (government bond yield-LGBY), and an indicator of openness of the economy (logarithm of trade in US$-LTRA). Using the benefits of the same data source for all variables, monthly data for all the variables have been obtained from *International Financial Statistics* (IFS) from January 1980 to April 2009.

3.3 Descriptive statistics

Before going into the detailed analysis of the impacts of exchange rate volatility on real macroeconomic variables, before and after the introduction of Euro, a short summary of descriptive statistics regarding the variables of the real economy is presented in Table 1. First part of the columns shows descriptive statistics for the two groups of European countries for the period up to December 1998, while second part of columns shows descriptive statistics for the two groups of European countries for the period January 1999 to April 2009.

Table 1. Descriptive Statistics

		Jan. 1980 to Dec. 1998					Jan. 1999 April 2009				
Country		**Obs.**	**Mean**	**STD**	**Max.**	**Min.**	**Obs.**	**Mean**	**STD**	**Max.**	**Min.**
					Industrial Production						
Group A	AUS	228	1.74	0.07	1.91	1.59	122	4.56	0.14	4.55	4.84
	BEL	228	1.89	0.06	1.99	1.69	122	4.59	0.08	4.60	4.77
	FIN	228	1.72	0.09	1.94	1.44	122	4.58	0.13	4.59	4.86
	FRA	228	1.92	0.06	2.02	1.70	122	4.60	0.10	4.61	4.75
	GER	228	4.35	0.11	4.57	4.08	122	4.59	0.10	4.58	4.82
	IRE	228	1.37	0.19	1.82	1.05	122	4.54	0.17	4.57	4.85
	ITA	228	1.93	0.10	2.04	1.52	122	4.61	0.18	4.66	4.76
	LUX	228	1.77	0.08	1.90	1.53	122	4.52	0.12	4.53	4.70
	NET	228	1.88	0.06	1.98	1.72	122	4.59	0.10	4.58	4.80
	POR	228	1.86	0.09	2.02	1.55	123	4.62	0.09	4.65	4.75
	SPA	228	1.87	0.08	2.00	1.57	123	4.59	0.12	4.62	4.77
Group B	DEN	228	4.26	0.19	4.68	3.66	122	4.60	0.11	4.62	4.78
	NOR	228	1.84	0.12	2.05	1.44	122	4.61	0.06	4.61	4.74
	SWE	228	1.85	0.10	1.98	1.39	122	4.57	0.14	4.58	4.78
	UK	228	1.94	0.05	2.05	1.81	122	4.61	0.05	4.61	4.76
					Growth rate of Trade						
Group A	AUS	227	0.23	5.12	13.84	-11.35	121	0.57	11.14	27.50	-26.85
	BEL	71	0.29	5.16	12.54	-11.74	121	0.57	10.47	29.53	-21.83
	FIN	227	0.18	5.58	21.64	-40.54	122	0.47	8.75	20.44	-23.59
	FRA	227	0.18	5.76	15.80	-16.05	120	0.42	12.10	33.59	-34.24
	GER	227	0.19	4.28	9.66	-12.25	122	0.63	6.88	16.02	-18.17
	IRE	227	0.34	4.52	12.57	-10.90	121	0.35	9.67	23.76	-23.50
	ITA	227	0.19	9.08	24.60	-26.43	120	0.45	18.28	47.01	-55.42
	LUX	46	0.27	5.23	13.23	-12.08	120	0.45	10.57	24.01	-31.92
	NET	227	0.15	3.92	10.69	-8.54	122	0.60	7.86	19.04	-17.48
	POR	227	0.29	7.51	20.07	-23.74	121	0.45	13.79	32.97	-40.51
	SPA	227	0.33	8.03	20.31	-25.91	121	0.65	12.74	34.32	-33.83
Group B	DEN	227	0.47	11.37	25.29	-31.12	122	0.43	9.29	21.87	-22.40
	NOR	227	0.14	4.77	13.07	-22.61	122	0.73	8.34	21.16	-18.55
	SWE	227	0.16	5.58	18.91	-16.09	121	0.35	10.43	23.03	-24.17
	UK	227	0.18	1.46	4.96	-4.52	122	0.23	4.05	10.53	-14.16
					Government Bond Yield						
Group A	AUS	228	0.88	0.08	1.06	0.61	124	1.47	0.15	1.75	1.13
	BEL	228	0.95	0.12	1.14	0.61	124	1.49	0.15	1.76	1.14
	FIN	228	0.96	0.14	1.14	0.61	124	1.47	0.15	1.75	1.12
	FRA	134	0.96	0.15	1.23	0.59	124	1.46	0.14	1.73	1.14
	GER	228	0.85	0.08	1.02	0.59	124	1.43	0.15	1.71	1.11
	IRE	228	1.00	0.15	1.28	0.60	124	1.49	0.16	1.76	1.11
	ITA	228	1.08	0.15	1.33	0.60	124	1.51	0.14	1.75	1.19
	LUX	228	0.89	0.09	1.04	0.61	123	1.48	0.15	1.74	1.12
	NET	228	0.87	0.10	1.09	0.60	124	1.46	0.15	1.74	1.14
	POR	228	1.12	0.17	1.36	0.61	124	1.50	0.15	1.76	1.16
	SPA	228	1.07	0.14	1.26	0.61	124	1.48	0.15	1.75	1.13
Group B	DEN	228	2.33	0.38	3.08	1.45	124	1.49	0.16	1.77	1.12
	NOR	228	0.98	0.15	1.14	0.67	122	1.55	0.25	1.94	1.06
	SWE	228	1.01	0.11	1.14	0.63	124	1.48	0.18	1.78	0.98
	UK	228	0.99	0.11	1.20	0.66	124	1.56	0.12	1.76	1.10

Industrial Production is presented as the logarithmic values of the Industrial Production Index, Growth rate of Trade is taken as the logarithmic difference of the Trade taken in US$ multiplied by 100, Government Bond Yield is presented as the logarithmic value of the Government Bond Yield.

The table shows that the mean of the industrial production increased in all European countries which either adopted Euro or not after the introduction of Euro. Moreover, standard deviation of the growth rate of industrial production also increased in the second part except for Germany, Ireland, Denmark and Norway where it slightly decreased. One thing to note is that growth rate of industrial production for Germany and Denmark is remarkably high before January 1999 as compared to other countries, while the differences become low after the introduction of Euro. Similarly, growth rate of trade follow similar trends after the introduction of Euro for almost all the countries. The average growth of trade is doubled for almost all countries except for Ireland, Denmark and the United Kingdom. In case of Denmark, it decreased during the second sub-period of analysis. The values of standard deviations indicate increase in the variation of growth rate of trade for all European countries after the introduction of common currency. The gap between the maximum and minimum values almost doubled in the second sub-period for all the countries.

Additionally, the arithmetic means of logarithmic values of government bond yield in two time periods indicate that government bond yield increased in the second sub-period for all countries except for Denmark. Before the introduction of Euro, the Denmark has enjoyed higher level of government bond yield. The standard deviation is higher in second sub-period for both types of the countries which either have adopted common currency or not. The countries that have adopted common currency faced same or lower level of deviations in government bond yield after the introduction of Euro as compared to the countries that have not adopted Euro as national currency. The United Kingdom is also an exception because it faced low level of variations in government bond yield in the second sub period.

Concluding this section, we can say that common currency has not helped to stabilize indicators of real economy. However, how variations in the real exchange rate responded to the introduction of Euro and how the real economy corresponded to changes in the variations of the real exchange rate still need to be explored with some detail.

4. Results and Discussion

In the present section, we will discuss results based on methodology presented in section 3 and using data of real macroeconomic variables from International Financial Statistics. Before going into the regression analysis, detailed graphical analysis of exchange rate volatility of each country is presented in the following sub-section.

4.1. Exchange Rate Volatility

The volatility of exchange rate is calculated on the basis of growth rate of the nominal as well as the real exchange rates. We employ *AR(k)-EGARCH(p,q)* models for two sub-periods before and after the introduction of the common currency for each country.[8] The volatility of exchange rate before January 1999 is calculated on the basis of exchange rate of national currencies with US-Dollar ($) while after January 1999 it is calculated on the basis of exchange rate of Euro with US$. Hence, any difference in volatility of nominal exchange rate is due to variation in nominal exchange rates, while any difference in volatility of real exchange rate across countries after January 1999 is due to the differences in nominal exchange rate and relative CPI. Both types of exchange rate volatility, for 11 European countries that switched to Euro as their common currency (Group-A) and 4 European countries that did not adopt Euro as their national currency (Group-B), are presented graphically in Figure 1.

Both, volatility in real exchange rate and volatility in nominal exchange rate show similar trends in all the countries before and after the introduction of Euro. The countries that have adopted common currency faced high level of volatility at the time of joining common currency but it stabilized in later periods. The countries that have not adopted common currency also faced high level of volatility in the beginning of 1999 but their intensity of shocks was less. Moreover, these countries faced higher number of peaks in exchange rate volatility after the introduction of Euro. This indicates exchange rate volatility of the countries that have not adopted common currency is more unstable after the introduction of Euro.

An overview of the exchange rate volatility of countries that have adopted common currency and countries that have not adopted common currency provide fruitful information. Countries that have adopted Euro as national currency faced same level of nominal exchange rate volatility after 1999. However, real exchange volatility differs across countries because of the variations in the inflation. Countries that have adopted common currency faced smaller and long lasting peaks in exchange rate volatility before the introduction of Euro. High peaks in exchange rate volatility for short periods can be observed for the countries that have adopted common currency. Absence of long lasting peaks in volatility of exchange rate after the introduction of common currency indicates that

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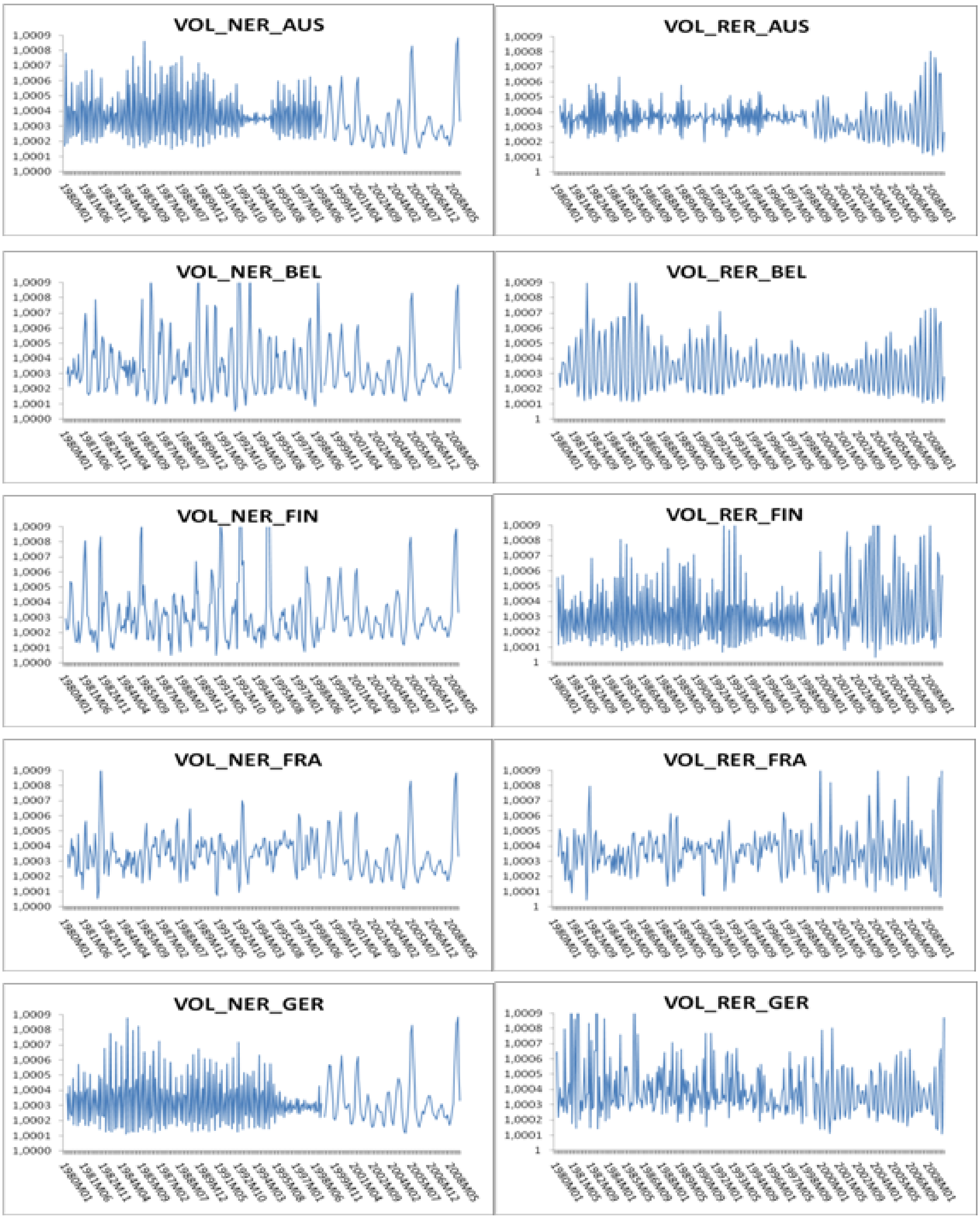
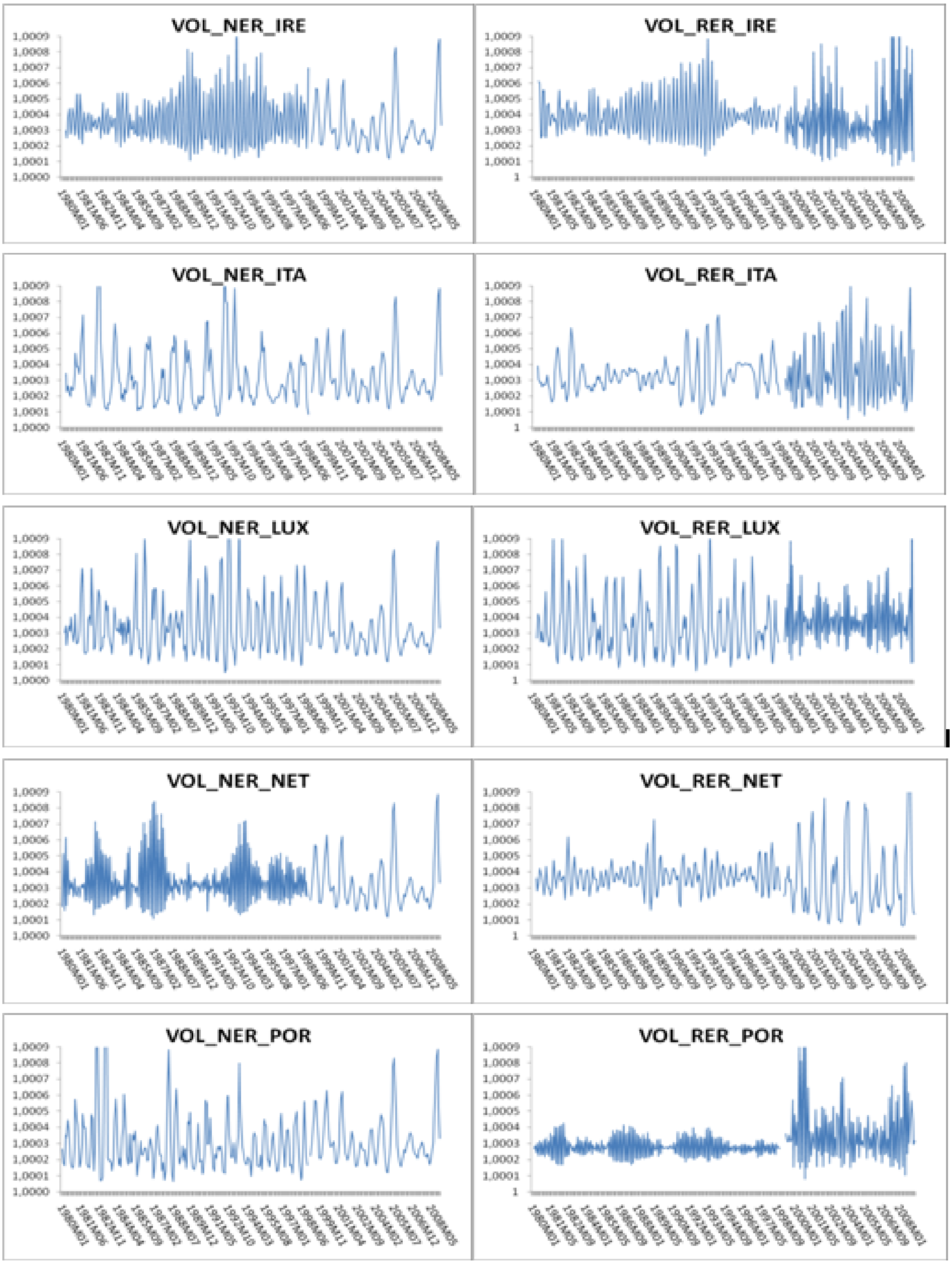
[8] Specification of AR(k)-EGARCH(p,q) models along with coefficients and significance is presented in Appendix A.

Euro helped these countries to stabilize shocks more quickly. Countries also faced high level of exchange rate volatility in the end of 2008 and in the beginning of 2009.

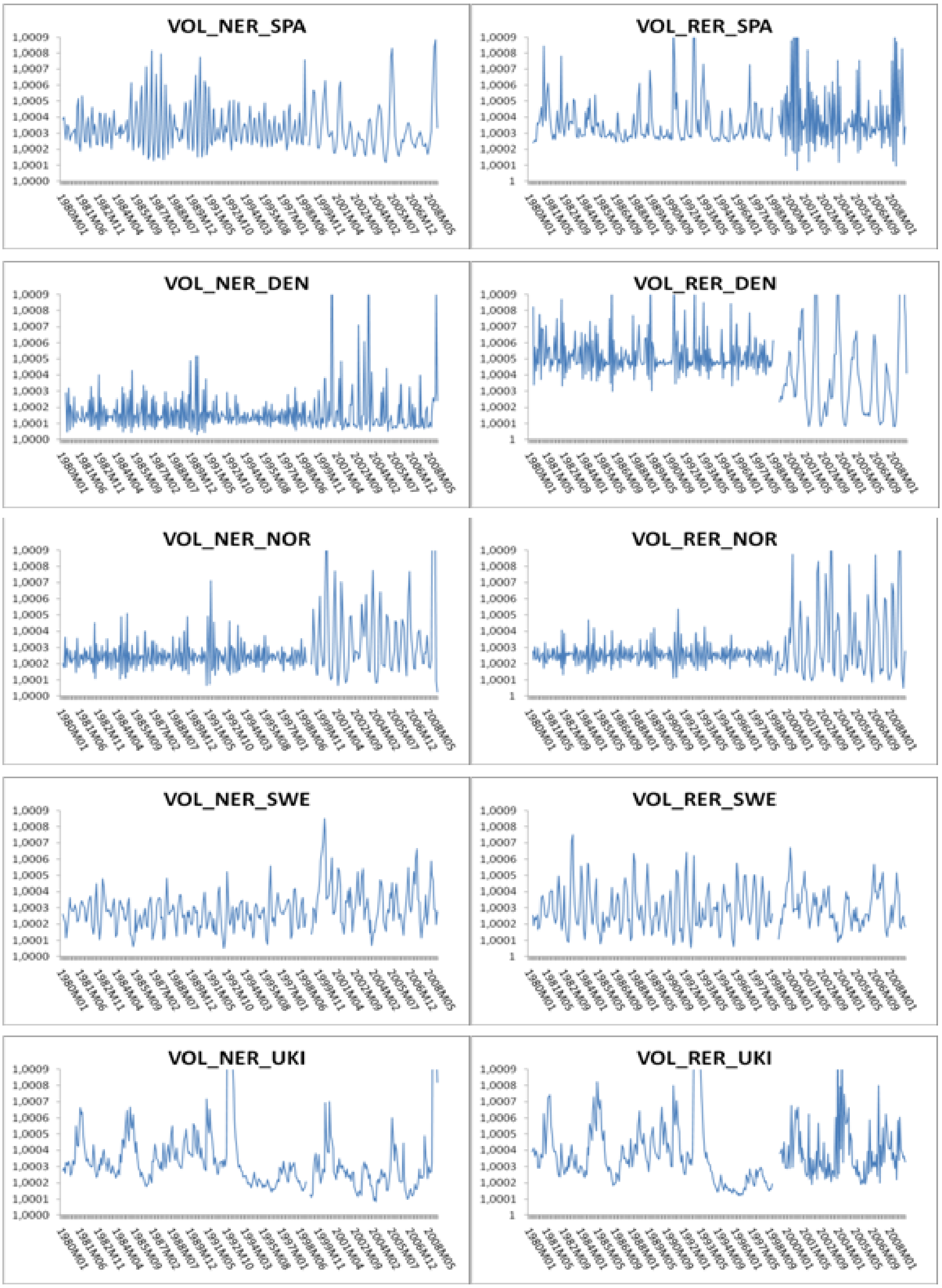
Figure 1. Exchange rate volatility bases on AR(k)-EGARCH(p,q) models



Continued Figure 1.



Continued Figure 1.

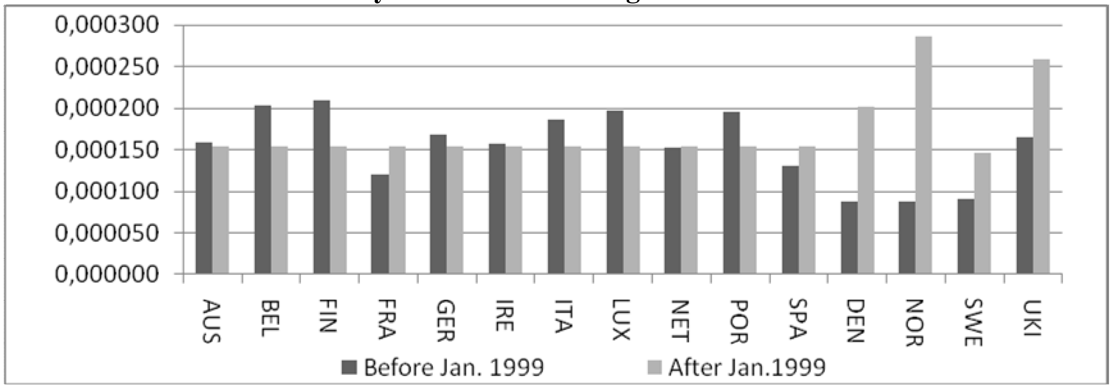


On the other hand, countries that have not adopted common currency, responded differently in their exchange rate volatility behaviours after the introduction of Euro. Countries that have not adopted common currency showed more stable exchange rate volatility before the introduction of common currency. High and frequent peaks in exchange rate volatility after the introduction of Euro indicate that exchange rate become more volatile in these countries. Norway shows more peaks in exchange rate volatility than other countries.

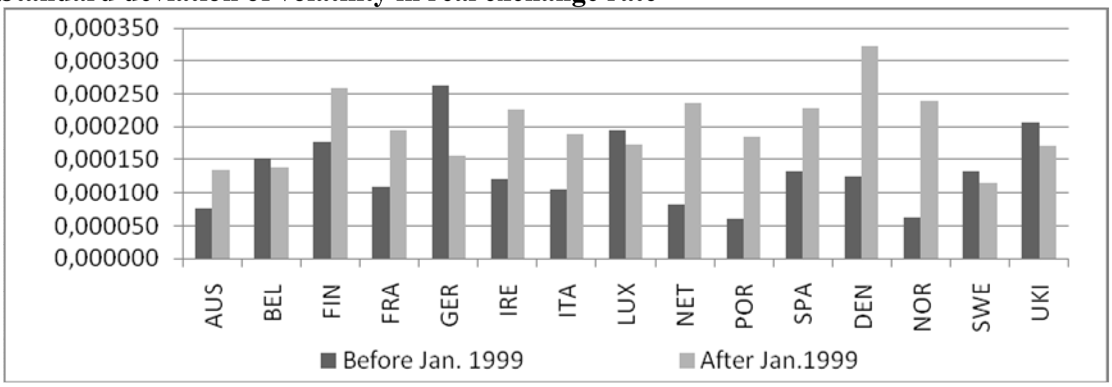
A similar pattern can be observed analysing standard deviations of exchange rate volatility before and after the introduction of common currency for these countries. Figure 2 (a, b) presents standard deviation of nominal and real exchange rate volatility of these countries. The standard deviation of nominal exchange rate volatility of Denmark, Norway and Sweden are lower as compared to other countries before the introduction of common currency. The standard deviation of volatility of nominal exchange rate increased for three countries (France, Netherlands and Spain) out of eleven. Clear and high increase in variations of nominal exchange rate volatility for all the countries that have not adopted the Euro can be observed after the introduction of common currency.

Figure 2. Variation in Volatility of exchange rate

(a) Standard deviation of volatility in nominal exchange rate



(b) Standard deviation of volatility in real exchange rate



The standard deviation of real exchange rate volatility shows a little bit different picture as compared to standard deviation of nominal exchange rate volatility. This is because of the differences in the inflation that countries faced before and after the introduction of common currency. Out of 11 countries that adopted common currency, 8 countries show increase in standard deviation of real exchange rate volatility after adopting common currency. Out of 4 countries that did not adopt common currency, 2 are able to reduce variations in real exchange rate volatility. On the basis of real exchange rate volatility, it can be seen that Germany is able to reduce more standard deviation of real exchange rate volatility as compared to other countries.

Summarizing the behaviour of nominal and real exchange rate volatilities, we can say: First, countries that have adopted common currency appeared with the same level of nominal exchange rate while different level of the real exchange rate volatility, after the introduction of common currency indicating the existence of the differences in relative inflation across countries; Second, exchange rate volatility appears to be more volatile at the time of introduction of Euro for most of the countries; Third, overall nominal exchange rate volatility show more volatile behaviour after the introduction of Euro for the countries that have not adopted common currency, while countries that have adopted common currency are able to decrease it; and last, only Belgium, Germany, Luxemburg, Sweden, and the United Kingdom are able to reduce standard deviation of the real exchange rate volatility after the introduction of the common currency. Despite all these, we are unable to identify sources and channels through which differences in volatility patrons across countries can be explained. Further research in the area is required.

4.2. Unit Root tests

As the common way of analyzing, the first step is to check for the unit roots in the series. For this reason, we have employed Augmented Dickey Fuller (ADF) tests to check the stationarity of the growth rate of exchange rate. Growth rate of exchange rate is integrated of order zero in case of all subsamples. Stationary time series data of growth rate of real exchange rate is used for the estimation of conditional variances in EGARCH models. Given the stationarity of the EGARCH model, constructed conditional variance obtained from the model will also be stationary.[9] Other than this, panel unit root tests are employed to check the stationarity of the industrial production. Results of the ADF tests and panel unit root tests are presented in Table 2. Growth rate of industrial production also appears to be integrated of order zero. On the basis of this, variables are used in levels for the regression analysis.

4.3. Impact of Exchange Rate Volatility on Industrial Production

In this section, we have used methodology regarding two-stage least square with pooled data to check the impact of exchange rate volatility on industrial production. Differences in the direction and level of impacts are analyzed across countries. Differences in the impacts of the exchange rate volatility before and after the introduction of common currency for the countries that have adopted Euro (Group-A) and for the countries that have not adopted Euro (Group-B) are also analyzed. Analysis is performed both on the basis of real and nominal exchange rates volatilities.

The results based on the regressions using two-stage least square with pooled data are presented in Table 3. The volatility in the nominal exchange rate, trade, and government bond yield are used as explanatory variables in the regressions while growth rate of industrial production index is kept on the left hand side. Separate coefficients of volatility in nominal exchange rate of each country are estimated. All the variables report signs according to the theory.

Countries that have adopted common currency show results similar to the theory. The coefficient of logarithmic value of trade indicates that trade is beneficial for growth rate of industrial production for both groups of countries. Similarly, coefficients of government bond yield show positive effect on the industrial production growth indicating that rise in bond yield precede an economic upturn. In the light of the regression results, we find negative and significant coefficients of volatility in nominal exchange rate for each country. This indicates that an increase in the nominal exchange rate volatility will generate an extra risk that will hamper industrial production. Furthermore, per unit negative effect of the nominal exchange rate volatility is higher in case of Germany. On the other hand, Portugal’s industrial production is least negatively affected by an increase in volatility of nominal exchange rate.

The signs and significance of explanatory variables are not changed across two groups of countries (Group A and Group-B). Similar to Group-A, trade and government bond yield are positively related with industrial production in regressions of Group-B. The level of impacts of trade and government bond yield of Group-A are lower than that of Group-B. Similarly, all the countries of Group-B find negative impact of volatility in nominal exchange rate on industrial production. Moreover, in case of Denmark, industrial production is most negatively affected by changes in volatility of nominal exchange rate as compared to other countries of Group-B. On the other hand, Norway’s industrial production is negatively less affected by volatility in exchange rate as compared to other countries of Group-B. The negative impact of volatility in exchange rate on industrial production is higher for all countries of Group-A as compared to the negative impact of volatility in nominal exchange rate of Group-B, except for Denmark where it is higher than the countries of Group-A.

[9] As volatility of nominal (real) exchange rate is also integrated of order zero, hence it indicates no co-integration among industrial production and nominal (real) exchange rate volatility.

Table 2. Results from Unit root tests

Country	Individual Unit Root Test (ADF-Test)			
	NER		RER	
	1980 to 1998	1999 to 2009	1980 to 1998	1999 to 2009
AUS	-10.82***	-8.74***	-9.87***	-9.63***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
BEL	-10.57***	-8.74***	-3.44***	-8.09***
	[0.0000]	[0.0000]	[0.0107]	[0.0000]
FIN	-10.35***	-8.74***	-8.40***	-9.25***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
FRA	-10.95***	-8.74***	-5.92***	-7.18***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
GER	-10.86***	-8.74***	-9.80***	-10.35***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
IRE	-11.81***	-8.74***	-2.94*	-7.27***
	[0.0000]	[0.0000]	[0.0566]	[0.0000]
ITA	-10.57***	-8.74***	-10.71***	-7.16***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NET	-10.62***	-8.74***	-3.59***	-10.26***
	[0.0000]	[0.0000]	[0.0067]	[0.0000]
POR	-10.21***	-8.74***	-11.89***	-8.25***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
SPA	-10.31***	-8.74***	-11.87***	-7.21***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
DEN	-14.36***	-10.78***	-14.41***	-10.99***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
NOR	-10.05***	-7.90***	-5.10***	-8.94***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
SWE	-9.47***	-7.49***	-12.04***	-14.02***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
UKI	-10.91***	-8.98***	-11.69***	-11.11***
	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Panel Unit Root Test for LIPI				
		Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
Group A	1980 to 1999	-3.29***	77.93***	523.65***
		[0.0000]	[0.0000]	[0.0000]
	1999 to 2009	-7.12***	116.01***	453.89***
		[0.0000]	[0.0000]	[0.0000]
Group B	1980 to 1999	-13.18***	177.25***	183.49***
		[0.0000]	[0.0000]	[0.0000]
	1999 to 2009	-4.51***	38.22***	193.09***
		[0.0000]	[0.0000]	[0.0000]

(a) Values in parentheses are P-values.
(b) LIPI-Logarithm of Industrial Production Index
(c) Group-A consist of 11 countries that adopted Euro while Group-B consist of 4 countries that did not adopted Euro.
(d) ***,**,* significant at: 1%, 5%, 10% respectively

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Table 3. Impact of exchange rate volatility (Nominal) on industrial production

$$Y_{it} = cLTRA_{it} + cLGBY_{it} + c_i VOLner_{it} + \varepsilon_{it}$$

Variables	Before 1998		After 1998	
	Group A	Group B	Group A	Group B
LTRA	1.273 (10.86)***	0.831 (9.72)***	0.064 (4.81)***	0.098 (3.42)***
LGBY	0.059 (10.43)***	0.052 (9.39)***	0.082 (3.22)***	0.020 (2.30)***
VOL_NER_AUS	-5.225 (-10.85)***		-0.743 (-4.74)***	
VOL_NER_BEL	-5.998 (-10.85)***		-0.810 (-4.76)***	
VOL_NER_FIN	-5.203 (-10.85)***		-0.704 (-4.73)***	
VOL_NER_FRA	-6.246 (-10.85)***		-0.835 (-4.76)***	
VOL_NER_GER	-6.576 (-10.85)***		-0.872 (-4.77)***	
VOL_NER_IRE	-5.311 (-10.81)***		-0.727 (-4.72)***	
VOL_NER_ITA	-6.292 (-10.85)***		-0.826 (-4.73)***	
VOL_NER_NET	-5.903 (-10.85)***		-0.811 (-4.76)***	
VOL_NER_POR	-5.119 (-10.84)***		-0.694 (-4.74)***	
VOL_NER_SPA	-5.741 (-10.85)***		-0.790 (-4.75)***	
VOL_NER_DEN		-9.215 (-9.73)***		-1.183 (-3.41)***
VOL_NER_NOR		-3.526 (-9.70)***		-1.006 (-3.40)***
VOL_NER_SWE		-3.768 (-9.70)***		-1.044 (-3.41)***
VOL_NER_UKI		-4.192 (-9.71)***		-1.181 (-3.41)***
Cross sections	10	4	10	4
Number of Observations	2005	901	1199	475

a) Group A consists of countries that have adopted common currency on January 1999 while Group-B consists of countries that did not adopted common currency on January 1999.
b) Luxembourg is dropped from the analysis because of unavailability of data for Industrial Production.
c) LTRA: Logarithmic value of the trade, LGBY: Logarithmic value of Government Bond yield, VOL_NER: Volatility of Nominal Exchange Rate.
d) ***,**,* significant at: 1%, 5%, 10% respectively.

Table 4. Impact of exchange rate volatility (real) on industrial production

$$Y_{it} = cLTRA_{it} + cLGBY_{it} + c_i VOLrer_{it} + \varepsilon_{it}$$

Variables	Before 1998		After 1998	
	Group A	Group B	Group A	Group B
LTRA	1.298 (10.79)***	0.840 (9.71)***	0.073 (5.19)***	0.098 (3.37)***
LGBY	0.060 (10.37)***	0.053 (9.42)***	0.095 (3.60)***	0.020 (2.26)***
VOL_RER_AUS	-5.327 (-10.78)***		-0.844 (-5.13)***	
VOL_RER_BEL	-6.111 (-10.78)***		-0.920 (-5.15)***	
VOL_RER_FIN	-5.300 (-10.78)***		-0.801 (-5.13)***	
VOL_RER_FRA	-6.363 (-10.78)***		-0.947 (-5.15)***	
VOL_RER_GER	-6.700 (-10.78)***		-0.989 (-5.16)***	
VOL_RER_IRE	-5.412 (-10.75)***		-0.826 (-5.11)***	
VOL_RER_ITA	-6.410 (-10.78)***		-0.938 (-5.11)***	
VOL_RER_NET	-6.013 (-10.79)***		-0.920 (-5.15)***	
VOL_RER_POR	-5.215 (-10.77)***		-0.787 (-5.13)***	
VOL_RER_SPA	-5.849 (-10.78)***		-0.898 (-5.14)***	
VOL_RER_DEN		-9.317 (-9.72)***		-1.186 (-3.36)***
VOL_RER_NOR		-3.570 (-9.69)***		-1.007 (-3.35)***
VOL_RER_SWE		-3.815 (-9.69)***		-1.046 (-3.35)***
VOL_RER_UKI		-4.242 (-9.70)***		-1.183 (3.36)***
Cross sections	10	4	10	4
Number of Observations	1997	897	1174	470

a) Group A consists of countries that have adopted common currency on January 1999 while Group-B consists of countries that did not adopted common currency on January 1999.
b) Luxembourg is dropped from the analysis because of unavailability of data for Industrial Production.
c) LTRA: Logarithmic value of the trade, LGBY: Logarithmic value of Government Bond yield, VOL_NER: Volatility of Nominal Exchange Rate.
d) ***,**,* significant at: 1%, 5%, 10% respectively.

Results of the regression analysis for both the groups, using data after the introduction of Euro, provide interesting findings. Again, trade and government bond yield are positively related with industrial production for both groups of the countries. Similar to before the introduction of common currency, in the second sub-sample, volatility in nominal exchange rate is negatively related with industrial production for both groups of the countries. However, intensity of the negative impact of the exchange rate volatility on industrial production decreased numerously after the introduction of Euro for both groups of countries. Among the countries of Group-A, still Germany has higher negative impact and Portugal has lowest negative impact of the volatility in exchange rate. On the other hand, among the countries of Group-B, Denmark has highest negative impact and Norway has lowest negative impact of exchange rate volatility on industrial production.

Comparing results of each country across two sub-samples with respect to time (before and after the introduction of common currency), provides interesting feedback for the benefits of common currency. In short, per unit positive impact of trade has decreased after the introduction of Euro for both groups of countries. The positive impact of GBY increased for Group-A while it decreased for Group-B. Moreover, the negative impact of the volatility in nominal exchange rate decreased after the introduction of Euro for each country. Interestingly, intensity of the negative impact was higher for Denmark before the introduction of Euro, while it become higher for all the countries of Group-B as compared to countries of Group-A in the second sub-sample. This indicates that the common currency helps each country of the European Union, whether if adopted common currency or not, to decrease the negative impact of the volatility in nominal exchange rates on industrial production but its reduction in impact is higher for the countries that adopted common currency.

Furthermore, results based on the real exchange rate volatility for both groups of countries are presented in Table 4. Again, results show similar trends for all the variables of both groups of countries. A positive impact of trade and government bond yield on industrial production is observed for all the countries. The volatility in real exchange rate is negatively related to the industrial production before and after the existence of Euro. The negative impact of the real exchange rate volatility on industrial production remained higher for the countries that have not adopted common currency after its introduction.

Summarizing current section, on the basis of coefficients of regression, trade contributes less for the countries that have adopted the common currency as well as for the countries that have not adopted the common currency. Moreover, Level of positive impact of government bond yield increased for Group-A while its intensity decreased for Group-B. Coefficients of the critical variable (volatility of nominal exchange rate and volatility of real exchange rate) show negative effect on the industrial production for both groups of countries. The coefficients of the exchange rate volatility are lower after the introduction of common currency indicating common currency has helped to decrease negative impact of the exchange rate volatility. Furthermore, Norway, Sweden, and United Kingdom are facing lower level of negative impact as compare to the countries of Group-A before the introduction of common currency. However, they have started facing higher level of negative impact as compared to countries of Group-A after the introduction of Euro.

5. Conclusion

The impact of exchange rate volatility on real economy appears to be more important because of changing policies and world scenario. The introduction of Euro provides new base for research and new questions need to be answered: Did introduction of Euro help to decrease volatility of the exchange rate for the European countries; Did the exchange rate volatility faced by different countries have similar impacts on the industrial production; Did exchange rate volatility have similar impacts for the countries which are part of Europe but have not adopted the common currency. This study employs monthly data from January 1980 to February 2009 for the analysis. Furthermore, we split the period of analysis to before and after the introduction of Euro.

Initial graphical and descriptive analysis indicates that members of European Union that have adopted the common currency face mixed evidence of volatility in exchange rate. Most of the countries that have adopted common currency are able to decrease variations in the volatility of the nominal exchange rate after the introduction of Euro. An increase in the standard deviation of the volatility of nominal exchange rate after the introduction of Euro is found for all countries that have not adopted common currency. On the basis of the real exchange rate, ratio of the countries that faced an increase in the standard deviation of volatility in the real exchange rate indicates the existence of huge variation in the inflation across two groups of countries. Moreover, we can conclude that due to un-availability of strong support for currency, countries that did not adopt common currency face more variations in the volatility of exchange rate in the second sub-period.

Pooled data regressions show that trade started contributing less effectively to the industrial production for the countries that have adopted common currency as well as for the countries that have not adopted it. On the other hand, intensity of per unit positive impact of government bond yield is increased for the countries that have adopted common currency while it is decreased for the countries that have not adopted the common currency. The negative impact of the nominal exchange rate volatility is decreased for both types of the countries after the introduction of common currency. All countries of the analysis are also facing reduction in the impact of real exchange rate volatility on the industrial production. Moreover, Denmark, Norway, Sweden and United Kingdom face higher negative coefficients of exchange rate volatility as compared to the countries of Group-A after the introduction of Euro. Among these countries that have adopted common currency, Germany faces higher level of negative impact of the exchange rate volatility before and after the introduction of Euro. On the other hand, among the countries that have not adopted Euro as common currency, Denmark faces higher negative impact of the exchange rate volatility before and after the introduction of common currency.

We can conclude on the basis of available findings that overall countries enjoy more benefits after adopting the common currency even if they also find an increase in the real exchange rate volatility. It can also be concluded that the basket of fruit is not same for every country that have adopted common currency.

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Appendix A

Appendix A-I: Specification of AR(k)-EGARCH(p,q) models using Nominal Exchange Rate data before 1998

$$R_t = \alpha_o + \sum_{i=1}^{k} \alpha_i R_{t-i} + \varepsilon_t h_t^{1/2} \ , \ \varepsilon_t / \psi_{t-1} \sim N(0, h_t) \ , \ h_t = \exp\left[\omega + \sum_{i=1}^{p} \gamma_j \log h_{t-j} + \sum_{j=1}^{q} \rho_j \left| \frac{u_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{m=1}^{r} \theta_m \frac{u_{t-m}}{\sqrt{h_{t-m}}} \right]$$

Coefficients	AUS	BEL	FIN	FRA	GER	IRE	ITA	LUX	NET	POR	SPA	DEN	NOR	SWE	UKI
								Mean Equation							
α_o	0.001	0.002***	0.001	0.002	-0.001	0.001	0.002***	0.002***	-0.001	0.002	0.003***	0.002	0.003***	0.002	0.001
α_1	0.349***	0.331***	0.388***	0.314***	0.326***	0.257***	0.398***	0.331***	0.281***	0.299***	0.474***		0.423***	0.427***	0.302***
α_2		-0.166***	-0.166***		-0.140***		-0.163***	-0.166***			-0.128**	0.144***	-0.190***	-0.122**	-0.154**
α_3		0.109***		0.118**	0.061		0.166***	0.109***				0.124**			
α_4				0.060		-0.082	0.155***					0.111***			
								Variance Equation							
ω	-25.18***	-4.02***	-2.05***	-5.98***	-26.69***	-16.32***	-1.07***	-4.02***	-18.28***	-3.78***	-12.41***	-29.34***	-20.16***	-5.23***	-1.09
ρ_1	-0.094	-0.444***	-0.480***	-0.433**	0.090	-0.028	-0.353***	-0.444***	-0.104	-0.417***	0.007	0.366***	-0.279**	-0.330**	0.283***
ρ_2		0.504***	0.698***		0.142**		0.392***	0.504***	-0.185	0.483***	0.277**	0.353***			
θ_1	-0.017	0.051**	0.019	-0.121	-0.031	0.111**	0.061***	0.051**	-0.070***	0.114***	-0.086**	0.057**	-0.099	0.192***	0.057
γ_1	-1.527***	1.310***	1.324***	0.602**	-1.576***	-0.271***	1.733***	1.310***	-1.250***	1.324***	0.287***	-1.669***	-1.060***	0.834***	0.881***
γ_2	-0.949***	-0.848***	-0.575***	-0.467***	-0.985***	-0.963***	-0.872***	-0.848***	-0.261	-0.815***	-0.944***	-0.844***	-0.597**	-0.553**	
GED PARAMETER	1.952***	2.901***	1.526***	1.631***	2.487***	1.631***	2.098***	2.901***	2.106***	2.212***	1.985***	2.124***	1.853***	1.454***	1.470***
AR(k)-EGARCH(p,q)	AR(1)-EGARCH (2,1)	AR(3)-EGARCH (2,2)	AR(2)-EGARCH (2,2)	AR(4)-EGARCH (2,1)	AR(3)-EGARCH (2,2)	AR(4)-EGARCH (2,1)	AR(4)-EGARCH (2,2)	AR(3)-EGARCH (2,2)	AR(1)-EGARCH (2,2)	AR(1)-EGARCH (2,2)	AR(2)-EGARCH (2,2)	AR(4)-EGARCH (2,2)	AR(2)-EGARCH (2,1)	AR(2)-EGARCH (2,1)	AR(2)-EGARCH (1,1)

a) AUS-Austria, BEL-Belgium, FIN-Finland, FRA-France, GER-Germany, IRE-Ireland, ITA-Italy, LUX-Luxembourg, NET-Netherlands, POR-Portugal, SPA-Spain, DEN-Denmark, NOR-Norway, SWE-Sweden, UKI-United Kingdom.
b) ***,**,* significant at: 1%, 5%, 10% respectively.

Appendix A-II: Specification of AR(k)-EGARCH(p,q) models using Nominal Exchange Rate data after 1998

$$R_t = \alpha_o + \sum_{i=1}^{k} \alpha_i R_{t-i} + \varepsilon_t h_t^{1/2} \ , \ \varepsilon_t / \psi_{t-1} \sim N(0, h_t) \ , \ h_t = \exp\left[\omega + \sum_{i=1}^{p} \gamma_j \log h_{t-j} + \sum_{j=1}^{q} \rho_j \left| \frac{u_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{m=1}^{r} \theta_m \frac{u_{t-m}}{\sqrt{h_{t-m}}} \right]$$

Coefficients	DEN	NOR	SWE	UKI	Europe
Mean Equation					
α_o	-0.001	0.000	0.001	0.001	-0.001
α_1		0.336***	0.339***	0.302***	0.214**
α_2	-0.131			-0.154**	
α_3	0.077				
α_4		-0.137**	0.201***		
Variance Equation					
ω	-1.084	-5.163***	-1.094***	-1.092	-1.926***
ρ_1	0.365	0.439***	-0.486***	0.283*	-0.030
ρ_2	-0.357				
θ_1	0.148	0.125**	0.204**	0.057	0.115*
γ_1	1.380**	1.242***	0.799***	0.881***	1.632***
γ_2	-0.523	-0.885***			-0.894***
GED PARAMETER	1.425***	3.721**	2.498***	1.470***	2.022***
AR(k)-EGARCH(p,q)	AR(3)-EGARCH (2,2)	AR(4)-EGARCH (2,1)	AR(4)-EGARCH (1,1)	AR(2)-EGARCH (1,1)	AR(1)-EGARCH (2,1)

a) DEN-Denmark, NOR-Norway, SWE-Sweden, UKI-United Kingdom
b) ***,**,* significant at: 1%, 5%, 10% respectively.

Appendix A-III: Specification of AR(k)-EGARCH(p,q) models using Real Exchange Rate data before 1998

$$R_t = \alpha_o + \sum_{i=1}^{k} \alpha_i R_{t-i} + \varepsilon_t h_t^{1/2} \;,\; \varepsilon_t / \psi_{t-1} \sim N(0, h_t) \;,\; h_t = \exp\left[\omega + \sum_{i=1}^{p} \gamma_j \log h_{t-j} + \sum_{j=1}^{q} \rho_j \left| \frac{u_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{m=1}^{r} \theta_m \frac{u_{t-m}}{\sqrt{h_{t-m}}} \right]$$

Coefficients	AUS	BEL	FIN	FRA	GER	IRE	ITA	LUX	NET	POR	SPA	DEN	NOR	SWE	UKI
								Mean Equation							
α_o	0.0007	-0.0002	0.0025**	0.0015	0.0009	-0.0005	0.0004	0.0024**	0.0010	-0.0012	-0.0014	0.0003	0.0011	0.0020	0.0005
α_1	0.298***	0.319***	0.316***	0.322***	0.346***	0.192***	0.408***	0.346***	0.320***	0.356***			0.375***	0.406***	0.292***
α_2	-0.131*	-0.128**		-0.085				-0.155***					-0.122*	-0.153***	-0.139**
α_3	0.163**	0.134***	0.042			0.214***	0.147***	0.176***	0.047		0.119*	0.048	0.017	0.081*	
α_4	-0.050			0.059		-0.236***		-0.086***							
								Variance Equation							
ω	-13.04***	-8.60***	-25.87***	-6.67***	-12.32***	-14.14***	-2.82***	-4.02***	-7.06***	-15.08***	-4.55**	-11.09***	-20.00***	-4.43***	-1.66
ρ_1	-0.199	-0.149**	-0.136***	-0.425**	0.291*	-0.137*	-0.154*	-0.489***	-0.174	0.092*	0.270*	0.137	-0.212	-0.395***	0.469**
ρ_2		0.166***			0.566***			0.517***							
θ_1	-0.037	-0.002	-0.078	-0.174	-0.181**	0.052	-0.072	0.076***	-0.070	-0.018	0.186*	0.152	-0.067	0.159*	0.103
γ_1	-0.823***	0.808***	-1.507***	0.499*	-0.625***	-0.037	1.428***	1.297***	0.776***	-0.994***	0.406	-0.593*	-1.062***	1.030***	0.107
γ_2		-0.973***	-0.925***	-0.458*		-0.941***	-0.826***	-0.835***	-0.771***				-0.590*	-0.656***	0.716***
GED PARAMETER	1.871***	1.955***	1.658***	1.515***	1.555***	1.806***	1.655***	2.927***	2.139***	1.800***	2.097***	1.616***	2.046***	1.421***	1.490***
AR(k)-EGARCH(p,q)	AR(4)-EGARCH (1,1)	AR(3)-EGARCH (2,2)	AR(3)-EGARCH (2,1)	AR(4)-EGARCH (2,1)	AR(1)-EGARCH (1,2)	AR(4)-EGARCH (2,1)	AR(3)-EGARCH (2,1)	AR(4)-EGARCH (2,2)	AR(3)-EGARCH (2,1)	AR(1)-EGARCH (1,1)	AR(3)-EGARCH (1,1)	AR(3)-EGARCH (1,1)	AR(3)-EGARCH (2,1)	AR(3)-EGARCH (2,1)	AR(2)-EGARCH (2,1)

a) AUS-Austria, BEL-Belgium, FIN-Finland, FRA-France, GER-Germany, IRE-Ireland, ITA-Italy, LUX-Luxembourg, NET-Netherlands, POR-Portugal, SPA-Spain, DEN-Denmark, NOR-Norway, SWE-Sweden, UKI-United Kingdom.
b) ***,**,* significant at: 1%, 5%, 10% respectively.

Appendix A-IV: Specification of AR(k)-EGARCH(p,q) models using Real Exchange Rate data After 1998

$$R_t = \alpha_o + \sum_{i=1}^{k} \alpha_i R_{t-i} + \varepsilon_t h_t^{1/2} \ , \ \varepsilon_t / \psi_{t-1} \sim N(0, h_t) \ , \ h_t = \exp\left[\omega + \sum_{i=1}^{p} \gamma_j \log h_{t-j} + \sum_{j=1}^{q} \rho_j \left| \frac{u_{t-j}}{\sqrt{h_{t-j}}} \right| + \sum_{m=1}^{r} \theta_m \frac{u_{t-m}}{\sqrt{h_{t-m}}} \right]$$

Coefficients	AUS	BEL	FIN	FRA	GER	IRE	ITA	LUX	NET	POR	SPA	DEN	NOR	SWE	UKI
Mean Equation															
α_o	-0.0016	-0.0023	-0.0033*	0.0008	0.0008	-0.0011	-0.0018	-0.0005	-0.0024**	-0.0014	-0.0025*	0.0000	-0.0006	0.0012	0.0000
α_1	0.256**	0.259***	0.313***	0.429***	0.382***	0.272***	0.381***	0.266***		0.159*	0.218*	0.000	0.280***	0.400***	0.225***
α_2	-0.021	0.016			-0.050	-0.025	-0.046	0.021	-0.038		-0.161*			-0.163**	
α_3	-0.073	-0.082		0.096	0.020						0.071				0.189***
α_4			0.112**			0.029	0.076	0.074		-0.121**	-0.099			0.136*	
Variance Equation															
ω	-12.84***	-12.94***	-12.28***	-12.11***	-12.21***	-27.70***	-12.03***	-22.11***	-2.00***	-14.01***	-13.90***	-18.39***	-5.21***	-0.98***	-24.01***
ρ_1	0.176	0.113	-0.386**	-0.351*	-0.169	0.355	-0.266*	0.010	-0.525***	0.519**	0.630***	0.144	0.678***	-0.388***	0.250
ρ_2			0.613***			0.393*	0.394*		0.519***						0.578***
θ_1	0.080	0.060	-0.378***	-0.343***	-0.205**	-0.048*	-0.398***	-0.161	0.067**	0.053	0.059	-0.400***	-0.017	0.053	-0.047
γ_1	0.335***	0.328***	0.017	0.048	0.196*	-1.733***	0.070	-1.411***	1.601***	-0.848***	-0.852***	-0.928***	1.012***	0.826***	-1.147***
γ_2	-1.050***	-1.045***	-0.654***	-0.722***	-0.879***	-0.944***	-0.677***	-0.638*	-0.868***			-0.630***	-0.633***		-0.889***
GED PARAMETER	2.045***	2.087***	2.089***	1.715***	1.655***	2.266***	1.861***	1.512***	3.114***	2.599***	2.268***	1.670***	2.176***	2.080***	2.503***
AR(k)-EGARCH(p,q)	AR(3)-EGARCH (2,1)	AR(3)-EGARCH (2,1)	AR(4)-EGARCH (2,2)	AR(3)-EGARCH (2,1)	AR(3)-EGARCH (2,1)	AR(3)-EGARCH (1,1)	AR(4)-EGARCH (2,2)	AR(4)-EGARCH (2,1)	AR(2)-EGARCH (2,2)	AR(4)-EGARCH (1,1)	AR(4)-EGARCH (1,1)	AR(2)-EGARCH (2,1)	AR(1)-EGARCH (2,1)	AR(4)-EGARCH (1,1)	AR(3)-EGARCH (2,2)

a) AUS-Austria, BEL-Belgium, FIN-Finland, FRA-France, GER-Germany, IRE-Ireland, ITA-Italy, LUX-Luxembourg, NET-Netherlands, POR-Portugal, SPA-Spain, DEN-Denmark, NOR-Norway, SWE-Sweden, UKI-United Kingdom.
b) ***,**,* significant at: 1%, 5%, 10% respectively.