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Do Stock Markets Lead or Lag Macroeconomic Variables?

Evidence from Select European Countries

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Abstract

This study examines the connections between stock prices and key macroeconomic indicators: inflation, industrial production, interest rates, money supply and select interactions between the latter group of variables. Such links are evaluated through vector-autoregressions (VARs) on monthly data spanning over the period 1999-2017, for Belgium, France, Germany, Netherlands and Portugal. We check whether such relations are confirmed across different sub-periods and also adopt a non-parametric approach by using a Pesaran-Timmermann test. We find different contemporaneous and lead-lag relationships between stock prices and the selected variables, although there are variations across countries. VAR models indicate that stock prices significantly lead inflation across all countries during the sample period and in most cases this relationship was positive. In addition, stock prices significantly lead industrial production in four of the sampled countries and these relationships were positive as well. Contrary to long-established finance theories, we did not find numerous significant links between interest rates and stock indices; however the interaction between interest rates and money supply was a leading indicator of stock prices in France, Germany and Portugal.

Keywords
Stock prices, Macroeconomic indicators, Pesaran-Timmermann test, Structural breakpoint tests, Vector autoregression

JEL Codes – G12, G15

1. Introduction

The interaction between stock markets and the real economy is of central importance to academics, policy-makers, and fund managers. In recent years, the liberalisation of financial markets and technological advances have increased the interdependence between the stock markets and money markets, while stock indices and interest rates may react promptly to changes in economic fundamentals. Academic literature analysed the linkages between stock markets and a variety of economic indicators such as industrial production, inflation, interest rates, consumption, money supply, and commodity prices. These relationships were considered both in the context of industrialised markets (Gan et al., 2006; Humpe and Macmillan, 2009) and emerging economies (Kandir, 2008; Hosseini and Ahmad, 2011).

Whilst this literature offers comprehensive insights regarding the spillover effects between stock markets and the real economy, typical assumptions of theoretical models have led to dramatically different conclusions on various economic relationships (Hacker et al., 2014) and findings suggest that the actual connections between stock prices and macroeconomic variables could be fluid (Valcarcel, 2012). In addition, insights are at times contradictory due to the use of different proxies to model a given variable, and outcomes which may have been period-specific or country-specific. Prior studies such as Antonakakis et al. (2017) suggest that it is important to emphasise the dynamic nature of the connections between stock markets and the macroeconomy for analysing the evolution of the conditional comovements between such variables. Further research is thus required about the linkages between financial markets and the real economy and it is the aim of this paper to add a worthy contribution, as outlined below.

This study explores the relationship between stock prices and select macroeconomic variables by considering contemporaneous and lead-lag effects for five European countries. We model how stock prices relate to inflation, industrial activity, interest rates and money supply in case of Belgium, France, Germany, Netherlands, and Portugal. In sharp contrast with the research for the US market, the studies for Europe have been much sparser and given the controversies about the nature and direction of these links, it is the aim of this paper to address the lacuna regarding such relationships in the highly integrated EU area. Our data set spans over the period 1999-2017 and given the inherent liquidity of the component markets, it offers the potential to model any possible feedback effects, even if the individual countries differ in their size and economic prominence.

In this paper we use monthly data to model the connections between stock markets and the real economy through a series of ordinary least squares (OLS) regressions, and subsequently through vector autoregressions (VARs) to test for Granger-causality. We lay particular emphasis on checking the robustness of the results by re-estimating models for specific sub-periods and through using Pesaran-Timmermann tests. We deem that the latter extension is of particular importance to inquire whether lead-lag effects are confirmed through a non-parametric approach which does not rely on any pre-set assumptions regarding the distribution of the population data. The importance which we lay on robustness checking is worthy of note, given the mixed insights in prior literature. In particular our inquiry into the consistency of the relationships over different sub-periods is vital in view of prior results which suggest that such connections may change over time (Antonakakis et al., 2017). Owing to the scarcity of studies which focus on European markets, the evolution of these links and the relative importance of the different economic factors have hardly been addressed.

Our paper aims to contribute to the literature with respect to other aspects as well. Most of the prior studies were either single country based, or have focused on only one direction of the two-way relationship, or have sidelined the important interactions between some of the macroeconomic variables (Suhaibu et al, 2017). By addressing such limitations, this paper offers more reliable insights, and proposes an interdependent empirical framework that captures a wider range of dynamics in the bidirectional relationship between macroeconomic factors and the stock market.

The paper is structured as follows. The next section reviews a selection of related literature. Section 3 summarises the methodology whilst section 4 offers a description of the data set.

We then present the estimated models in the subsequent section, while section 6 assesses the robustness of the results, by the re-estimation of select VARs for different sub-periods and through Pesaran-Timmermann tests. Section 7 concludes.

2. Literature Review

The links between stock prices and macroeconomic indicators have occupied a prominent role on the research agenda. Studies such as Fischer and Merton (1984) considered the stock market as a leading indicator, since security prices should reflect a company's expected earnings. However, other research suggests that stock markets may also act as lagging indicators, for instance when they react to economic data (Stock and Watson, 1990) or when they adjust to changes in macroeconomic variables in the long-term (Ratanapakorn and Sharma, 2007). In this section, we summarise the results of a selection of prior research, focussing on the macroeconomic variables which we consider in this study: inflation, industrial production, interest rates, and money supply.

Inflation

A comprehensive strand of literature shows that inflation is not simply a monetary phenomenon which mirrors the quantity of money per unit of output, but also influences the stock market and therefore plays an important role in the monetary policy-stock market nexus (Suhaibu et al, 2017). There are various theoretical explanations regarding the possible links between inflation and stock prices. For instance, as per the Gordon (1962) model, stock prices partly depend on dividend expectations. In this way, an increase in money supply may cause inflation, and at the same time stimulate economic activity expectations which would raise stock prices. The impact of inflation on stock prices could be in the negative direction. For instance, expansionary monetary policy may result in higher inflation expectations which increase long-term interest rates leading to lower stock prices due to the reduced present value of future dividends (Sargent, 1999; Cogley and Sargent, 2001). Conversely, stock market returns could affect inflation through a mediating effect in terms of consumption; for instance, as stock prices fall, stockowners feel less wealthy and therefore reduce spending which reduces inflationary pressures. In addition, given that stocks are pledged as collateral, the reduction in stock prices reduces borrowing capacity which may curtail economic activity and result in decreased inflation (Antonakakis et al., 2017).

Bredin and Hyde (2005) analysed the links between stock prices and inflation for a sample of European and other countries. The use of the single and two transition function regressions, as applied to data spanning from 1980 to 2004, suggested that inflation strongly impacts on stock prices in the sampled countries. Naik and Padhi (2012) considered the Indian market during the period 1994-2011 and reported a negative relationship between inflation and the stock index, and that the latter is cointegrated with macroeconomic variables. Similar results were reported by Akbar et al. (2011) who reported a cointegrated and negative relationship in case of the Karachi stock index from 1998 to 2008. On the contrary, Bampinas and Panagiotidis (2016) found that over the period 1993-2012, there was no significant cointegrating relationship between stock prices and the consumer price index in the US and their underlying linkages varied over time.

In the context of German stock returns and inflation, Kim (2003) reported a negative relationship which is asymmetric in the sense that it is sensitive to the direction of inflation changes. Further studies which reported a negative relationship between stock prices and inflation include Chen et al. (1986), and Humpe and Macmillian (2009). Anderson et al. (2018) considered the effects of different macroeconomic announcements on various sectoral indices in the US and the EU. Whilst the effects differed across sectors, they reported a significant impact on a range of sectors following CPI announcements, even if it was not always in the expected negative direction.

Other studies documented a positive connection between these variables. Ratanapakorn and Sharma (2007) studied US data from 1975 to 1999 and concluded that there is no Granger-causality in the short-term, but a contemporaneous positive relationship. Asmy et al. (2010) reported a positive relation between stock prices and inflation but no causality in the context of the Malaysian markets. Their results also showed that the variables are cointegrated. In the context of thirteen different emerging stock markets, Bai and Green (2010) documented a positive connection between inflation and nominal stock returns. Alam (2017) analysed the impact of several macroeconomic variables on Indian stock indices from 2005 until 2013 using a heteroscedastic cointegration approach and reported a long-term positive link between inflation and stock prices.

Colure and Wahab (2008) studied US data, and reported a positive connection during high inflation periods, and an inverse relation during low inflation periods. Similarly, Antonakakis et al. (2017) reported significantly positive and significantly negative correlations between inflation and stock prices in the US over various time periods, when analysing data for the years 1791 to 2015. Al-Shami and Ibrahim (2013) reported contradictory results in case of Kuwait, where an increase in inflation leads to an increase in stock prices after one month, and a decrease in stock prices after two months. Stock markets may also be sensitive to inflationary factors in overseas countries; for instance, Balcilar et al. (2017) found that during the period 1994 – 2014, Asian stock prices were impacted by news about US inflation.

Industrial production

According to Ikoku (2010) there are at least four theoretical approaches which support the hypothesis that stock prices constitute a leading indicator of economic activity. *i)* If stock prices depend on expected profitability, then the former should account for investors' expectations about future economic performance. *ii)* Rising equity prices lower the cost of funding for firms and lead to increased real investment and higher subsequent economic activity. *iii)* As stock prices rise, the creditworthiness of stockholders improves and leads to higher borrowing capacity and increased future economic activity (Bernanke et al. 1996). *iv)* As stock prices rise, shareholders feel wealthier and therefore they will be inclined to spend more, generating higher economic activity (Plíhal, 2016).

Humpe and Macmillian (2009) found a positive relationship between stock prices and industrial production in case of the US and Japan. Narayan et al. (2014) reported a significant positive linkage between the Industrial Production Index (IPI) and thirteen Indian bank stocks from 1998 until 2008, and in addition IPI Granger-causes stock prices. Naik and

Padhi (2012) obtained similar results for the Indian markets using data from 1994 to 2011 and confirmed the presence of a significant and positive long-term relationship and bidirectional Granger-causality between these variables.

Two studies on the Polish stock market yielded similar results for distinct time periods. Gurgul and Lach (2010) found a long-run bidirectional linear link between IPI and stock prices when modelling data from 1998 to 2008 using Granger-causality techniques. Hsing and Hsieh (2012) used GARCH methodology on data ranging from 2000 up to 2010 and also found a positive relationship. Anderson et al. (2018) found that the effects of industrial production announcements on various sectoral indices in the US and the EU differed across sectors and was not always in the expected positive direction.

Laopodis (2011) reported that from 1990 to 1998, stock prices in France resulted in only minimal variations in the IPI, yet results varied in between countries; for instance, in Italy stock prices highly influence changes in the IPI. The author also reported that IPI is insignificant in explaining stock prices in all countries. Conversely, Peiró (2016) focused on France, Germany, and UK during the period 1969 to 2012 and found that IPI accounted for a considerable portion of the annual changes in stock prices. In addition, the author found that stock prices lead IPI across the sampled countries. Plíhal (2016) reported that stock prices Granger-caused IPI in the case of Germany during the time period 1999 to 2015.

Interest Rates

There are various theoretical links between interest rates and stock prices. For instance, interest rate fluctuations affect the present value of dividends and therefore stock prices (Chen et al. 1986). In addition, interest rates affect the cost of funding and therefore impact on the opportunity cost of borrowing and stock prices (Mok, 1993). Another possible explanation for the negative relationship between interest rates and stock prices is that as rates rise, investors substitute stocks in favour of bonds (Alam, 2017). In addition, interest rates constitute a core component of monetary policy, and stock markets not only respond to monetary policy decisions, but also provide feedback to central banks regarding the private sector's expectations about future macroeconomic variables (Bernanke and Gertler, 2000; Bjornland and Leitemo, 2009).

Studies by Humpe and Macmillian (2009), Adam and Tweneboah (2008), Hussain et al. (2013) and Alam (2017) found that interest rates may negatively affect stock prices both directly and indirectly. Peiró (2016) considered the cases of France, Germany and UK and reported that interest rates are key factors in determining stock returns in the short run (but not in the long term) across all countries. Similar results were found in an earlier study by Laopodis (2011) where the cases of France, Germany, UK and Italy, from 1990 until 2009 were considered. Gurgul and Lach (2010) focused on the Polish stock market from 1998 to 2008 and noted Granger-causality effects from interest rates to the respective stock market index.

Jammazi et al. (2017) reported a significant bidirectional causal relationship between stock prices and interest rates for the US markets between 1993 and 2014, and such links strengthened following the start of the US sub-prime mortgage crisis in mid-2007. During times of instability, investors replace stocks with high quality bonds resulting in a decrease in stock prices and lower bond yields, causing a positive correlation. Andrieș et al. (2014) reported that stock price movements tended to lead interest rates in the first part of their sample period which is consistent with adaptive behaviour on part of monetary authorities; however stock prices subsequently lagged interest rates.

A study on Latin American markets by Abugri (2008) yielded contrasting results. A negative and significant relationship exists between the index and interest rates in case of Brazil, Argentina and Chile, whereas the nominal interest rates were insignificant in explaining stock returns in Mexico. Further mixed evidence was reported by Ratanapakorn and Sharma (2007) who found that in case of the US stock markets the S&P500 is negatively related to long-term interest rates but positively related to short-term interest rates.

A study on the US and German markets by Krieger et al. (2015) considered the reactions to interest rate announcements in terms of implied volatility. The authors reported that volatility in the US market tends to abate in response to scheduled announcements, irrespective of the degree to which the announcements are in line with expectations. The effect in case of German implied volatility is less clear and may be sensitive to the direction of interest rate movements. Gupta et al. (forthcoming) analysed UK data and found that stock price volatility is responsive to the term structure of interest rates and to the changes in its pattern.

Money Supply

The money supply can be linked to stock prices through portfolio substitution or inflationary expectations effects (Abdullah and Hayworth, 1993; Cheung and Lai, 1999). In case of the portfolio-balance model, an increased money supply may result in portfolio shifts from idle money to financial assets including equities. Alternatively, an increase in money supply may cause unanticipated increases in inflation and inflation uncertainty. This leads to higher interest rates and causes a negative relationship between money supply and stock prices (Mukherjee & Naka 1995; Humpe and Macmillian, 2009). Another possible connection is that an increase in money supply raises liquidity which reduces interest rates and consequently boosts stock prices (Thorbeke, 1997; Sellin, 2001)).

Ratanapakorn and Sharma (2007) documented a contemporaneous positive relationship between money supply and stock prices for the US markets. Money supply does not Granger-cause stock prices in the short run, but it influences stock prices in the long term. Plíhal (2016) reported a bidirectional relationship between money supply and the German stock index after applying Granger-causality techniques on data spanning over 1999 to 2015. Hanousek and Filer (2000) analysed this relationship for Eastern European countries from 1993 to 1999. In the case of Poland and Hungary they concluded that money supply has a predictive power for stock returns while no Granger-causality was found in case of Slovakia and the Czech Republic.

Abugri (2008) used VARs to model data from different Latin American markets. The author reported a significant and negative relationship between money supply and stock prices for Argentina and Brazil, yet money supply was insignificant in explaining stock market movements in Chile and Mexico. Humpe and Macmillian (2009) used cointegration techniques and reported a negative relationship between money supply and stock prices for Japan, yet a positive and insignificant link for the US. Naik and Padhi (2012) and Alam (2017) focused on the Indian market using post-2004 data. Using cointegration approaches, both studies pointed at a significantly positive link between money supply and stock prices.

Al-Shami and Ibrahim (2013) estimated a VAR for the Kuwait stock market, using data from 2001 to 2010. The authors reported that an increase in money supply leads to an increase in stock prices after one month, and a subsequent decrease after two months. Rjoub et al. (2009) reported contradictory results when studying the impacts of money supply on various portfolios comprising stocks traded on the Istanbul Stock Exchange. Whilst some portfolios were positively impacted by changes in money supply, other ones experienced the opposite effect. Ariff et al., 2012, analysed Canadian quarterly data for the time period 1960-2011 and concluded that an increase in the money supply leads to an increase in stock prices, due to increased liquidity in the financial system. Dhakal et al. (1993) examined US share prices using VARs and found that changes in the money supply had an indirect significant impact on share prices through changes in interest rates and inflation rates, as predicted by theory.

Overall, prior studies do not lead to clear-cut inferences regarding the links between stock prices and macroeconomic variables since these may vary across countries and time periods. In this way, finance literature stands to benefit from further empirical work which may contribute towards a deeper understanding of such relations.

3. Methodology

In investigating the links between stock prices and macroeconomic variables in our data set, we start by estimating a series of OLS regressions to look for any contemporaneous relationships. We then consider lead-lag effects through VAR models which test for Granger-causality. This concept is based on the principle that if shocks in variable x lead to fluctuations in variable y, then the former 'Granger-causes' the latter (Granger, 1969). VARs model a variable as an autoregressive process, with the added lags of other variables and a residual term. In this way VARs can model feedback effects, where two or more time series Granger-cause each other, as in the following bivariate model:

$$x_t = \sum_{i=1}^{n} \alpha_{1i} x_{t-i} + \sum_{i=1}^{n} \beta_{1i} y_{t-i} + u_{1t} \tag{1}$$

$$y_t = \sum_{i=1}^{n} \alpha_{2i} x_{t-i} + \sum_{i=1}^{n} \beta_{2i} y_{t-i} + u_{2t} \tag{2}$$

where x_t and y_t are the variable observations at time t, n is the number of observations, and u_t is a residual term.

While Granger-Causality was applied to model relationships between a wide range of variables, one should note that statistical significance in such models does not necessarily imply actual causality. For instance, a significant relationship between two variables may be the outcome of respective interactions with an exogenous variable. Therefore, Granger-causality models the predictability power rather than actual causality.

We also use Pesaran-Timmermann (1992) tests to counter check the significance of any lead-lag relationships in the VARs. In this way we do not rely exclusively on parametric techniques where the distribution of the population data is usually assumed to be normal (when this is not necessarily the case). The test proposed by Pesaran and Timmermann measures the dependence between variables, in terms of whether they fluctuate in the same (or the opposite) direction. Therefore, this approach considers the direction of the changes and ignores the magnitude of the fluctuations. The procedure tests the null hypothesis that the variables are independent, and the test statistic is normally distributed when the sample is sufficiently large.

The test statistic for assessing the relationship between variables x_t and y_t is computed as follows:

$$S_n = \frac{\hat{P} - \hat{P}_*}{\sqrt{\{\hat{V}(\hat{P}) - \hat{V}(\hat{P}_*)\}}} \xrightarrow{a} N(0,1) \tag{3}$$

where

$$\hat{P} = \frac{1}{n}\sum_{t=1}^{n} Sign(y_t x_t) \tag{4}$$

$$\hat{P}_y = \frac{1}{n}\sum_{t=1}^{n} Sign(y_t) \tag{5}$$

$$\hat{P}_x = \frac{1}{n}\sum_{t=1}^{n} Sign(x_t) \tag{6}$$

$$\hat{P}_* = \hat{P}_y \hat{P}_x + (1-\hat{P}_y)(1-\hat{P}_x) \tag{7}$$

$$\hat{V}(\hat{P}) = \frac{1}{n}\hat{P}_*(1-\hat{P}_*) \tag{8}$$

$$\hat{V}(\hat{P}_*) = \left[\frac{1}{n}(2\hat{P}_y - 1)^2 \hat{P}_x(1-\hat{P}_x)\right] + \left[\frac{1}{n}(2\hat{P}_x - 1)^2 \hat{P}_y(1-\hat{P}_y)\right] + \left[\frac{4}{n^2}\hat{P}_y \hat{P}_x(1-\hat{P}_y)(1-\hat{P}_x)\right] \tag{9}$$

and the function *Sign(Z)* takes a value of 1 when the variable is positive and zero otherwise.

Thus, $P^\wedge$ is a measurement of the number of occurrences where both variables fluctuate in the same direction. $P^\wedge$ takes a maximum value of 1 when all the respective changes are in the same direction, and a minimum value of 0 when all contemporaneous changes are always in an opposite direction. The terms $P_*^\wedge$, $V^\wedge(P^\wedge)$, and $V^\wedge(P_*^\wedge)$ adjust this rudimentary yardstick by considering the individual proportions of negative and positive changes in both variables and scale the original measurement to a normal distribution. Pesaran-Timmermann tests may be used to detect lead-lag effects when applied to the relationships between x_t and y_{t-i} or between x_{t-i} and y_t.

4. Data

The sample used in this study comprises five European economies: Belgium, France, Germany, Netherlands and Portugal. Being part of the Eurozone, these countries adopted the Euro as their common currency since January 1999. Belgium, France, Germany and Netherlands were chosen on the basis that their stock markets are amongst the most liquid in the Eurozone. As for Portugal, it was one of the countries which were most effected by the

European sovereign debt crisis, although it registered a subsequent recovery. In this way, our sample captures a representation of prominent and peripheral economies, whilst offering the inherent advantages of using data emanating from considerably liquid markets. Being Eurozone economies, these countries follow coordinated monetary policies and adopt common data compilation methodologies. Thus, one may expect the sampled macroeconomic variables to be consistent with each other.

The indices which were used to model stock prices were: BEL-20 (Belgium), CAC 40 (France), DAX (Germany), AEX (Netherlands), and PSI-20 (Portugal). The source of data for DAX was the Frankfurt stock exchange, while the other time series were obtained from Euronext NV stock exchange.

The selected macroeconomic variables were: inflation, industrial production, long-term interest rates (IR), and money supply (MS). The Consumer Price Index (CPI) was used as a proxy for inflation. CPI data were obtained from the International Monetary Fund's International Financial Statistics. In order to capture the production of goods and services in an economy we used IPI which measures the output of industrial establishments such as mining, manufacturing and public utilities. The monthly data were obtained from the International Monetary Fund's International Financial Statistics and they were already seasonally-adjusted. We did not use gross domestic product as a measurement of economic activity since such data are typically available at quarterly intervals.

As a measure of IR, we used the yields on ten-year government debt securities. During the period June - September 2016, German interest rates were negative and since the logarithms of negative values are undefined, all observations of German interest rates were increased by 100 basis points. This linear shift eliminated the negative occurrences, but still preserved the relative distance and directional change of the observations. As for MS, we used the M3 yardstick across all EU countries which includes liquid money, deposits, repurchase agreements, money market funds, and debt securities. IR and MS data were retrieved from the European Central Bank Statistical Data Warehouse.

The time series were sampled at monthly intervals, starting from January 1999 up to September 2017 (225 observations). Each variable was checked for stationarity using Augmented Dickey-Fuller tests. All variables were modelled as log returns except MS (for all countries) and CPI (for all countries except Belgium) which were modelled as the first difference of log returns.

Finally, we also set up two moderating variables to account for the expected interactions between select macroeconomic variables. In view of the connections between money supply and inflation (e.g. Bekiros et al., 2017) we set up a moderating variable MSxCPI being the product of MS and CPI for the respective countries. Similarly, we specify moderating variable IRxMS being the product of IR and MS. The latter two variables may be expected to interact together as shown for instance by Bhattarai (2011).

5. Estimations

We now report the empirical results relating to the contemporaneous and lead-lag effects in our data set. We estimated a series of OLS models where the stock index of each country was set as the dependent variable, and the macroeconomic data were used as explanatory variables. As noted above, the macroeconomic variables for each country were then included in subsequent VARs to check for intertemporal effects.

As shown in Table 1, CPI and IPI are significant at the 95% level of confidence in the case of Belgium. As for France, none of the macroeconomic variables are significant, yet IPI is nearly significant at the 90% confidence level. In case of Germany and Portugal, IR is significant at the 95% and 99% confidence levels respectively. As for Netherlands, no macroeconomic variable is significant. The contemporaneous relationship between money supply and stock prices is insignificant across all countries.

Table 1 about here

Given the inter-relationships between some of the selected macroeconomic variables, we set up two moderating variables to regress over the respective stock indices: MSxCPI (the product of MS and CPI) and IRxMS (the product of the monetary policy variables IR and MS). We did not include the moderating variables in the former OLS regressions to minimise the possibility of multicollinearity. The OLS estimations featuring the moderating variables are shown in Table 2. In case of Portugal, MSxCPI and IRxMS are significant at the 90% and the 99% confidence levels respectively. IRxMS is *nearly* significant at the 90% level in case of Germany.

Table 2 about here

We now proceed with modelling the intertemporal effects between the stock indices and their macro-economic counterparts through the estimation of VARs. The optimum number of lags for each VAR was determined through the Akaike Information Criterion, except where stated otherwise. Given that we estimated six bivariate VARs for each of the five countries, for the sake of brevity we only report those lags which suggest a statistically significant relationship between the respective indices and the macroeconomic variables.

As reported in Table 3, the index leads the CPI across all countries; in most cases the relationship is positive, and this goes counter to our expectations. In case of France and Portugal, the CPI negatively leads the index. When assessing the contemporaneous and the lagged Index-CPI connections, we note that both positive and negative relationships are evident. In case of Belgium, there is a negative significant contemporaneous relationship, but a positive relationship of the first Index lag with the CPI. Similar reversals of signs are evident in France and Portugal. This suggests that the relationship between stock prices and inflation may be ambiguous; for instance, it is commonly held that businesses benefit from mild inflation, but economic activity may be negatively affected by relatively high inflation rates.

Table 3 about here

Table 4 offers a summary of the VAR estimations of the stock index - IPI relationships. We observe that the index leads IPI in four of the sampled countries and the positive coefficients are in line with expectations. This suggests that industrial production levels are sensitive to prior stock market trends or to general business performance, but industrial production levels do not have a significant impact on subsequent stock market trends. This result is also in line with the evidence presented by Ozcelebi (2014) in the context of Eastern European markets.

Table 4 about here

In case of the VARs concerning IR (Table 5), most of the stock market - macroeconomic links are insignificant, and this seems surprising in view of the theoretical relationships between these variables. Our results are somewhat backed by the findings of Peiró (2016) in the context of European countries where stock prices were not influenced by interest rates in the long term (although the author reported causality in the short term). In case of Belgium, interest rates positively lead stock prices and the direction is in line with expectations. Stock prices positively lead interest rates in the case of Germany, which goes counter to an expected negative relationship. The latter suggests that German interest rates (and therefore those across the Eurozone) are sensitive to Germany's stock market performance, and this is not surprising when considering the weight of the country on the Eurozone's policymaking process.

Table 5 about here

The VARs which model the relationship between stock prices and MS yield mixed insights (Table 6). In particular, we note a positive lead from MS to stock prices in Belgium and Netherlands which is significant and in line with expectations. In addition, stock prices positively lead MS in case of the former two countries while this effect is negative in case of Portugal. It is also pertinent to pin-point the reversal in signs for the three countries when comparing the lagged relationships with the contemporaneous ones. This is somewhat similar to the reversal in signs between these variables as reported by Al-Shami and Ibrahim in the context of Kuwait. In case of France and Germany our results indicate that there is no significant relationship between MS and stock prices. The results suggesting an interaction between these two variables are somewhat in line with prior studies such as Plíhal (2016) for the German market and the findings of Hanousek and Filer (2000) for Poland and Hungary.

Table 6 about here

The VARs which feature the moderating variables are summarised in Table 7. In case of MSxCPI the only significant relationship was for Belgium where the index leads the moderating variable. In case of the second lag, the relationship is negative, whereas it is positive for the third lag. This reversal of signs casts doubts regarding the robustness of this relationship. In case of IRxMS, the first lag leads the index in case of France, Germany and Portugal. The latter similarity across countries was not evident when modelling IR or MS individually.

Table 7 about here

6. Robustness Checking

In view of the mixed evidence conveyed in prior literature, we deem that it is vital to assess the robustness of the above empirical results. We thus counter check whether the significant relationships in the former VARs are confirmed when considering different sub-periods, and when using a non-parametric methodology.

In order to look for any potential regime switching in the identified causation relationships, we applied endogenous structural break tests using Bai and Perron (2003) methodology to the pairs of variables which were found to be significant in Tables 3 to 7. The Bai and Perron (2003) breakpoint test has the advantage of allowing for multiple unknown breakpoints. The test results for the Granger causation relationships where structural breaks were evident are reported in Table 8. We then re-estimated VAR models using different sub-periods for those relationships which featured structural breakpoints. For the sake of comparability, we retained the same order of the respective VARs in this set of estimations, rather than selecting an optimal lag-length for each sub-period.

Tables 8 and 9 about here

Table 9 summarises the relationships between the variables of interest over the respective sub-periods. One may note that out of fourteen cases where structural breakpoints were evident, four relationships proved insignificant across all the sub-periods. Although this reduction in significance may be partly attributed to the re-estimation of VARs using less observations when splitting the sample period, it also indicates that the underlying relationships may not be as strong as the original VARs suggest. In addition, we note reversals of the signs of the coefficients over particular sub-periods in eight cases. This suggests that the underlying connection between the variables of interest was prone to change over time – at least in those cases where the data revealed structural breakpoints.

A number of breakpoints concerning the relation of stock prices with MS, IR and CPI occurred in April 2003 and this is evident in Belgium, France and Netherlands. This could be related to the noteworthy appreciation of the Euro against the US Dollar during that year which one may expect to impact on different monetary variables. Breakpoints taking place in 2007-2009 may probably be attributed to the financial crisis ongoing at the time. This assertion is supported by various studies such as Kotkatvuori-Örnberg et al. (2013) which suggest that correlations and equity market links may change during unstable periods.

Overall, the former results indicate that the connections between financial variables and macroeconomic indicators such as CPI, IPI, and MS may not be consistent across time, since contrary to the assumptions of most theorical models these relationships are in reality prone to a range of exogenous factors.

Our additional check upon the reliability of the links found in Section 5, consists of Pesaran-Timmermann tests, which investigate dependencies across variables in terms of whether these move in the same (or in opposite) directions. Test statistics shown in Table 10 corroborate the significance of eleven out of 38 relationships. The fact that the significance of the majority of relationships is not confirmed through the Pesaran-Timmermann tests, could be due to the possibility that non-parametric tests prove less powerful when they ignore substantial information – in this case the tests discard the magnitude of the fluctuations to focus on the direction of the change. It is pertinent to note that in some cases, the above robustness checks yield contradictory insights. In case of some of the Index - lagged MS relationships for Belgium and Netherlands, the significance is confirmed by the Pesaran-Timmermann tests, but not when re-estimating the VARs for the sub-periods.

Table 10 about here

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7. Discussion of Results and Conclusion

In this paper we sampled data from five different countries to investigate the interaction between stock prices and macroeconomic variables – an issue which is of central importance not only within academic finance literature, but also to investors and policy-makers. In view of the fact that numerous prior studies have focused on the US markets, we have extended this literature by sampling European economies where markets are reasonably liquid and yield reliable data which are consistent across countries. We considered both directions of the possible two-way relationships between the stock market and the macroeconomic variables. In particular, our results are noteworthy in view of the comprehensive sample period which ranges from 1999 to 2017, our modelling of interactions between select variables, the adoption of both parametric and non-parametric approaches, and our delving into specific sub-periods. The latter extension is of particular importance in view of prior results which suggest that such connections may be fluid (Antonakakis et al., 2017).

The sampled macroeconomic variables CPI, IPI, IR and MS were employed in OLS regressions, with a stock index as a dependent variable. We also set up two moderating variables – MSxCPI and IRxMS – to account for possible inter-relationships. Intertemporal relationships between the variables were then modelled as VARs. Robustness checks were conducted by using Pesaran-Timmermann tests, and by delving into the consistency of the relationships where structural breakpoints were discerned. Overall, our results support the notion that stock prices may behave both as leading indicators (Fischer and Merton, 1984) and as lagging indicators (Chauvet and Potter, 2000). Having said this, most relationships are not uniform across countries, and the re-estimation of VAR models on different sub-periods confirms that such linkages may change over time.

We summarise the salient aspects of the interactions between stock prices and each macroeconomic variable hereunder, together with possible interpretations of the results.

CPI

In our study, inflation is the variable which features most connections with the stock market and this link is evident across all countries in the sample. The contemporaneous relationship between stock prices and inflation, was only significant in case of Belgium, and it was an inverse relationship, similar to previous studies such as Humpe and Macmillian (2009). In line with studies described in Section 2, the impacts of lagged stock prices on inflation were mainly positive and stock prices significantly lead CPI across all countries during the sample period. The significance of such relationships was robust to the Pesaran-Timmermann tests only in case of Netherlands. Structural break-points were evident in case of Belgium and Netherlands and for both countries, this relationship was not significant across all sub-periods, however the direction was consistent. The effects of lagged inflation on stock prices in our study were significant in France and Portugal and the negative sign supports the theory that higher inflation may encourage policy makers to raise interest rates which then decrease stock prices (Sargent, 1999). The significance of some of these lags was confirmed through Pesaran-Timmermann tests.

IPI

The contemporaneous relationship between stock prices and industrial production was significant only in case of Belgium, and in this case it was in the positive direction, as per expectations. Stock prices significantly lead IPI in all countries except Portugal, and these relationships were positive. This is in line with the theories discussed in Section 2 and given the various channels which may lead to spillovers from the stock market to industrial production, it is not surprising that this variable ranks among the most important ones in terms of interactions with the stock market. When conducting Pesaran-Timmermann tests, the significance was only confirmed for particular lags in France and Germany. Structural breakpoints were evident in case of the latter countries, and when VARs were re-estimated for the respective sub-periods, the relationships were only significant in one sub-period. The positive link between IPI and lagged stock prices is also in line with prior empirical studies such as Humpe and Macmillian (2009) and Narayan et al. (2014). The insight that IPI ranks amongst the most significant macroeconomic variables that interact with stock prices supports the evidence presented by Peiró (2016) for European countries.

IR

Despite the strong theoretical links between IR and stock prices, the contemporaneous relationship between these variables was only significant in case of Germany and Portugal. The relationship was negative in case of Belgium and Portugal, whereas in the other countries the direction was positive. This is in line with the mixed expectations. In terms of inter-temporal effects, we cannot speak of any discernible pattern across countries and following tests that indicated the presence of structural breakpoints in case of Belgium, this lead-lag relationship was no longer significant within the sub-periods. Despite this, the observation that the lagged index significantly impacts on IR in case of Germany was robust to the Pesaran-Timmerman test. Being a positive relationship, this is in line with theoretical expectations. This may either suggest that monetary policy makers attempt to curb stock market exuberance by increasing IR, or that a stock market boom may lead to increased real investment creating upward pressures on IR due to higher funding requirements. Lagged IR is insignificant in explaining stock prices for the majority of the sampled countries. While this is similar to the Mexican evidence presented by Abugri (2008), it runs counter to prior studies such as Alam (2017) in the context of the Indian markets.

MS

In case of MS, no significant contemporaneous relationship with stock prices was evident. MS was found to positively lead the index in case of Belgium and Netherlands. While this relationship was not consistent across all sub-periods, in case of the latter country it proved robust when counterchecked through the Pesaran-Timmermann test. In three of the sampled countries, stock prices lead MS. In case of Belgium and Netherlands the relationship was positive, whereas in Portugal the connection was negative. The difference in the signs across countries may be explained by the fact that while stock markets yielded overall positive returns during the sample period in case of Belgium and Netherlands, the Portuguese stock market registered cumulative negative returns (whereas MS moved in common directions for the three countries due to expansionary monetary policies post-2007). The leading effect from stock prices to MS proved robust to the Pesaran-Timmermann test only in case of Portugal, yet the direction is in line with the expectations.

MSxCPI

We found a positive contemporaneous relationship between stock prices and MSxCPI in case of Portugal. The only significant intertemporal relationship was evident in case of Belgium, where the index leads MSxCPI. In this case, one significant coefficient was positive while the other was negative, and Pesaran-Timmemann tests did not confirm the significance of these lags.

IRxMS

The contemporaneous relationship between stock prices and the interaction of interest rates and money supply was significantly positive in the case of Portugal. IRxMS was found to lead stock prices in France, Germany and Portugal. The sign was negative in the latter country, whereas it was positive in case of the others. The difference in signs may be attributed to the fact that the Portuguese market registered overall negative returns in contrast to other countries; whereas IRxMS broadly moved in common directions. Pesaran-Timmemann tests confirmed the significance of this relationship for France and Germany, whereas in case of Portugal, the relationship was no longer significant when evaluated over different sub-periods. The finding that the moderating variable IRxMS is a leading indicator of stock prices seems inconsistent with an efficient market. The peculiarity that stock markets react to IRxMS with a one-month delay, could be explained by the conjecture that it takes time until the effects of the interaction between IR and MS are felt in the real economy and subsequently reflected in stock prices. The lagged stock market reaction could also be due to the period of time involved in reporting MS data. The observed leading effect from IRxMS to stock prices is in line with the findings of Dhakal et al. (1993) who observed that in the US, changes in money supply lead stock prices, partly through changes in interest rates.

The above insights should be interpreted in the context of the limitations of this study. One should note that Granger-causality effects do not imply actual causality. For instance, it could be that variables respond to exogenous factors, such as data reports which change the attitude towards real and financial investment. In such cases, one may expect a prompt reaction on part of stock prices whilst industrial production or inflation may take longer to adjust. Such timing differences could result in Granger-causality.

Another limitation typically arises when modelling stock prices, in the sense that one does not usually account for all the intricacies inherent in such data. For instance, the study did not consider factors such as spillovers from other markets (Camilleri, 2010; Mensi et al., 2017), non-synchronous trading (Day & Wang, 2002; Camilleri & Green, 2014), and the trading setup (Camilleri, 2015; Hendershott & Moulton, 2011). Despite that this study abstracts from the former aspects, we do not feel that this compromises the validity of the results, particularly in view of the emphasis which we laid on robustness-checking and the different methodologies applied.

Additional research potential lies in investigating how the relationships between stock prices and macroeconomic variables differ across developed and emerging economies, given that the latter may behave somewhat distinctly from the former (Camilleri & Galea, 2009; Fufa and Kim, 2018). Further insights may also be gleaned by the inclusion of additional macroeconomic indicators such as capital flows (Liew et al., 2018), economic productivity (Camilleri & Falzon, 2013) and equity market openness (Ngoc Tran, 2017).

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Table 1: Stock Indices regressed over Macroeconomic Variables

	Belgium		France		Germany		Netherlands	Portugal	
Intercept	0.0044		0.0013		0.0046		-0.0001	-0.0040	
	(1.16)		(0.37)		(1.09)		(-0.03)	(-0.72)	
CPI	-2.7545	**	0.0179		0.9639		-0.4629	0.3228	
	(-2.28)		(0.02)		(1.24)		(-0.71)	(0.37)	
IPI	0.3147	**	0.4090	(*)	0.3834		0.1965	-0.0469	
	(2.16)		(1.62)		(1.45)		(1.14)	(-0.21)	
IR	-0.0130		0.0016		0.1594	**	0.0018	-0.2135	***
	(-0.47)		(0.06)		(2.14)		(0.09)	(-2.72)	
MS	-0.5334		0.3050		0.5597		-0.1177	0.2746	
	(-0.88)		(0.46)		(0.72)		(-0.17)	(0.26)	
R^2	0.0442		0.0144		0.0386		0.0088	0.0347	
Adj. R^2	0.0266		-0.0037		0.0209		-0.0094	0.0170	

The table summarises the OLS estimation for each country, where the stock index was set as a dependent variable while the explanatory variables were the macroeconomic time series specified in the rows. Each estimation was based on data for the time period January 1999 - September 2017 (223 observations). Regression coefficients are shown on top and t-ratios are reported underneath.

NB. *** and ** denote statistical significance at the 99% and 95% confidence level respectively. (*) denotes that the variable is *nearly* significant at the 90% confidence level.

Table 2: Stock Indices regressed over Moderating Variables

	Belgium	France	Germany		Netherlands	Portugal	
Estimation (a)							
Intercept	0.0006	0.0014	0.0045		0.0001	-0.0033	
	(1.18)	(0.40)	(1.06)		(0.02)	(-0.59)	
MSxCPI	-209.74	75.202	62.003		-103.36	371.02	*
	(-1.08)	(0.55)	(0.55)		(-1.10)	(1.86)	
R^2	0.0052	0.0014	0.0014		0.0055	0.0154	
Adj. R^2	0.0007	-0.0031	-0.0031		0.0010	0.0109	
Estimation (b)							
Intercept	0.0008	0.0013	0.0045		0.0000	-0.0024	
	(0.23)	(0.38)	(1.08)		(0.00)	(-0.43)	
IRxMS	-1.7486	5.9569	25.645	(*)	3.1202	51.236	***
	(-0.24)	(0.78)	(1.62)		(0.51)	(2.58)	
R^2	0.0002	0.0027	0.0117		0.0012	0.0293	
Adj. R^2	-0.0043	-0.0018	0.0073		-0.0034	0.0250	

The table reports two separate OLS estimations for each country, where the stock index was set as a dependent variable and regressed over the moderating variables MSxCPI and IRxMS respectively. Regression coefficients are shown on top and t-ratios are reported underneath.

NB. *** and * denote statistical significance at the 99% and 90% confidence level respectively. (*) denotes that the variable is *nearly* significant at the 90% confidence level.

Table 3: Summary of VAR Models (Index – Inflation)

Country: Belgium — **Order of VAR: 1**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
CPI	INDEX $_{(t-1)}$	0.0070	1.91	*	0.0547

Country: France — **Order of VAR: 11**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	CPI $_{(t-6)}$	-5.4073	-2.39	**	0.1381
INDEX	CPI $_{(t-8)}$	-4.4002	-2.19	**	0.1381
INDEX	CPI $_{(t-9)}$	-3.1779	-1.73	*	0.1381
INDEX	CPI $_{(t-10)}$	-3.0308	-1.93	*	0.1381
CPI	INDEX $_{(t-1)}$	0.0074	2.12	**	0.7522

Country: Germany — **Order of VAR: 11**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
CPI	INDEX $_{(t-1)}$	0.0054	1.75	*	0.7902
CPI	INDEX $_{(t-2)}$	0.0051	1.67	*	0.7902

Country: Netherlands — **Order of VAR: 11**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
CPI	INDEX $_{(t-6)}$	-0.0060	-1.81	*	0.8279
CPI	INDEX $_{(t-9)}$	0.0089	2.66	***	0.8279

Country: Portugal — **Order of VAR: 11**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	CPI $_{(t-4)}$	-4.3560	-1.90	*	0.1511
INDEX	CPI $_{(t-7)}$	-4.4342	-1.71	*	0.1511
INDEX	CPI $_{(t-9)}$	-4.1281	-1.91	*	0.1511
CPI	INDEX $_{(t-6)}$	0.0100	3.58	***	0.7997

The table summarises the VARs which model the relationship between stock prices and CPI for the respective countries. Only the significant lags in the models are reported.

NB. *t-i* denotes the '*i*'-th lag, while ***, ** and * denote statistical significance at the 99%, 95% and 90% confidence level respectively.

Table 4: Summary of VAR Models (Index – Industrial Production)

Country: Belgium **Order of VAR: 4**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
IPI	INDEX $_{(t-2)}$	0.0659	2.23	**	0.2322
IPI	INDEX $_{(t-3)}$	0.0528	1.78	*	0.2322
IPI	INDEX $_{(t-4)}$	0.1059	3.61	***	0.2322

Country: France **Order of VAR: 3**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
IPI	INDEX $_{(t-1)}$	0.0303	1.79	*	0.1951
IPI	INDEX $_{(t-2)}$	0.0386	2.27	**	0.1951
IPI	INDEX $_{(t-3)}$	0.0350	2.03	**	0.1951

Country: Germany **Order of VAR: 3**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
IPI	INDEX $_{(t-1)}$	0.0542	3.43	***	0.1949
IPI	INDEX $_{(t-2)}$	0.0294	1.81	*	0.1949
IPI	INDEX $_{(t-3)}$	0.0349	2.15	**	0.1949

Country: Netherlands **Order of VAR: 2**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
IPI	INDEX $_{(t-2)}$	0.0749	3.00	***	0.1330

The table summarises the VARs which model the relationship between stock prices and IPI for the respective countries. Only the significant lags in the models are reported, and VARs without significant lags are not shown on the table.

NB. *t-i* denotes the '*i*'-th lag, while ***, ** and * denote statistical significance at the 99%, 95% and 90% confidence level respectively.

Table 5: Summary of VAR Models (Index – Interest Rates)

Country: Belgium — **Order of VAR: 4**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	IR $_{(t-2)}$	0.0575	1.73	*	0.1153

Country: Germany — **Order of VAR: 1**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
IR	INDEX $_{(t-1)}$	0.1204	2.04	**	0.0671

The table summarises the VARs which model the relationship between stock prices and IR for the respective countries. Only the significant lags in the models are reported, and VARs without significant lags are not shown on the table.

NB. *t-i* denotes the '*i*'-th lag, while ** and * denote statistical significance at the 95% and 90% confidence level respectively.

Table 6: Summary of VAR Models (Index – Money Supply)

Country: Belgium — **Order of VAR: 8**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	MS $_{(t-6)}$	2.2212	1.70	*	0.1775
INDEX	MS $_{(t-7)}$	2.8000	2.52	**	0.1775
MS	INDEX $_{(t-8)}$	0.0149	2.52	**	0.5036

Country: Netherlands — **Order of VAR: 8**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	MS $_{(t-7)}$	2.4796	1.90	*	0.1160
MS	INDEX $_{(t-5)}$	0.0099	2.00	**	0.4967
MS	INDEX $_{(t-8)}$	0.0110	2.23	**	0.4967

Country: Portugal — **Order of VAR: 4**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
MS	INDEX $_{(t-4)}$	-0.0070	-2.12	**	0.4599

The table summarises the VARs which model the relationship between stock prices and MS for the respective countries. Only the significant lags in the models are reported, and VARs without significant lags are not shown on the table.

NB. *t-i* denotes the '*i*'-th lag, while ** and * denote statistical significance at the 95% and 90% confidence level respectively.

Table 7: Summary of VAR Models (Index – Moderating Variables)

Panel A:

Country: Belgium — **Order of VAR: 4**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
MSxCPI	INDEX $_{(t-2)}$	-6.5E-05	-2.75	***	0.1001
MSxCPI	INDEX $_{(t-3)}$	4.4E-05	1.82	*	0.1001

Panel B:

Country: France — **Order of VAR: 4**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	IRxMS $_{(t-1)}$	16.8300	2.18	**	0.0601

Country: Germany — **Order of VAR: 1 #**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	IRxMS $_{(t-1)}$	31.5670	1.98	**	0.0215

Country: Portugal — **Order of VAR: 1**

Dependent Variable	Explanatory Variable	Coefficient	T-ratio		R^2:
INDEX	IRxMS $_{(t-1)}$	-45.6764	-2.28	**	0.0453

The table summarises the VARs which model the relationship between stock prices and MSxCPI (Panel A) and IRxMS (Panel B) for the respective countries. Only the significant lags in the models are reported, and VARs without significant lags are not shown on the table.

NB. *t-i* denotes the '*i*'-th lag, while ***, ** and * denote statistical significance at the 99%, 95% and 90% confidence level respectively.

In this case, the AIC suggested that the optimal VAR would feature no lags. Given that the intention is to model lead-lag effects, we chose a VAR(1) model instead.

Table 8: Multiple Breakpoint Tests

							A	B	C	D	
Country	Indep. Variable	Dep. Variable	No. of breaks	Break date 1	Break date 2	Break date 3	*Scaled F-statistic*	*Scaled F-statistic*	*Scaled F-statistic*	*UDMax statistic*	*WDMax statistic*
Belgium$^{\#}$	*INDEX* $_{(t-1)}$	CPI	*1*	2008M09	-	-	*15.99**	*15.99**	*15.99**	*15.99**	*15.99**
Belgium$^{\#}$	IR $_{(t-2)}$	*INDEX*	*3*	*2003M04*	*2006M04*	*2009M03*	*6.64*	*6.64*	*18.72**	*10.30*	*14.13**
Belgium	MS $_{(t-6)}$	*INDEX*	*2*$^{\$}$	*2003M04*	*2007M06*	-	*5.46*	*5.46*	*5.46*	*10.70*	*12.59*
Belgium	MS $_{(t-7)}$	*INDEX*	*3*	*2003M04*	*2006M04*	*2009M03*	*5.23*	*5.23*	*15.33**	*9.60*	*13.17**
France	CPI $_{(t-6)}$	INDEX	*3*$^{\$}$	*2003M04*	2006M04	2009M03	8.24	8.24	8.24	8.92	12.01
France	CPI $_{(t-9)}$	INDEX	*3*$^{\$}$	2002M10	2006M04	2010M07	*7.50*	*7.50*	*7.50*	*7.50*	*11.57*
France	CPI $_{(t-10)}$	INDEX	*3*	*2003M04*	*2007M06*	*2012M07*	10.15	10.15	10.15	10.54	13.63*
France	INDEX $_{(t-1)}$	IPI	1	2008M08	-	-	12.98*	12.98*	12.98*	12.98*	12.98*
France	INDEX $_{(t-2)}$	IPI	1	2011M01	-	-	13.57*	13.57*	13.57*	13.57*	13.57*
Germany$^{\#}$	INDEX $_{(t-1)}$	IPI	1	2012M05	-	-	12.30*	12.30*	12.30*	12.30*	12.30*
Germany	INDEX $_{(t-3)}$	IPI	2	2005M09	2009M05	-	6.97	6.97	15.04*	10.39	12.23
Portugal	IRxMS $_{(t-1)}$	INDEX	1	2014M12	-	-	11.94*	11.94*	11.94*	11.94*	11.94*
Netherlands$^{\#}$	INDEX $_{(t-6)}$	CPI	1	2010M03	-	-	13.76*	4.12	13.76*	13.76*	13.76*
Netherlands$^{\#}$	MS (t-7)	INDEX	2	2003M04	2007M04	-	3.40	3.40	20.26*	12.62*	14.85*

Notes: 1. * denotes significance at the 5% level, based on Bai-Perron (Econometric Journal, 2003) critical values.
2. Column A: Bai-Perron tests of L + 1 vs. L sequentially determined breaks;
3. Column B: Bai (1997) tests of breaks in all recursively determined partitions;
4. Column C: Bai-Perron tests of L + 1 vs. L globally determined breaks;
5. Column D: Bai-Perron tests of 1 to M globally determined breaks (The sup F type test has the null hypothesis of no structural breaks (m = 0) versus the alternative hypothesis that there are m = k breaks.); the double maximum test specifies a null hypothesis of UDmax and WDmax of no structural breaks against an unknown number of breaks given some upper bound M;
6. In all the tests, we have allowed error distributions to differ across breaks, i.e. to specify different error distributions for different regimes.
7. Most of the identified number of break point(s) and break date(s) are consistent across four different tests.
8. $^{\#}$ The structural breaks found are based on contemporaneous relationship; $^{\$}$: According to the Bai-Perron tests of 1 to M globally determined breaks significant scaled F-statistic largest breaks.
9. Tests results for those relationships where no structural breakpoints were evident are omitted for the sake of brevity.

Table 9: Changes in significant VAR lags over different sub-periods					
Relationship	Comment	*Sub-period 1*	*Sub-period 2*	*Sub-period 3*	*Sub-period 4*
Belgium: INDEX $_{(t-1)}$ – CPI	Only significant in one sub-period; Consistently positive relationship	0.0013 (0.22)	0.0114 ** (2.52)	- -	- -
Belgium: IR $_{(t-2)}$ – *INDEX*	No longer significant in sub-periods; Consistently positive relationship	0.2789 (1.00)	0.0022 (0.02)	0.2923 (0.87)	0.0424 (1.52)
Belgium: MS $_{(t-6)}$ – *INDEX*	Only significant in one sub-period; Reversal of sign in one sub-period	3.0798 (0.99)	-3.8323 * (-1.78)	2.1633 (1.10)	- -
Belgium: MS $_{(t-7)}$ – *INDEX*	No longer significant in sub-periods; Reversal of sign in one sub-period	3.3922 (1.28)	-0.7320 (-0.30)	7.9939 (1.58)	1.6798 (1.14)
France: CPI $_{(t-6)}$ – INDEX	Only significant in one sub-period; Reversal of sign in one sub-period	-17.9381 (-1.53)	-5.4482 (-1.16)	2.8991 (0.46)	-6.0839 ** (-2.20)
France: CPI $_{(t-9)}$ – INDEX	Only significant in one sub-period; Reversal of sign in two sub-periods	4.2551 (0.35)	1.4282 (0.41)	-4.5324 (-0.98)	-4.3317 * (-1.79)
France: CPI $_{(t-10)}$ – INDEX	Only significant in one sub-period; Reversal of sign in one sub-period	2.6575 (0.29)	-1.1112 (-0.51)	-3.2205 (-0.80)	-3.9938 * (-1.95)
France : INDEX $_{(t-1)}$ – IPI	Only significant in one sub-period; Reversal of sign in one sub-period	-0.0309 (-1.49)	0.1000 *** (3.90)	- -	- -
France : INDEX $_{(t-2)}$ – IPI	Only significant in one sub-period; Reversal of sign in one sub-period	0.0672 *** (3.32)	-0.0318 (-1.12)	- -	- -
Germany: INDEX $_{(t-1)}$ – IPI	Only significant in one sub-period; Consistently positive relationship	0.0510 *** (2.76)	0.0351 (0.98)	- -	- -
Germany: INDEX $_{(t-3)}$ – IPI	Only significant in one sub-period; Consistently positive relationship	0.2043 (1.66)	0.1610 *** (3.21)	0.0145 (0.54)	- -
Portugal: IRxMS $_{(t-1)}$ – INDEX	No longer significant in sub-periods; Consistently negative relationship	-35.5150 (-1.61)	-56.4600 (-0.97)	- -	- -
Nether. : INDEX $_{(t-6)}$ – CPI	Only significant in one sub-period; Consistently negative relationship	-0.0067 * (-1.78)	-0.0044 (-0.50)	- -	- -
Nether. : MS (t-7) – INDEX	No longer significant in sub-periods; Reversal of sign in one sub-period	2.4527 (0.73)	-0.5825 (-0.23)	2.8890 (1.63)	- -

The table reports the changes across different sub-periods for those relationships where structural breakpoints were detected. The main insight for each case is summarised by a comment. For each sub-period, we also report the coefficient of the particular lag and the t-ratio in brackets.

NB. *t-i* denotes the '*i*'-th lag, while ***, ** and * denote statistical significance at the 99%, 95% and 90% confidence level respectively.

Table 10: Pesaran-Timmermann Tests

Country	Variables	Test Statistic	
Belgium	INDEX $_{(t-1)}$; CPI	1.214	
France	INDEX ; CPI $_{(t-6)}$	-1.062	
France	INDEX ; CPI $_{(t-8)}$	-1.745	*
France	INDEX ; CPI $_{(t-9)}$	0.247	(a)
France	INDEX ; CPI $_{(t-10)}$	-0.926	
France	INDEX $_{(t-1)}$; CPI	1.568	
Germany	INDEX $_{(t-1)}$; CPI	0.053	
Germany	INDEX $_{(t-2)}$; CPI	0.259	
Netherlands	INDEX $_{(t-6)}$; CPI	-2.447	**
Netherlands	INDEX $_{(t-9)}$; CPI	1.593	
Portugal	INDEX ; CPI $_{(t-4)}$	-0.761	
Portugal	INDEX ; CPI $_{(t-7)}$	1.928	* (a)
Portugal	INDEX ; CPI $_{(t-9)}$	0.159	(a)
Portugal	INDEX $_{(t-6)}$; CPI	0.391	
Belgium	INDEX $_{(t-2)}$; IPI	1.311	
Belgium	INDEX $_{(t-3)}$; IPI	0.162	
Belgium	INDEX $_{(t-4)}$; IPI	0.038	
France	INDEX $_{(t-1)}$; IPI	0.522	
France	INDEX $_{(t-2)}$; IPI	1.807	*
France	INDEX $_{(t-3)}$; IPI	-0.563	(a)
Germany	INDEX $_{(t-1)}$; IPI	2.102	**
Germany	INDEX $_{(t-2)}$; IPI	0.526	
Germany	INDEX $_{(t-3)}$; IPI	1.420	
Netherlands	INDEX $_{(t-2)}$; IPI	0.889	
Belgium	INDEX ; IR $_{(t-2)}$	0.917	
Germany	INDEX $_{(t-1)}$; IR	1.731	*
Belgium	INDEX ; MS $_{(t-6)}$	1.028	
Belgium	INDEX ; MS $_{(t-7)}$	1.950	*
Belgium	INDEX $_{(t-8)}$; MS	1.422	
Netherlands	INDEX ; MS $_{(t-7)}$	3.026	***
Netherlands	INDEX $_{(t-5)}$; MS	0.196	
Netherlands	INDEX $_{(t-8)}$; MS	1.632	
Portugal	INDEX $_{(t-4)}$; MS	-2.580	***
Belgium	INDEX $_{(t-2)}$; MSxCPI	-1.007	
Belgium	INDEX $_{(t-3)}$; MSxCPI	1.487	
France	INDEX ; IRxMS $_{(t-1)}$	2.520	**
Germany	INDEX ; IRxMS $_{(t-1)}$	2.700	***
Portugal	INDEX ; IRxMS $_{(t-1)}$	-1.463	

The table reports Pesaran-Timmermann Test statistics for lead-lag relationships which proved significant in the VAR models of Section 5. The test statistics are normally distributed with critical values of 2.58, 1.96 and 1.65 for the 99%, 95% and 90% confidence level respectively. *t-i* denotes the '*i*'-th lag while ***, ** and * denote significance at the 99%, 95% and the 90% confidence level respectively.

(a) The sign of the test statistic is opposite of the coefficient of the particular lag in the respective VAR. This may be explained by the fact that the Pesaran-Timmermann tests are based on the exclusive interaction between the respective variables at the specified time lags, whereas the VARs include additional lags and variables.