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Dynamic Macroeconomic Effects on the German Stock Market before and after the Financial Crisis

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Abstract

Today we live in a post-truth and highly digitalized era characterized by the flow of (mis-)information around the world. Identifying the impact of this information on stock markets and, moreover, forecasting stock returns and volatilities has become a much more difficult, and perhaps an almost impossible, task purpose. This paper investigates the impact of macroeconomic factors on the German main stock index, the DAX30, for the time period from 1991 to 2016. There are no comparable investigations for the DAX regarding this time period and the GARCH approach in the literature. Using a dataset about 23 variables and over a timeframe of about 25 years, we find evidence that the growth rates of money supply M1 have a strong impact on the stock returns. The results illustrate that in the post-crisis period more macroeconomic factors have a significant impact on the German stock market compared to the pre-crisis period. This implies that in the post-crisis period a macro-driven market is prevailing. In the post-crisis period, however, increasing saving rates, M2 and M3 lead to shrinking stocks values due to higher risk aversion.

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1 Introduction

For as long as stock markets in Europe and the US have existed, traders have tried to investigate and forecast the stock price and the capital markets. Familiar to traders and other interested parties is the finding that macroeconomic factors do indeed influence the stock price, as do corporate results, political situations and branch industry figures. Identifying the impact of this information on stock markets and, moreover, forecasting stock returns and volatilities plays a crucial role in the economic sciences, especially regarding the discussion about the efficient market hypothesis. Since we now live in a post-truth and highly digitalized era where a lot of information flows around the world, it gets more difficult to estimate the markets returns and risks regarding the huge amount of information available or possible factors. Macroeconomic factors, which are the focus of this research, represent (only) a fraction of the variables which have explanatory power vis-à-vis stock returns.

The inflationary era in the 1970s lead researchers to investigate primarily the relationship between stocks and inflation especially for the US stock market. Bodie (1976), Fama and Schwert (1977), Fama (1981), Chen, Roll & Ross (1986) and Pearce and Roley (1983) (1985) have found for the US a negative relationship between inflation and asset returns and found that stocks act as a poor hedge against inflation. Fama (1981) explains the negative relationship with the "proxy effect hypothesis": the negative correlation between inflation and real activity and the positive correlation between real activity and stocks lead jointly to the negative relationship between inflation and stock returns. A further explanation for the negative relationship is given with the "inflation illusion hypothesis" by Modigliani and Cohn (1979): Regarding the Fisher hypothesis, increasing inflation expectations lead to higher discounts of the future expected dividends meaning lower stock values.

Using the Arbitrage Pricing Theory, Chen, Roll & Ross (1986) found for the US stock market that the term strucure spread (difference between long and short term interest rates), expected and unexpected inflation, industry production and the spread between high and low level bonds are significant risk factors for the stock market. Ferson and Harvey (1991) also show similar findings to those of Chen, Roll & Ross (1986). Hamilton and Susmel (1994) investigate not only the equity returns but also their volatilities by estimating Markov-switching GARCH models using the monthly US equity returns and found that the real economic conditions significantly explain the switching from low to high volatility regimes. The investigation shows an increasing incidence of months with high volatility in bust phases. Fama (1990) argued that if equity prices reflect expected future cash flows, equity price changes should predict future macro conditions. Using monthly, quarterly and annual US stock returns, he empirically found for the period of 1953 – 1987 a positive correlation between stock returns and industrial production growth.

The papers written after the 1990s focused more on the announcement effect of macroeconomic factors on stock returns. McQueen and Roley (1993) argue that market participants' reactions to announcement surprises differ at different points of the business cycle in the USA. Thus in boom phases, stock returns respond negatively to higher real activity. The authors explain this finding with the larger increase in discount rates than the increase of expected cash flows, which leads to shrinking stock values in the boom phases. The time dependency of the impact of macro-announcements is also shown by Boyd, Jagannathan and Hu (2001). They found that announcements of higher unemployment have a positive effect on stocks during an economic expansion and have a negative effect during economic contractions. To explain this finding the authors regard higher unemployment as a predictor of lower interest rates and lower corporate profits. The relative strength of these two outcomes differs in boom and bust cycles, so that sign of the unemployment announcement effect is business cycle

dependent. Flannery and Protopapadakis (2002) show that stock market returns are significantly correlated with inflation and money growth. They estimate a GARCH model of daily US equity returns, where realized returns and their conditional volatility depend on 17 macro series announcements. They find six candidates for priced factors: three nominal (CPI, PPI, and a Monetary Aggregate) and three real (Balance of Trade, Employment Report, and Housing Starts). Errunza and Hogan (1998) investigate, via VAR-models markets for 1959-1993, whether macroeconomic factors explain time variation in seven European stock market volatilities. The authors show that money supply volatility has a significant impact on stock volatility in Germany and France and that the volatility of industrial production has an effect on stock market volatility in Italy and the Netherlands. Cheung and Ng (1998) used Johanson's cointegration technique for Germany, Italy, USA, Canada and Japan, and found long-term co-movements between the national stock market and macroeconomic factors including the real oil price, real consumption, real money supply and real GNP output. An international comparison is made in Rapach, Wohar and Rangvid (2005), where the predictive ability of nine macroeconomic factors is tested in 12 industrialized stock markets. Among the factor set, the interest rates are stated to be the most consistent and reliable predictors of stock returns across countries. Ratanapakorn and Sharma (2007) document, using a vector error correction model and Johansen's cointegration technique, that between 1975 and 1999 US stock prices negatively relate to the long-term interest rate. Their results show that industrial production, money supply, inflation, exchange rate and the short-term interest rate have a positive relation to stock prices. Humpe and Macmillan (2009) also use cointegration analysis for the US and Japanese stock markets between 1965 and 2005 to examine the long-term relationship to macroeconomic factors, namely industrial production, consumer price index, money supply and the long-term interest rate. For the Japanese stock market, the authors detect a positive impact of industrial production and a negative impact

of the money supply on stock prices. Further, they show that the consumer price index and the long-term interest rate have a negative effect on industrial production. For the US stock market, they found a positive impact of industrial production and a negative impact of the consumer price index and the long-term interest rate on stock prices. Masuduzzaman (2012) applies Johansen co-integration, error correction model, variance decomposition and impulse response functions to investigate the long-run and the short-run dynamics between macroeconomic factors and stock returns in Germany and the United Kingdom for the period from 1999 to 2011. He found that the consumer price index, interest rates, exchange rates, money supply and industrial production lead to short-term adjustments and to long-term dynamic movements of stock prices.

The main motivation of this research is to detect the macroeconomic factors which have a significant impact on returns of the German stock market DAX30. In particular, we focus on macroeconomic impacts in the pre- and post-crisis period and check whether the market got more "macro-driven" during or after the financial crisis. In particular, we apply the GARCH model using quarterly data from 1991 to 2016 and investigate the delayed and dynamic impacts of macroeconomic factors. Thus, since we use lagged factors, our results also provide conclusions about the market efficiency hypothesis. To the best of our knowledge, comparable investigations for the DAX30, the time period in question and employing the GARCH model do not exist.

2 Data and Variables

For our investigation we work with three separate datasets. The first dataset is comprised of eighteen macroeconomic factors for Germany from Deutsche Bundesbank, European Central Bank (ECB), the Federal Statistical Office

(Statisisches Bundesamt), the Center for European Economic Research (ZEW), Thomson Reuters and the Institute for Economic Research (ifo) from 1991 to 2016. These are:

- GDP
- Exports
- Money supply (M1, M2, M3)
- CPI & PPI
- Effective exchange rates (real & nominal, indirect quotation)
- Unemployment rate
- Savings rate
- Financial account
- 10-year German government bond yields
- Stock levels
- Manufacturing orders
- Industrial production
- Ifo Business Climate Index
- Ifo Business Expectations Index
- ZEW Indicator of Economic Sentiment
- Consumer Confidence Indicator Germany
- Lending to enterprises and individuals in Germany
- Real earnings

The ZEW Index and the Consumer Confidence Index are stationary, whereby the quarterly differences of the 10-year German government bond yields are calculated for further analysis. For the other factors, the quarterly growth rates are calculated and checked for stationarity. If necessary, seasonal adjustments are made using the Census X-13 method.

The second and main dataset relates to the quarter-to-quarter DAX returns from 1991 to 2016, calculated with the DAX-Total-Return Index from Deutsche Börse AG.

The third dataset features data from Thomson Reuters also for the same time period and including the gold and oil prices.

3 Model Specification

GARCH processes differ from homoskedastic models, which assume constant volatility and are used in basic ordinary least squares (OLS) analysis. OLS aims to minimize the sum of squared deviations between data points and a regression function to fit these points. With asset returns, volatility seems to vary during certain periods of time and depends on past variance. By applying an OLS on these heteroskedastic time series, periods with high volatility have a greater impact on the estimation of the coefficients, leading to inefficient coefficients and biased test statistics.

GARCH models handle heteroskedastic time series by modeling simultaneously the returns (mean equation) and the time-dependent changes in volatility (variance equation). By doing so, changes in the volatility are absorbed by the variance equation, so that the coefficients of the mean equation are efficient and unbiased.

The macroeconomic factors are partly highly correlated. Therefore, a common GARCH model, which includes all macroeconomic factors, leads to problems of multicollinearity. In this case, the test statistics are biased and it is impossible to obtain the isolated effect of a factor, which is the aim of the research. To determine the dynamic impact of macroeconomic factor (*MF*) on stock returns (*r*) over several quarters, for each individual factor we run a separate GARCH(1,1) regression. In this way, the estimated coefficients and the test statistics are free of the multicollinearity issue. The mean and variance equations of our approach are as follows:

$$\text{Mean equation:}\quad r_t = \beta_0 + \beta_1 MF_{t-1} + \beta_2 MF_{t-2} + \cdots + \beta_k MF_{t-k} + \varepsilon_t\,, \quad (1)$$

$$\text{with} \quad \varepsilon_t \sim \mathrm{N}(0, \sigma_t^2),$$

$$\text{Variance equation:}\qquad \sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2. \qquad (2)$$

This means that the stock returns are modeled by the last k periods of the macroeconomic factor, whereby the conditional variances of the stock returns σ_t^2 are modelled by the variance and the squared error terms of the prior period.

To measure the joint impact of the lagged macroeconomic factor, we perform the Wald test with the following null hypothesis:

$$\beta_1 + \beta_2 + \cdots + \beta_k = 0. \qquad (3)$$

The calculated test statistic, which follows a χ^2-distribution, reveals not only the significance of the sum of the lagged factor, but also the way in which the macroeconomic factor affects stock returns.

An additional test for the joint significance is the likelihood-ratio test. The test statistic, which also follows asymptotically a χ^2-distribution, is calculated by dividing the likelihood of the GARCH-model with the lagged factors by the likelihood without the lagged factors. A high resulting ratio is an indicator of a significant impact of the lagged factors on stock returns.

4 Discussion of the Results

4.1 Results of the whole time period

First of all, we measure the lagged impact of macroeconomic factors on DAX returns for the whole sample, the results of which are shown in Table 4.1. Both the Wald test and the likelihood ratio test show strong evidence for a significant impact of lagged quarterly growth rates of **M1 on DAX stock returns**. The number of lags included in the GARCH specification is four and, according to the Wald test, the cumulative impact of these lags is positive. This means that the past four quarters jointly have a positive effect on stock returns. An

explanation for this finding can be the excess liquidity caused by expansionary monetary policy, for example open market operations, which leads to increasing bond prices and decreasing interest rates. Considering that stock prices are reflecting the value of discounted future cash flows, lower interest rates lead to higher stock valuations. Additionally, the excess liquidity could increase the demand for stocks, so that stock prices rise. Furthermore, companies benefit from a lower cost of capital and increase their investments, which could have a positive effect on future cash flows and thus on stock returns.

Also positive and with one lag, the quarterly growth rates of **the real and nominal effective exchange rate (NEER, REER)** affect stock returns. Regarding the implications on the goods market, these positive effects appear inconsistent. Since an increase of the REER reflects a relative inflation adjusted appreciation of the domestic currency, and thus a loss in trade competitiveness on the part of domestic firms, corporate sales and earnings decrease along with stock prices. The positive sign measured can be explained from the perspective of a portfolio balance model: a relatively good domestic economic environment (e.g. along with increasing interest rates) attracts inflows of foreign capital, which increases the demand for domestic currency and assets. The significant positive impacts of both REER and NEER corroborate the portfolio allocation effect and shows that the nominal factor has the principal impact on stocks with a delay of one quarter.

An interesting result is the negative impact of the **Consumer Confidence Index on stocks.** This means, a positive mood of consumers leads to decreasing returns in the stock market, which is not consistent with the Keynesian view: higher consumption should lead to higher sales and thus to higher stocks. An explanation for this could be the composition of the DAX30 index with relatively less consumer companies. The negative relation can arise from the inverse relationship of consumer confidence and savings behavior. Lower

consumption leads to higher savings and, as a result, to higher investments. Thus, the supply of capital in financial markets will increase, so that asset prices, including stock prices, tend to increase. Additionally, the higher supply of capital leads to shrinking interest rates, so that the valuations of stocks increase due to the lower discount rate for future cash flows. This finding is consistent with the results of Fisher & Statman (2003), who found for the USA that higher consumer confidence is followed by lower stock returns, and Jansen & Nahuis (2003), who found for Germany that there is a negative correlation between consumer confidence and stock markets.

According to both tests, the one quarter lagged quarterly growth rate of the Ifo Business Expectations Index shows a significant and positive correlation on stocks. This finding is not very surprising since this factor is a leading indicator for expected economic activity and business environment. The interesting thing here is rather the number of lags - with just one quarter - which means that the effect of business expectations on stocks is not very persistent.

The impact of quarterly **German 10y government yield** differences is according to the Wald test significant and negative with three lags, whereby the likelihood ratio test shows less significance. A reason for this finding could here also be the rising (long-term) interest rate, which shrinks the valuation of stocks due to higher discount rates for future cash flows.

A similar explanation pertains to the **Producer Price Index,** whose quarterly growth rates show at least a weak and negative impact on stocks regarding the Wald test: increasing inflation leads to higher nominal interest rates and thus to a devaluation of the present value of expected cash flows. Additionally, higher prices for firms lead to higher costs and lower company earnings. Especially in the case of an elastic demand, the ability of companies to pass these costs on to consumers is very limited.

Factor	Number of lags	Wald-Tests (χ^2)	Direction of the impact	Likelihood ratio
Money supply M1 (in % q-o-q)	4	16.44 *** (0.0001)	+	22.12 *** (0.0002)
Real effect. exch. rate (in % q-o-q)	1	8.83 *** (0.0038)	+	6.17 ** (0.0130)
Nominal effect. exch. rate (in % q-o-q)	1	9.21 *** (0.0024)	+	6.25 ** (0.0125)
Consumer Confidence Index	2	7.24 *** (0.0072)	-	7.16 ** (0.0279)
Ifo Business Expectations Index (in % q-o-q)	1	3.65 * (0.056)	+	3.98 ** (0.0461)
German 10-y gov. yield (q-o-q differences)	3	4.23 ** (0.0396)	-	6.19 (0.1029)
Producer Price Index (in % q-o-q)	2	3.46 * (0.0630)	-	4.47 (0.1072)
Stock level (in % q-o-q)	2	5.21 ** (0.0224)	-	4.00 (0.1352)
Unemployment rate (in % q-o-q)	4	6.18 ** (0.0149)	+	6.73 (0.1509)

Table 4.1: Results of the GARCH estimations for the whole sample, showing significant macroeconomic factors, their lag structure, the Wald test - including the direction of the impact on stock returns - and the likelihood ratio test.

Note: * = 1% significance level; ** = 5% significance level; * = 5% significance level)**

With a lag up to two periods, the quarterly growth rates of the stock level shows, according to the Wald test, a significant and negative impact on stocks. The likelihood-ratio test cannot support the significant impact. Because rising stock levels lead to production without sales, this phenomenon is an exposure for companies and could lead to shrinking stock returns. Moreover, a rising stock level indicates a business cycle downturn, so that company earnings are under

stress. Ostensibly, the effect of the shrinking interest rate in the downturn cycle on stocks remains inapparent.

Although the likelihood-ratio test shows insignificance, the Wald test indicates a significant and positive impact of the quarterly growth rates of the unemployment rate. Remarkable is the relatively long persistence of this effect - spanning four quarters. This finding could be explained by an economic contraction, which leads to higher unemployment rates and lower interest rates and, as a result, to higher discounted cash flows.

4.2 Results Before and After the Financial Crisis

As a next step, we divide the sample into a **pre-crisis period (Q1 1991 – Q2 2007) and a post-crisis period (Q3 2007 – Q2 2016).** Table 4.2 contains the results of taking this approach. At first glance, the results illustrate that in the post-crisis period more macroeconomic factors have a significant impact on the German stock market compared with the pre-crisis period. **This implies that in the post-crisis period a macro-driven market is prevailing.**[1]

The second interesting finding concerns the money supply variables: in the pre-crisis period, the **money supply M2**, which in addition to M1 also includes longer-term deposits, also has a positive impact on stocks as does M1. Particularly, the increase of longer-term deposits, like money-market or savings accounts, positively affects the market over a time lag of two quarters. **However, in the post-crisis period the money supply M2 also becomes significant as does M3**, whereby both money aggregates show negative signs.

[1] Indeed, some explanatory variables such as the oil price and the Consumer Price Index could be correlated so that we double-count macroeconomic effects since we conduct a separate estimation for each factor. Nevertheless, even if the double-counting leads to an exaggeration, the results are proving the macro-driven statement.

So, after a time lag of one quarter, **positive M3 and M2 growth rates lead to lower stocks.** Regarding the positive impact of M1 on stocks in the post-crisis period, this result can only be explained with longer-term and less liquid assets, which are not included in M1 but are included in the broader monetary aggregates M2 and M3.

Table 4.3 shows further GARCH(1,1) estimations with the **differences between** M2 **and M1 and between M3 and M2.** The results show that in the pre-crisis period neither of the differences are significant. For the post crisis-period, the figures show that both differences **have a significant and negative impact on stocks**. In the period between Q3 2007 and Q4 2012, where the financial crisis and the European debt crisis caused turmoil in the capital markets, this impact becomes more intense and more clear.

Moreover, the adjusted R-squared figures indicate that the growth rate of **M2 minus M1 has more effect on stocks than the growth rate of M3 minus M2**. The results also make clear that the positive impact measured in the pre-crisis period arises from M1, because the difference of M3 and M2 has no significant effect on stocks in the pre-crisis period.

Factor	Pre-crisis			Post-crisis		
	P-Value of the Wald-Tests	Direction of the impact & number of lags		P-Value of the Wald-Tests	Direction of the impact & number of lags	
Money supply M1	0.0008 ***	+	4	0.0000 ***	+	2
Money supply M2	ns			0.0000 ***	-	1
Money supply M3	0.0020 ***	+	2	0.0020 ***	-	1
Manufact. orders	0.0691 *	+	1	0.0000 ***	+	1
Savings rate	0.0001 ***	+	1	0.0000 ***	-	4
Stock level	0.0286 **	-	2	0.0094 ***	-	4
Producer Price Index	ns			0.0037 ***	-	2
Consumer Price Index	ns			0.0000 ***	-	4
Consumer Conf. Index	ns			0.0000 ***	-	1
German 10-y gov. yield	ns			0.0006 ***	-	4
Ifo Business Exp. Index	ns			0.0000 ***	+	1
Unemployment rate	ns			0.0775 *	+	2
Wages Index	ns			0.0000 ***	-	1
Oil price	ns			0.0020 ***	+	1
ZEW Econ. Sent. Index	ns			0.0000 ***	+	1
Real effect. exch. rate	0.0304 **	+	1	ns		
Nominal effect. exch. rate	0.0345 **	+	1	ns		
Real GDP	0.0001 ***	-	6	ns		

Table 4.2: Results of the GARCH estimates for pre- and post-crisis period containing the Wald test with the direction of the impact and the lag structure.

Note: Except for the German 10-year government bond yields, where the quarterly differences are taken, the quarterly growth rates of all macroeconomic factors are used for the regressions.

Note: * = 1% significance level; ** = 5% significance level; * = 5% significance level; ns= not significant**

A possible explanation for this finding could be that market participants undertake a portfolio reallocation due to higher risk aversions: in times of insecurity and crisis, investors prefer safer and liquid assets, so that the demand for stocks shrinks and the demand for liquid and low-risk assets rises. These low risk-assets are, for example, deposits with a maturity of up to two years or deposits redeemable at a period of notice of up to three months (M2 component), and money market instruments or marketable instruments issued by monetary financial institutions (M3 component). Considering this, it is not very surprising, that the impact of M2 is higher than M3, since M2 has more liquid and low-risk deposits than M3.

A notable change of the sign is also measured regarding the impact of the savings rate. In the pre-crisis period, increasing **savings rates lead to higher stocks,** which seems, at first glance, very intuitive since more savings induce more investments. In the post-crisis period, however, **increasing savings rates lead to shrinking stocks.** An explanation for this finding could again be higher risk aversion among market participants in the period following the crisis, leading to falling demand for (riskier) stocks despite larger savings.

Factor	Sample	P-Value of the Wald-Tests	Direction of the impact & number of lags		Adj. R squared
M2 - M1 (in % q-o-q)	2007 Q3 - 2016 Q2	0.0244 **	-	1	0.16
M3 - M2 (in % q-o-q)	2007 Q3 - 2016 Q2	0.0268 **	-	1	0.08
M2 - M1 (in % q-o-q)	1992 Q1 - 2007 Q2	0.8765	ns	ns	-
M3 - M2 (in % q-o-q)	1992 Q1 - 2007 Q2	0.8512	ns	ns	-
M2 - M1 (in % q-o-q)	2007 Q3 - 2012 Q4	0.0000 ***	-	1	0.21
M3 - M2 (in % q-o-q)	2007 Q3 - 2012 Q4	0.0037 ***	-	1	-0.04

Table 4.3: Results of the GARCH estimates using quarterly growth rates of the differences between M2 and M1 and between M3 and M2 for various periods.

Note: * = 1% significance level; ** = 5% significance level; * = 5% significance level; ns= not significant**

5 Conclusions

The results for the whole period show a positive and highly significant impact of the money supply M1, the real exchange rate and the nominal effective exchange rate.

Also highly significant but negative is the impact of Consumer Confidence Index on the DAX index.

In most cases, the interest rate effect plays a major role in our findings, particularly regarding the direction of the impact due to our interpretation.

We demonstrate that in the post-crisis period both M2 and M3 have negative impacts on stocks. An explanation for this finding could be the portfolio reallocation of market participants due to higher risk aversions: in times of insecurity and crisis, investors prefer safer and liquid assets, so that the demand for stocks shrinks and the demand for liquid and low-risk assets rises.

A notable change of the sign is also measured regarding the impact of the savings rate. In the pre-crisis period, increasing savings rates lead to higher stocks which, at first glance, seems very intuitive since more savings induces more investments.

In the post-crisis period, however, an increasing saving rates leads to shrinking stocks. An explanation for this apparent paradox is that there is a higher risk aversion on the part of market participants in the period following the crisis, leading to falling demand for (riskier) stocks despite larger savings.

The results illustrate that in the post-crisis period more macroeconomic factors have a significant impact on the German stock market compared with the pre-crisis period. This implies that in the post-crisis period a macro-driven market is prevailing.

On the whole, the results show a significant and delayed impact of macroeconomic factors on German stocks. Since the information regarding changes in these factors is publicly available and their changes are priced with a time lag, the strong and the semi-strong market efficiency theory can be rejected from this standpoint.

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