

Asymmetries and the Effect of Macroeconomic News on Stock Market Volatility: An Empirical Examination of the Warsaw Equity Market

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Abstract

In this paper the volatility of the Polish stock market over the period 1991 to 1997 is investigated using the GARCH estimation method. Over this period the Warsaw stock exchange was re-established, in addition to financial sector reform, the modernization of corporate enterprises, the restructuring of the Polish economy and the gradual listing of newly privatized firms on the market. As a result of these developments, it would be expected that macroeconomic news announcements on inflation, money supply figures, and industrial production would bear influence on stock prices. One means of assessing the effect of macroeconomic news on stock prices is by investigating stock market volatility, with particular emphasis on its main drivers and responses to shocks. Using daily returns on the WIG index, the evidence points to substantial asymmetries in the dynamics of daily price changes within the market while additional tests on monthly data indicate that the volatility process is strongly conditioned by the impact of macroeconomic news. It is also discovered that forecasts for inflation and growth of the monetary base are significant factors having a strong impact on market volatility.

Keywords: Asymmetry; Macroeconomic news; Volatility; Warsaw stock market

JEL classification: G14, G15

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1. Introduction

The transitory behaviour of stock market volatility has preoccupied economists since the 1980s,¹ yielding a rich array of empirical financial research on causality, particularly with regard to the causes of volatility, the persistence of shocks to volatility, and the speed of transmission of volatility across international markets. Using a variety of empirical methods, most of the empirical studies in this area relate stock market volatility to a range of financial and macroeconomic conditions. For example, Merton (1980) and French et al. (1987) relate stock market volatility to the volatility of expected returns, while Black (1976) and Christie (1982) relate stock market volatility to financial leverage. They argued that a fall in stock prices motivates an increase in the debt to equity ratio (i.e., financial leverage) of the firm, while the risk and volatility as a measure of risk related to the firm increases afterwards. In addition, Cambell and Hentschel (1992) contend that ‘volatility feedback’ is the main explanatory factor behind the negative relationship between return shocks and volatility. According to this approach, an anticipated increase in perceived risk induces a high-risk premium on the stock leading to an immediate fall in the stock price. In other words, if the expected stock return increases when its volatility increases, then the stock price must fall as a result of the effect of volatility increases. For their part, Schwert (1989) and Poon and Taylor (1992) conduct a battery of tests on the macroeconomic causes of stock market volatility, while Malliaris and Urrutia (1992), Chan et al. (1992), and Rahman and Yung (1994) lend themselves to the transmission of

¹ See Schwert (1989, 1990) and Bollerslev et al. (1992) for an overview of the literature.

volatility across markets. These studies measure risk by the volatility of the asset under investigation, though the results themselves tend to be far from conclusive. The collection of mixed results posit that negative shocks to the market lead to larger return volatility than positive shocks of a similar nature; see inter alia Christie (1982), Poterba and Summers (1986), French et al. (1987), Campbel (1987), Chou (1988), Baillie and DeGennaro (1990), Lamoureux and Lastrapes (1990), Schwert (1989, 1990), Nelson (1991), Poon and Taylor (1992), Glosten et al. (1993), and Kim and Kon (1994).²

Of this extensively referenced studies Poon and Taylor (1992), using daily, weekly, fortnightly, and monthly returns, documented persistence in volatility in the UK stock market, while Poterba and Summers (1986) by investigating the time series property of volatility argued that shocks to volatility must persist for a very long time in order for volatility to have a significant effect on stock prices. If shocks to volatility are only transitory, then the market will make no adjustments of the future discount rate. Therefore, expected stock returns are not affected by the volatility moment. Similarly Schwert (1989) examined a number of factors that could potentially influence stock volatility, but found only a weak link between stock volatility and the influence of macroeconomic variables, though he is able to demonstrate that financial leverage and trading volatility influence stock volatility.³ A sub sample of this literature also investigates the intertemporal relation between expected returns and volatility, i.e., market risk. Specifically empirical evidence reported in Malkiel (1979) and Pindyck (1984) indicate that much of the decline in U.S. stock prices during the 1970s and 1980s owes much to volatility increases, while the empirical analysis of Bollerslev et al. (1988)

² Chou (1988) for example, found that persistence of shocks to stock returns volatility was high in the US market during the sample period examined. On the other hand, Lamoureux and Lastrapes (1990) provide evidence that demonstrates that persistence of shocks may well be overstated owing to possible structural shifts in the parameters of the model.

³ Similar conclusions are advanced by Cutler et al. (1989) who note that macroeconomic news can only explain between one-fifth and one-third of the movements of a stock market index and that, moreover, it is difficult to connect major movements in the market to releases of economic or other information.

indicates that the conditional volatility of stock market returns tends to affect their expected value in more significant ways than expected. On the other hand French et al. (1987) and Baillie and DeGennaro (1990) find only a mild and tenuous relationship between stock market volatility and expected returns when using a Generalized Autoregressive Conditional Heteroscedasticity model with mean effects (GARHC-M).

Although the above studies have enhanced our understanding of the causes of stock market volatility and its change over time for a select number of mature capital markets, which are characterized by high levels of liquidity, informed investors with access to reliable information and few institutional obstacles. To our knowledge, the extant literature does not furnish findings on this issue for central and eastern European emerging capital markets, such as Poland. Furthermore, very little research has been conducted on the general applicability of the models that have been advanced by the literature for testing volatility in mature capital markets to emerging central and east European markets. A general belief about equities in emerging markets is that they have vastly different characteristics from equities in mature markets and exhibit higher volatility compared to mature, well-organized, and more efficient capital markets such as the London stock market⁴. More important, since the stability of an economy is much related to the stability of its financial market, volatility of financial markets could be due to macroeconomic news announcements such as inflation, money supply figures, industrial production data and other government policy announcements? Indeed, many market participants believe that such news ultimately impact financial markets.

The intent of this paper is to investigate whether volatility patterns observed between the period 1991 and 1997 can be ascribed to shock dependence, and whether the arrival of information reflecting the underlying economic conditions (money supply,

⁴ In addition, emerging market are characterised by much higher average returns, limited correlation with developed capital market returns and higher predictability.

inflation and industrial production) has a role in driving market volatility, and by so doing shed light on some of the issues earlier discussed, particularly in view of the evidence reported for a sample of Pacific Rim economies; see Divecha et al. (1992), Cheung and Ho (1991) and Cheung (1993). The period under study covers several political and market events, with the mass privatisation of state owned firms, the expansion of the Polish stock market, the liberalization of the financial system, the modernization of corporate enterprises and the restructuring of the Polish economy being the most notable highlights. An examination of the features of the Polish stock market's WIG index return volatility, using a selection of the GARCH family of models, with particular emphasis on its main drivers and responses to shocks will not only shed light onto an important area of the finance literature, but its findings should also be of interest to policy makers, mutual funds, and other institutional and private investors interested in investing in Polish stocks. After all, from the perspective of mutual funds, and other institutional investors, issues such as the optimal proportion of Polish stocks to include in an internationally diversified portfolio, as well as the influence of volatility in the Warsaw stock market (WSM) on portfolio risk will be an important consideration; see Gooptu (1993) and Howell (1993).

In this paper, we model *ex post* volatility as an 'augmented' Generalised GARCH process (Bollerslev, 1986, Bollerslev et al., 1992).⁵ This has the added advantage of enabling us to reflect on the applicability of GARCH models in modelling the volatility process of an emerging equity market. The results of our analysis suggest that, purely from the perspective of asymmetric volatility, macroeconomic news explain stock market volatility. The findings also demonstrate the link between stock market behaviour and the macroeconomic environment by showing how unexpected developments in the Polish economy, be they revealing changes in fundamentals or new equilibrium rate of returns

⁵ GARCH models are common in studies of stock market data from industrial economies.

or just imperfections in economic agents' forecasting models, are likely to impact the volatility of the market significantly. The remainder of this paper is organized as follows. Section 2 briefly discusses the major developments and structure of the WSM since it was reopened in July 1991. Section 3 summarise the main features of the data. Section 4, outlines the basic empirical methodology for investigating Polish stock market volatility using the GARCH estimation method and discusses the test results for asymmetric responses to stock price movements. Section 5 estimates and discusses the results of the effect of macroeconomic news on returns volatility. Finally, Section 6 concludes the paper.

2. Developments and Structure of the Warsaw Equity Market

This section provides a brief overview of the major changes and developments in Poland that enabled the only stock market, the WSM, to achieve the relative success that it has within such a short period of time. The origins of change giving rise to the re-launch of the WSM can be traced back to October 1990 when the Polish government passed laws allowing the mass privatisation of state owned firms. The objective of the privatisation programme was to privatise 15 to 20 firms in the first year only, with many more to follow as the privatisation process took firm effect. For their part, foreign investors were allowed to purchase at most a 10 percent share in each privatised firm with a possibility of purchasing additional shares following flotation. The shares of the first five firms to be privatised during the first stage of the process went on sale on December 1 1990.⁶

⁶ These were Exbund (a construction service company), Tonsil (a consumer electronics enterprise), Krosno (a glass making firm), Slaska Fabryka Kabli (a producer of wire cable), and Prochnik (a garment manufacturer). At Tonsil, Krosno, and Exbund, employees were offered one fifth of the shares and, in the case of four of these firms, the government continued to hold a 30 percent share of the capital.

Although embryonic, these shares paved the way for the WSM to be launched and to subsequently play a pivotal role in the privatisation programme. The WSM was to provide an effective instrument with which to measure the value of public companies, and an efficient mechanism through which new capital could be raised. This, in turn, helped to stimulate economic growth as well as to facilitate the modernisation of corporate enterprises and the restructuring of the Polish economy more generally.⁷

Operationally, the WSM operates an order driven system with quantity constraints, where there is a 10 percent limit imposed on the movement of prices from one day's trading to the next. At the outset, the only shares traded on the WSM were those of the five initial firms that had been sold. As the privatisation process accelerated, increasingly more shares of private companies were listed on the market. The framework of privatisation, largely based on the British model, was at first rather sluggish and gave way to discussions of other methods, such as direct sales of shares to foreign firms and mass privatisation, which was fully implemented in 1995.⁸ Since then, the WSM has flourished, attracting over 40 broking houses, as well as over 600,000 investors and a number of newly-listed companies which in turn have used the market as a mechanism to generate new capital. In 1993, the relative performance of Poland's listed companies helped to engineer a substantial rise in the WIG Index of well over 700 percent, resulting

⁷ To be listed on the exchange, a company must have conformed to the specific standards outlined by the Polish Securities Exchange Commission, the most important one being the adequate release of information. Companies listed on the stock exchange must make a public announcement of any information likely to affect share price within 24 hours. Price sensitivity information is released to both the Securities Commission and the PAP press agency. Companies must also submit preliminary copies of interim and full-year financial information to the Securities Commission.

⁸ Frydman et al. (1993) provides further details on the operation of the stock exchange and the place of joint stock companies and public offerings in Poland's privatization program.

in an inflow of new institutional investors attracted to the investment potential of Polish stocks and by the performance of the WSM.⁹

Though still developing, the WSM has attracted increasing attention from both domestic and international investors. In particular, the expansion of the stock market has, since it was re-launched, been remarkable not only in terms of trading volume and listed firms but also in terms of total market capitalisation. For example, total stock market volume of 6,691 in 1995 was significantly larger than in 1993 (3,973), while listed companies and market capitalisation were 65 and 11,259, respectively, as opposed to 22 and 5,803 in 1993. This performance not only emphasises the exceptional performance of the market but also the growing importance of the WSM to the Polish economy. As the programme of mass privatisation proceeded, National Investment Funds, which had themselves a controlling interest in 30 or more enterprises as well as residual holdings in many other firms, were gradually listed on the market. The actual unfolding of this process was to further increase the growth of market capitalisation to higher than expected levels, and now it accounts for more than 30 percent of Poland's gross domestic product.

Regarding market composition, the Warsaw stock market consists of equities with solid earnings, specifically companies that are not merely the remains from the socialist era. Overall, and in the context of the general performance of the WSM over the period marked by the data, it is expected that as more shares are listed and trading volumes grow, there will be significant inflows of much needed foreign capital to meet the needs of an economy, which still remains short of capital today.

⁹Notably, the programme of wholesale privatisation of state-owned enterprises, the restructuring of the corporate sector, and the opening up of different sectors of the economy to foreign investors proved to be a catalyst. Thus private investors and multinational enterprises perceive the economy alike as being potentially somewhat of a good bet, in terms of risk/return relationship.

During its short period of operation, the market demonstrated trading, regulatory, and other characteristics of a more developed rather than an emerging capital market.¹⁰ Therefore, the study of the volatility on the WSM becomes even more important if only because the Polish economy is in a process of transition towards a market based economy. In addition, the economy is small, and Polish firms are, in the main, price takers in world markets and thus are more likely to react to trading conditions rather than to bear influence on these conditions. This is quite different from the major stock markets of advanced economies of the European Union, of which Poland is a recent member; there may be volatility trends and observations that are particularly unique to the WSM. Additionally, and especially since the mid 1990s, Poland has attracted a considerable share of foreign investment, partly as a result of the privatisation programme and because of market liberalisation; this growing internationalism in the Polish economy may have had some implications for volatility estimates in recent years.

3. Data and Preliminary Analysis

The data used in this study consists of daily and monthly observations of the stock price index in the Warsaw stock market. The daily series cover the period from April 16, 1991 to July 7, 1997 and was obtained directly from the exchange. The macroeconomic variables used in the latter part of this study include a measure for money supply, a consumer price index (CPI) and an industrial production index. These series range from

¹⁰ The Act on Public Trading of Public Securities and Trust Funds, passed on 22 March 1992, outlined the Polish Securities Exchange Commission's (PSEC) role in shaping the overall development of the Polish stock market. In this document strong reference is made to the governing agency's key responsibilities. They are as follows (The Polish Securities Commission 1993): (i) ensuring the observance of the rules of fair trading and competition in the public trading of securities, (ii) protecting investors and overseeing the efficient operation of the securities market, (iii) disseminating knowledge of the principles which govern the operation of the securities market.

January 1992 through to December 1996 and are taken from the Polish Central Statistical Office Monthly Bulletin. The return on the WSM index (WIG), R_t , is the continuously compounded return defined as follows:

$$R_t = \ln\left(\frac{WIG_t}{WIG_{t-1}}\right)$$

The sample daily return series is plotted in Figure 1.

[Insert Figure 1 Here]

Figure 1 presents the Polish equity returns for the sample period. The figure clearly indicates that there were periods of considerable variability of stock returns overtime. In particular, it is immediately apparent from the plot that the initial period is characterised by significantly higher volatility. In the return series the clustering of fluctuations are consistent with processes where large absolute *ex post* returns are more likely to trigger similarly large shocks (in absolute value), whilst small shocks (in either direction) to expected returns have a higher probability of occurring if preceded by similarly small unexpected changes. This is a typical occurrence for many financial data series.

Table 1 presents the descriptive statistics for the daily return series for the period 1991 to 1997. The first two sections in Table 1 examine the stochastic properties of the log price series. Both the Augmented Dickey-Fuller (1979) (ADF) and the Phillips-Perron (1988) (PP) tests fail to reject the null hypothesis of a unit root.¹¹ Given the marked difference in the patterns observed in the early period of activity and in the later

¹¹ The tests were carried out using 3 lagged first differences, as suggested by the Schwarz Information Criterion.

period, it is possible that the above results are due to structural breaks that might have manifested themselves into changes in both levels and rate of growth, especially in consideration of the exceptional pace at which reforms were enacted over the period marked by the data. The tests were therefore repeated on the log ‘detrended’ series (see Perron, 1989), WIG_d . The results summarised in the second section of Table 1, still point towards the presence of a unit root.

[Insert Table 1 Here]

Next, we examine the distributional properties of the return series. *Ex post* mean returns over the period have been extremely high at about 0.11%. This is not surprising when considered alongside the magnitude of changes observed in the market. With a range of over 11% and a standard deviation of 1.3, the high mean returns may well be compensating for the relatively high risk. Table 1 also reveal positive one-day return of 6.4% and one-day losses of 4.9%. Consistent with the pattern observed in Fig. 1, the distribution of returns is far from Gaussian, as suggested by a Studentised Range value of 8.4. In particular, the distribution appears non-skewed but significantly leptokurtic. Findings of heavily tailed distributions are generally in line with evidence available for developed countries; the lack of skew is, however, somewhat surprising.

There is strong evidence that daily returns are serially correlated. A large value of ρ indicates a strong and positive 1st-order serial correlation whilst the $LB_y(15)$ confirms that the correlation extends up to 15 trading sessions. To confirm the presence of volatility clusters (leptokurtosis), the Ljung-Box test on the squared returns clearly points at the presence of time dependence. Interestingly, evidence of time dependence in the returns distribution is much feebler when returns are calculated on a monthly basis. In

particular, it can be seen from Table 2 below that while the kurtosis measure still points towards fat tails in the series, the evidence from the Studentised Range and from the Ljung-Box test on squared returns suggests that leptokurtosis may not be as pronounced as observed in daily returns.¹²

[Insert Table 2 Here]

4. Testing Methodology: The Volatility Process for Daily Returns

4.1. Basic model Specification

In this section we briefly discuss the GARCH models, estimation and testing procedures, which is considered appropriate for the joint modelling of conditional first and second moments; see for a complete treatment Engle (1982), Bollerslev (1986), Engle, Lilien and Robins (1987), and Bollerslev et al. (1992).¹³ On the premise of this framework, let y_t be a process with conditional expectations $E(y_t | \mathbf{x}_t) = f(\mathbf{x}_t)$. The heteroscedasticity in the error term $\varepsilon_t = y_t - f(\mathbf{x}_t)$ can then be represented as $\varepsilon_t = u_t h_t$, where u_t is a sequence with zero mean and unit variance whilst h_t describes the dependence in the conditional second moments. ARCH and GARCH formulations subsume specific functional forms for h_t . In the analyses that follow, it will be assumed that the sequence u_t is normal and the ensuing models estimated by maximum likelihood. Traditionally, the GARCH(1,1) is adopted for its ease of use, while the more elaborate GARCH(p,q) model is in theory

¹² Unit root diagnostics, not reported, still suggest the presence of a unit root.

¹³ The application of this model can also be found in Bollerslev et al. (1988) and French and Stambaugh (1987) among others.

more appealing. Nelson (1991), for example, points out that an elaborate GARCH model provides similar results to that of GARCH(1,1), which is parsimonious in its parameters. On this basis, we specify the conditional variance of returns as a GARCH (p,q) process which provides a measure of expected or ex-ante volatility and allows for volatility shocks to persist over time. Such a framework has been proved to be ideally suited to examining the volatility of a small stock market such as the WSM; see, for example, Bollerslev et al. (1992), Divecha, et al. (1992), Speidell and Sappenfield (1992), Cheung and Ho (1991), and Sewell et al. (1993).

The identification of the return processes used in this study is achieved by imposing the requirement of ‘well-behaved’ residuals. The observed return behaviour can be approximated reasonably well by a GARCH (2,3) model:

$$\Delta \ln(WIG_t) = \mu + \varepsilon_t, \quad (1)$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, h_t^2), \quad (2)$$

$$h_t^2 = \lambda_0 + \sum_{i=1}^2 \beta_i h_{t-i}^2 + \sum_{j=1}^3 \gamma_j \varepsilon_{t-j}^2, \quad (3)$$

where Ω_t is the conditioning information set and λ_0 , β_i and γ_j are the parameters to be estimated. Under the null hypothesis of independence of daily stock price changes, parameters β_i and γ_j are equal to zero, and errors ε_t are serially uncorrelated with zero mean and constant variance λ_0 . As already mentioned, the model given by Equations 1-3 assumes that u_t is a (conditional) standard normal sequence. Also, the conditional variance of daily stock returns h_t^2 is specified as a linear function of its own lagged 2

conditional variances and the lagged 3 squared residuals. For $p = 0$, equation (3) describes an ARCH(3) process, and, for $p = q = 0$, the variance of daily stock returns is simply a white noise process. This linear GARCH(2,3) process becomes ‘integrated’ (hence referred to as IGARCH) if shocks to the current volatility of stock returns persist. The condition for this to occur is that $\sum\beta_i + \sum\gamma_j = 1$; see Engle and Bollerslev (1986).

4.2. Tests for Asymmetric Responses

In the case of stock prices, volatility may be asymmetric: higher during periods of falling stock prices (bear markets) and lower during periods of rising stock prices (bull markets) (see, for example, Pagan and Schwert, 1990, Engle and Ng, 1991). To investigate the possibility of asymmetric responses to stock price movements, we extend the GARCH model to an Exponential GARCH (EGARCH); see Nelson (1991), Black (1976), and Christie (1982). Nelson (1991) has shown that the magnitude of future volatility tends to be negatively correlated with the direction of actual price changes. However, at an aggregate level, such asymmetries suggest that ex-post market returns may incorporate information regarding informed agent’s overall perceptions regarding economy wide future business conditions – sentiments which may will be reflected in future market volatility. Therefore, we relax the symmetry restrictions and evaluate the following GARCH(2,3) model:

$$\text{(Model 1)} \quad h_t^2 = \lambda_0 + \sum_{i=1}^2 \beta_i h_{t-i}^2 + \sum_{j=1}^3 \gamma_j (|\varepsilon_{t-j}| - \sqrt{2/\pi} - \eta \varepsilon_{t-j}) \quad (4)$$

which allows for positive and negative shocks observed in the previous three periods to have different impacts upon volatility. Exponentiation means that the variance will

remain positive even when the variance parameters are negative. Asymmetric responses can also be modelled, perhaps more simply, as an intercept change in the original GARCH(2,3) triggered by the realisation of a negative return in the previous period. The presence of the lagged conditional variance implies that the effect of the intercept change cumulates through time in a way determined by the coefficient of lagged variance. This ‘augmented’ GARCH model is specified as:

$$(Model\ 2) \quad h_t^2 = \lambda_0 + \sum_{i=1}^2 \beta_i h_{t-i}^2 + \sum_{j=1}^3 \gamma_j \varepsilon_{t-i}^2 + \eta D_{t-1}, \quad (5)$$

where D_{t-1} is a dummy variable taking the value of 1 when the previous period’s *ex-post* return is negative and 0 otherwise.

4.3. Empirical Results and Interpretation of Findings

The results from implementing the models outlined in the previous sections are set forth in Tables 3 and 4. Table 3 contains maximum likelihood estimates of the basic GARCH(2,3) model where responses are assumed symmetric. The Ljung-Box statistics and the tests carried out on the skewness and kurtosis measures suggest the standardised residuals, $\hat{\varepsilon}_t/h_t$, residuals are well behaved and that the model is well specified.¹⁴ Interestingly, the sum of the volatility slope parameters is less than, but quite close to unity, which is consistent with a mean reverting volatility process albeit the evidence may well suggest a tendency towards volatility persistence. The imposition of symmetric

¹⁴ Under the null of i.i.d. normally distributed standardised residuals, the sample skewness and excess kurtosis should be approximately normally distributed with mean 0 and variance $6/\sqrt{T}$ and $24/\sqrt{T}$, respectively. When compared with the raw series, it is clear that the specified model eliminates any significant skew or excess kurtosis.

responses to shocks implied by the use of a standard GARCH structure may be perceived to be at odds with evidence obtained in (mainly) developed stock markets. Nonetheless and in light of the results obtained when the symmetry restriction is relaxed, the expectation that asymmetric responses should be relevant to the WSM remains unmet. Looking at the results summarised in Table 4, it is noticeable that it fails to reveal any trace of asymmetric reaction to shocks. In the EGARCH case (model 1), a significant non-zero estimate for η would have constituted evidence of asymmetries. In particular, for values of $\eta \in (-1,0)$, the increase in volatility would be higher if triggered by a positive surprise, whilst, $\eta < -1$ would imply that a positive surprise would reduce, rather than increase, market volatility.

[Insert Table 3 Here]

The estimate of η in Table 4 is not significantly different from zero; this entails that asymmetric dynamic responses, if any, are not consistent with an EGARCH-type process. Thus an alternative, and more parsimonious, specification of the volatility process also fails to generate evidence of asymmetries in the market's response. According to the 'augmented' GARCH process (model 2), significant and strictly positive values for η would bear the implication that only negative *ex post* returns in the previous period would increase volatility. The estimate reported in Table 4 is not significantly different from zero. But it is immediately evident from the diagnostics provided that asymmetric response models fail to describe sufficiently well certain features of the distribution of (standardised) residuals.

[Insert Table 4 Here]

Although not reported here, the model specification process also examined the possibility that the return realisations on the WSM may be characterised by a time-varying risk premium: ARCH-in-Mean specifications (see Engle, Lilien and Robins, 1987) failed to provide any evidence in this regard.

To summarise, the evidence supplied in Tables 3 and 4 forcefully suggests the presence of time dependence in the volatility observed in the WSM. In particular, the GARCH(2,3) model, with its imposed symmetric market behaviour to surprises, appears well suited to describe such dependence. But the reasons for the existence of this behaviour are, however, difficult to ascertain with the data available.

5. Macroeconomic News Announcements and Volatility

5.1. Model Specification

In this section, we empirically investigate the effects of macroeconomic news announcements on stock returns volatility. Here, the consensus is that stock prices are influenced by a mix of unanticipated events be it of a financial, economic or political nature, some of which tend to have a more pervasive effect on stock prices than others. The information most likely to affect stock prices stems mainly from financial as well as economic announcements, such news about inflation, industrial production, corporate earnings, and national income, among other variables. Significant change in any of these variables are thus likely to bring about changes in the level of stock returns volatility which in turn may have a significant effect upon capital investment and macroeconomic activity, more generally. Along these lines, the categories of macroeconomic variables considered in the analysis of the WSM include measures of money supply, a measure of

inflation (CPI), and industrial production. Although this is a limited set of variables, it does include those macroeconomic variables considered important because their announcements are generally assumed to have an influence on the stock market's aggregate behaviour.

Analysing the impact of news about the state of the macroeconomy imposes the use of monthly, rather than daily, returns and consequently requires the estimation of a new baseline volatility process. The diagnostics presented for the monthly returns series summarised in Table 2 suggests that time dependence is now much weaker than observed in daily returns. Furthermore, while the kurtosis measure still points towards fat tails in the series, the Studentised Range and the Ljung-Box test on squared returns suggests that leptokurtosis in unconditional monthly returns may not be as pronounced. Consequently, the structure of the volatility process may be simpler than the one adopted in the preceding sections. Most notably, we find that the following 'augmented' ARCH(1) model is well suited to the evaluation of the impact of macroeconomic news concerning money supply, prices and industrial production:

$$\Delta \ln(WIG_t) = \mu + \eta_t$$

$$\eta_t \mid \Omega_{t-1} \sim N(0, h_t^2),$$

$$\text{(Model 3)} \quad h_t^2 = \lambda_0 + \beta \eta_{t-1}^2 + \gamma_1 \varepsilon_{t-1} + \gamma_2 \varepsilon_{t-1}^2, \quad (6)$$

where λ_0 , β , γ_1 , and γ_2 are the parameters to be estimated, h_t^2 is the variance of the error term η_t , ε_t is a proxy for 'announcements' about the macroeconomy and ε_t^2 its squared

value. This formulation allows for asymmetric effects of news on volatility. A significant coefficient (γ) for the forecast error would bear the implication that the market reacts differently depending on the sign (as well as the magnitude) of the discrepancy. A non-significant γ accompanied by a significant γ_2 would, on the other hand, substantiate claims that a reduced ability of agents to forecast macroeconomic developments has an impact on stock market volatility. Of course, these results, whilst documenting a statistical regularity in the series, would say nothing about the cause of this reaction. This is because increased return volatility may ensue, for example, on account of lower liquidity in the market or weaker fundamentals than expected or, alternatively, be due predominantly to noise or speculative (i.e. feedback) market traders.

5.2. Empirical Results and Interpretation of Findings

The analysis described above is performed on monthly series of stock index returns and selected macroeconomic indicators recorded in Poland during the period from January 1992 to December 1996. The estimation process consists of two stages. First, we obtain an estimate of the ‘news’ series; second, we estimate the time-varying volatility model.

To estimate the ‘news’ series, we first construct naïve forecasts of growth rates for CPI, M1, M2, (M2-M1) and Industrial Production (Y) by univariate ARMA modelling.¹⁵ Model identification is achieved by way of Box-Jenkins (1976) methodology. The following processes best approximated the series and produced well-behaved residuals:

¹⁵ Although this way of modelling *news* is somewhat *ad hoc*, it allows making the most of the limited data available. More complex, possibly multivariate, models might be more suited but could not be estimated in this particular case. Moreover, increased sophistication in extracting *news* from fundamentals does not appear to sensibly alter the results according to some (see, for example, Copeland, 1989, p. 316).

$$\Delta \ln(CPI_t) = 0.021 + \varepsilon_t^{CPI} + 0.5213\varepsilon_{t-1}^{CPI},$$

$$\Delta \ln(M1_t) = 0.02526 + \varepsilon_t^{M1} + 0.694\varepsilon_{t-1}^{M1},$$

$$\Delta \ln(M2_t) = 0.0297 + \varepsilon_t^{M2} + 0.4\varepsilon_{t-12}^{M2},$$

$$\Delta \ln(M2_t - M1_t) = 0.03117 + 0.4323\Delta \ln(M2_{t-1} - M1_{t-1}) + \varepsilon_t^{M2-M1},$$

$$\Delta \ln(Y_t) = 0.684\Delta \ln(Y_{t-12}) + \varepsilon_t^Y - 0.417\varepsilon_{t-1}^Y.$$

$\hat{\varepsilon}_t^{CPI}$, $\hat{\varepsilon}_t^{M1}$, $\hat{\varepsilon}_t^{M2}$, $\hat{\varepsilon}_t^{M2-M1}$ and $\hat{\varepsilon}_t^Y$ represent deviations from agents' (naïve) forecasts, or 'news', and may therefore be used within the volatility process specified above with a view to investigating to what extent unexpected changes to the macroeconomy are associated with a more volatile stock market environment.

The results are summarised in Table 5.¹⁶ Firstly, the proposed augmented ARCH(1) models eliminate much of the kurtosis present in the raw returns series. Agents' errors in forecasting inflation and money supply growth appear to be relevant drivers of the market's volatility. In particular, whilst industrial production and M1 prove unimportant, underestimating future (next-period) inflation results in higher volatility, possibly because of the implied expectation of excessively high real rates of return and consequent downward revision. On this very issue, Fama (1981) uncovered evidence which points to a negative relationship between inflation and real activity, as well as a

¹⁶ Notably, results for the M1 and Y forecast errors are not reported here since they never entered the model significantly.

positive relationship between stock return and real activity. Here, the negative relationship between stock returns and inflation becomes a proxy for the positive relationship between stock returns and real activity. The increase in stock return volatility following an upward revision of inflation forecasts is reflected in a higher required rate of return on Polish stocks, which in turn induces a fall in stock prices and reduces realised returns.

[Insert Table 5 Here]

In Poland, economic liberalisation and widespread privatisation of state-owned enterprises have almost certainly brought significant changes to the financial system over a short period of reform years. Included in this are also changes to the monetary base through currency convertibility, which would have made future monetary policy more uncertain and ultimately impacted on the perceived risk of financial assets. The evidence in Table 5 specifically points to increased volatility as a result of higher-than-expected monetary (M2) growth, perhaps in correspondence of upward revisions of expected returns triggered by stronger expectations of inflationary pressures in the near future and/or increased market rates induced by the government's open-market operations.

Persistent failure to correctly forecast the growth of less liquid assets (M2-M1) in the financial system also causes volatility to surge. This reaction can be motivated along a similar line of argument to that used to explain the effect of M2 growth. Furthermore, we believe that the reaction prompted by deviations from expectations about the growth of M2-M1 has an alternative explanation. Although imperfect, the difference between 'broad' and 'narrow' money can be interpreted as a measure of financial depth. On this very issue, empirical studies of the relationship between financial market development and economic growth often choose measures of financial sector development that are

based on various monetary aggregates definitions (see, for example, King and Levine, 1993). Thus if we accept that the growth of monetary aggregates is a fair, though imperfect, representation of certain features observed in emerging financial markets, then the difference between broad and narrow definitions of money supply may prove to be quite a refined one. Rather than focussing on all the financial activity encompassed by a broad money measure, this indicator filters the expansion in liquidity out of the definition of financial sector growth to describe the evolution of more sophisticated instruments, possibly coupled with growing confidence in the Polish economy and the financial markets. And whilst this argument may sound irrelevant in the context of developed economies, the use of this proxy in the context of markets at early stages of development may be justified.

Overall, the unforeseen expansion of financial activity in Poland would appear to bear some direct relation to the volatility of the Warsaw stock market, which is not difficult to rationalise, particularly when the exceptional pace of market liberalisation is taken into account. Undoubtedly, the Warsaw stock market has helped to encourage savings by providing individuals with an additional instrument, which may well satisfy their risk preferences and liquidity needs. Significantly, the voucher privatisation programme is clear evidence that the Warsaw stock market provided individuals with a relatively liquid means of sharing risk. But also financial liberalisation, including credit markets, in parallel with the growth of the Warsaw stock market would seem to have helped to speed up the process of transition and thus the growth and development of the economy over the period marked by the data.

6. Conclusions

This paper investigates the volatility of the Warsaw equity market from 1991 through to 1997 in order to uncover patterns and drivers of changes in the WIG index return volatility over the period. GARCH equations are used to examine the effects of macroeconomic news on stock market volatility. Specifically, we find that a GARCH process is well suited to approximate *ex post* daily stock returns and that the underlying process is unlikely to give rise to asymmetric responses to shocks. The estimation results also provide empirical support to the relationship between stock market behaviour and the macroeconomic environment. In particular, it points out how unexpected developments in the economy - whether revealing changes in fundamentals, new equilibrium rate of returns or just imperfections in agents' forecasting models, are likely to significantly impact the volatility of markets. This is perhaps quite telling in light of the exceptional measures introduced to ease market activity and the flow of information on the WSM. A furthermore important point is that as the market opens up even more to international investors and as trading volumes mount, more and better information will be readily available and so wider asset diversification is likely to reduce the need for the liquidation of relatively important positions as economic conditions in the Polish economy change.

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Figure 1

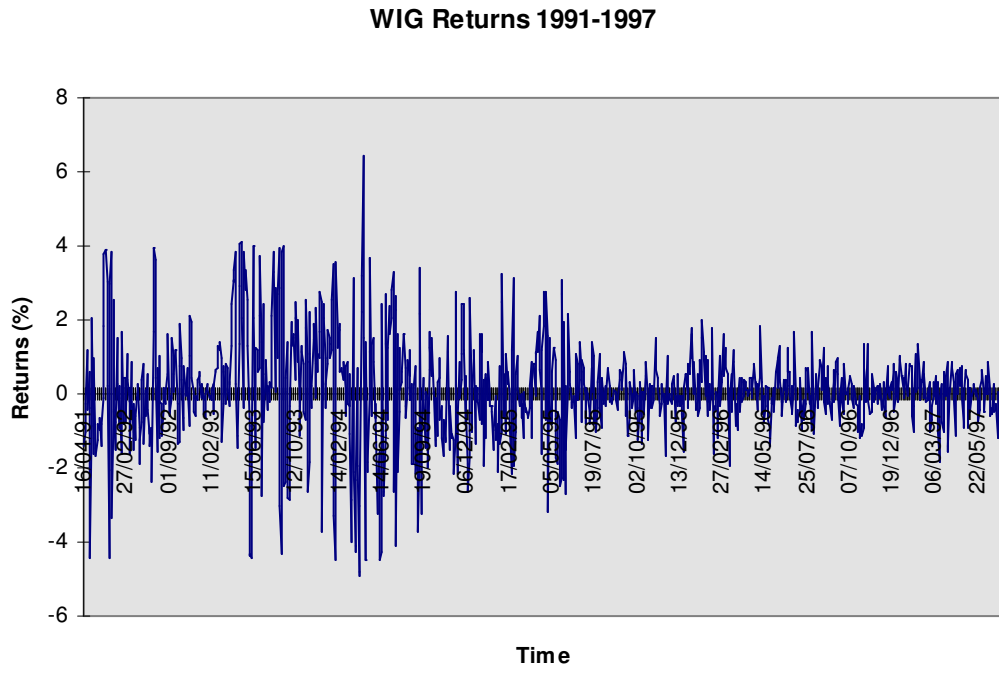


Table 1. Descriptive statistics of daily series ^a (16/04/1991-07/07/1997)

ln(WIG)	
Phillips- Perron	-1.18639
Augmented Dickey-Fuller	-1.3611
ln(WIG)_d	
Phillips- Perron	-3.63271
Augmented Dickey-Fuller	-3.5630
WIG Returns (in %)	
Mean ($\times 10^2$)	0.108483
Max ($\times 10^2$)	6.420197
Min ($\times 10^2$)	-4.92678
Standard Deviation	1.344505
Skewness	-0.0567
Kurtosis	2.42353
Studentised range	8.43952
$\rho(1)$	0.373
LB _y (15)	181.78
LB _{y²} (15)	1557.06

^a The returns series contains 1,102 observations. LB_y(n) and LB_{y²}(n) are Ljung-Box test statistics for serial correlation of up to nth order in the stock index returns and squared returns, respectively. $\rho(1)$ is the 1st- order autocorrelation coefficient.

Table 2. Descriptive statistics of monthly series ^a (January 1992-December 1996)

WIG Returns (in %)	
Mean ($\times 10^2$)	2.008
Max ($\times 10^2$)	31.372
Min ($\times 10^2$)	-18.883
Standard Deviation	8.1258
Skewness	0.6799
Kurtosis	2.5174
Studentised range	6.185
$\rho(1)$	0.1035
$LB_y(3)$	3.839
$LB_{y^2}(3)$	4.822

^a $LB_y(n)$ and $LB_{y^2}(n)$ are Ljung-Box test statistics for serial correlation of up to n^{th} order in the stock index returns and squared returns, respectively. $\rho(1)$ is the 1st-order autocorrelation coefficient.

Table 3. The volatility process

$$\Delta \ln(WIG_t) = \mu + \varepsilon_t$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, h_t^2)$$

$$h_t^2 = \lambda_0 + \sum_{i=1}^2 \beta_i h_{t-i}^2 + \sum_{j=1}^3 \gamma_j \varepsilon_{t-j}^2$$

Parameters and Diagnostics	Estimates
μ t	0.3581×10^{-3} 1.4776
λ_0 t	0.2039×10^{-5} 3.29182
β_1 t	-0.01216 -0.37015
β_2 t	0.841 23.1562
γ_1 t	0.473 7.026
γ_2 t	0.07801 4.1218
γ_3 t	-0.394 -6.57407
Skewness	-0.10647 (.15)
Kurtosis	0.23636 (.11)
LB(15)	8.2947 (.41)
LB(30)	31.46 (.11)

Table 4. Asymmetric responses in the volatility process

$$\Delta \ln(WIG_t) = \mu + \varepsilon_t$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, h_t^2)$$

(Model 1) $h_t^2 = \lambda_0 + \sum_{i=1}^3 \beta_i h_{t-i}^2 + \sum_{j=1}^2 \gamma_j (|\varepsilon_{t-j}| - \sqrt{2/\pi} - \eta \varepsilon_{t-j})$

(Model 2) $h_t^2 = \lambda_0 + \sum_{i=1}^2 \beta_i h_{t-i}^2 + \sum_{j=1}^3 \gamma_j \varepsilon_{t-j}^2 + \eta D_{t-1}$,

$$D_t = 1 \quad \text{if} \quad \Delta \ln(WIG_t) < 0$$

$$D_t = 0 \quad \text{otherwise}$$

Parameters and Diagnostics	Estimates	
	Model 1	Model 2
μ	0.5002×10^{-3}	0.3877×10^{-3}
t	2.05359	1.6306
λ_0	-1.38005	0.3164×10^{-5}
t	-4.97563	3.03634
β_1	-0.5389	-0.01134
t	-7.5989	-0.33742
β_2	0.901256	0.840
t	45.1124	22.669
β_3	0.48775	-
t	6.8587	
γ_1	0.63673	0.472
t	11.77065	7.009
γ_2	0.66304	0.07719
t	11.7669	4.0863
γ_3	-	-0.392
t		-6.5682
η	-0.05838	-0.2346×10^{-5}
t	-1.1545	-1.4128
Skewness	-0.14411 (.051)	-0.1324 (.073)
Kurtosis	0.46196 (.0018)	0.20369 (.169)
LB(15)	14.6918 (.04)	8.0859 (.33)
LB(30)	35.0345 (.038)	31.8456 (.08)

Table 5. Macroeconomic news and stock market volatility

$$\Delta \ln(WIG_t) = \mu + \eta_t$$

$$\eta_t | \Omega_{t-1} \sim N(0, h_t^2)$$

(Model 3) $h_t^2 = \lambda_0 + \beta \eta_{t-1}^2 + \gamma_1 \varepsilon_{t-1} + \gamma_2 \varepsilon_{t-1}^2$

Parameters and Diagnostics	Estimates		
	CPI	M2	M2-M1
μ	0.35495×10^{-2}	0.011816	0.01389
t	0.496	2.254	1.601
λ_0	0.34615×10^{-2}	0.278×10^{-2}	0.1626×10^{-2}
t	3.973	3.701	2.114
β	0.59088	1.0662	0.203
t	2.456	3.265	1.1757
γ_1	0.1577	0.1929	-
t	2.0197	2.866	
γ_2	-	-	16.497
t			2.348
Skewness	0.08756 (.79)	0.16519 (.62)	0.30629 (.35)
Kurtosis	0.75241 (.27)	0.51706 (.45)	0.81317 (.23)
LB(9)	6.3312 (.28)	9.0942 (.11)	4.9045 (.43)
LB(12)	16.7252 (.033)	13.6554 (.09)	5.3316 (.72)