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# Effects of Macroeconomic Variables on the Stock Market: The Case of the Czech Republic

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**Abstract.** *Applying the GARCH model, this paper finds that the Czech stock market index is positively associated with real GDP and the German and US stock market indexes, is negatively influenced by the ratio of government borrowing to GDP, the domestic real interest rate, the CZK/USD exchange rate, the expected inflation rate and the euro area government bond yield, and exhibits a quadratic relationship with the ratio of M2 to GDP. It suggests that the Czech stock market index and the M2/GDP ratio have a positive (negative) relationship if the M2/GDP ratio is less (greater) than the critical value of 60.0%. Hence, to promote a robust stock market, the authorities are expected to pursue or maintain economic growth, fiscal discipline, currency appreciation, a relatively low interest rate and expected inflation rate, and the M2/GDP ratio which is below the critical value of 60.0%.*

**Keywords:** stock market index; government borrowing; money supply; interest rates; exchange rates; foreign stock markets.

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## 1. Introduction

Many countries have experienced declining asset values including stock prices during the recent global financial crisis. The Czech Republic is no exception. The Prague Stock Exchange Index had dropped 67.5% from 1,936.1 on October 29, 2007 to 628.5 on February 18, 2009, which was worse than the 56.6% decline of the S&P 500 index during its recent worst-performing period. Although the index has risen from the trough, as of February 9, 2011, it was still 35.4% below the all time high. The significant decrease in stock prices is expected to affect household consumption spending due to the wealth and liquidity effects and business investment spending due to Tobin's q theory and the balance sheet effect. While individual stock prices may be subject to firm specific factors, the overall stock market index is expected to be influenced by the aggregate economic conditions and the global factors such as fiscal policy, monetary policy, the exchange rate, the inflation rate, the foreign stock market index, the foreign interest rate, etc.

This paper attempts to examine the relationship between the Czech stock market index and relevant macroeconomic variables and has several focuses. First, it attempts to analyze whether the Czech stock market index and the money supply may have a nonlinear relationship, suggesting that they have a positive (negative) relationship when the money supply is less (greater) than a certain critical value. A moderate increase in the money supply would be needed to accommodate increased economic activities. On the other hand, too much money supply would cause inflationary expectations, higher interest rates, and lower stock prices. Second, other relevant variables such as fiscal policy, the interest rate, the exchange rate, major foreign stock market indexes, the foreign interest rate and other relevant variables are considered in order to estimate their respective impacts on the Czech stock market index. Third, advanced econometric techniques are employed in empirical work so that parameter estimates would be unbiased, consistent, and more efficient.

Most of the previous works examining the relationship between macroeconomic variables and the stock market are for the US or other advanced countries (Fama, 1981, 1990, Campbell, Shiller, 1988, Fama, French, 1989, Chen, Roll, Ross, 1986, Bulmash, Trivoli, 1991, Abdullah, Hayworth, 1993, Dhakal, Kandil, Sharma, 1993, Mukherjee, Naka, 1995, Ajayi, Mougoue, 1996, Cheung, Ng, 1998, Nieh, Lee, 2001, Kim, 2003, Chaudhuri, Smiles, 2004, Ratanapakorn, Sharma, 2007, Humpe, Macmillan, 2009, and others).

Several recent studies analyze the subject for the Czech Republic and related countries. Hanousek and Filer (2000) indicate that only the contemporaneous values of imports and foreign capital inflows have additional explanatory power to the Czech stock market index during the full sample period whereas the contemporaneous or lagged values of the German DAX or US DJIA do not have any additional explanatory power to the Czech stock market index. Grambovas (2003) shows that the CZK/DEM exchange rate and the German stock market index Granger cause the Czech stock market index in the short run whereas the CZK/DEM exchange rate, the Czech stock market and the German stock market do not have a long-term equilibrium relationship. Samitas and Kenourgios (2007) analyze stock market movements for the four new EU economies, namely, the Czech Republic, Hungary, Poland and Slovakia. The results vary among countries. For the Czech Republic, they find that, in the short run, the Czech stock market index is negatively affected by the domestic interest rate, the US interest rate, or the German interest rate and that the sign of the error correction term is negative and significant.

Moore and Wang (2007) and Wang and Moore (2008) reveal that the Czech stock market index exhibited relatively high volatility during the early transition stage mainly due to the Russian and Asian financial crises and has shown relatively low volatility since it joined the EU and that the stock markets in the Czech Republic and Hungary and the eurozone stock market are significantly correlated after joining the EU and during the Russian and Asian financial crises mainly attributable to the financial market developments in these two countries. Horobet and Dumitrescu (2009) find that the Czech stock market index is positively affected by real GDP, the CPI, M1 money supply and the real interest rate and negatively influenced by the real effective exchange rate. It suggests that real appreciation of the Czech currency would hurt the Czech stock market index. Kasman, Turgutlu and Ayhan (2009) analyze whether stock markets in four Central European countries may have long memory. Their results show that the there is weak evidence of long memory for the Czech Republic and Hungary whereas there is support for long memory in Slovakia's stock market and short memory in Poland's stock market. It suggests that investors could still make unexploited returns in Slovakia's stock market.

These previous studies have made significant contribution to the understanding of the behavior of the Czech stock market. This paper attempts to formulate a more comprehensive model examining the relationship between the Czech stock market index and monetary policy, fiscal policy, and other relevant variables.

## 2. The model

Extending previous studies, we can express the Czech stock market index as:

$$C = f(Y, B, M, R, E, \pi^e, S', R') \qquad (1)$$
$$+ \; ? \; ? \; - \; ? \; - \; + \; ?$$

where

C = the Czech stock market index,
Y = real output,
B = government borrowing,
M = the money supply,
R = the domestic real interest rate,
E = the CZK/USD exchange rate,
$\pi^e$ = the expected inflation rate,
$S'$ = the foreign stock market index, and
$R'$ = the foreign interest rate.

We expect that the Czech stock market index is positively affected by real output and the foreign stock market index is negatively influenced by the domestic real interest rate and the expected inflation rate, and may be positively or negatively associated with government borrowing, the money supply, the exchange rate or the foreign interest rate.

Increased government deficit-financed spending would increase aggregate demand in the short run, business opportunities, the interest rate and the price level and crowd out some of the private spending (Darrat, 1990a, 1990b, Ardagna, 2009). In the long run, deficit or debt-financed government spending may have a neutral effect on the stock market index and real GDP due to the Rcardian equivalence theorem (Barro, 1974). Hence, its net impact is uncertain.

Increased money supply is expected to increase the expected inflation rate and real output, reduce the interest rate, and increase the demand for stocks (S) due to the portfolio adjustment (Dhakal, Kandil, Sharma, 1993, Abdullah, Hayworth, 1993, Mukherjee, Naka, 1995, Cheung, Lai, 1999, Chaudhuri, Smiles, 2004, Ratanapakorn, Shamar, 2007, Humpe, 2009):

$$\partial C \big/ \partial M = \left(\frac{\partial C}{\partial \pi^e} \times \frac{\partial \pi^e}{\partial M}\right) + \left(\frac{\partial C}{\partial Y} \times \frac{\partial Y}{\partial M}\right) + \left(\frac{\partial C}{\partial R} \times \frac{\partial R}{\partial M}\right) + \left(\frac{\partial C}{\partial S} \times \frac{\partial S}{\partial M}\right) > \text{or} < 0. \qquad (2)$$

In order to test a potential quadratic relationship between the stock market index and the money supply, we specify the following equation:

$$C = h(Y, B, M, M^2, R, E, \pi^e, S', R'). \quad (3)$$

The partial derivative of C with respect to M is given by:

$$\partial C / \partial M = \delta_3 + 2\delta_4 M, \quad (4)$$

where $\delta_3$ and $\delta_4$ are the respective coefficients of M and $M^2$ in equation (3), $\delta_3 > 0,$ and $\delta_4 < 0.$ Setting the first-order condition to zero and solving for the critical value of M that maximizes C, we have:

$$\overline{M} = -\frac{\delta_3}{2\delta_4}. \quad (5)$$

Currency depreciation is expected to help exports, raise import costs or domestic prices, and reduce international capital inflows because domestic assets are less attractive to international investors. Increased exports would help raise stock prices whereas increased import costs or domestic prices and decreased international capital inflows would reduce business profits or the demand for stocks and the price of stocks. Thus, its net impact is unclear (Choi, 1995, Abdalla, Murinde, 1997, Nieh, Lee, 2001, Ratanapakorn, Sharma, 2007).

A higher foreign interest rate relative to the domestic interest rate would reduce international capital inflows and the demand for stocks but may cause the depreciation of the Czech koruna and help net exports. Therefore, its net impact is ambiguous.

## 3. Empirical results

All the data were collected from the *International Financial Statistics* published by the International Monetary Fund. C is measured by the share price index with 2005 as the base year. Y is represented by the real gross domestic product in billions at the 2005 constant price. B is represented by the ratio of government borrowing to nominal GDP. The data for the government deficit after 2007.Q2 are incomplete. M is measured by the ratio of M2 money supply to nominal GDP. R is measured by the money market rate minus the expected inflation rate, which is the average inflation rate of the last four quarters. E is measured by the CZK/USD exchange rate. An increase in the CZK/USD exchange rate means depreciation of the Czech koruna. The choice of the CZK/USD exchange rate is because the absolute value of the correlation coefficient of -0.722 between the CZK/USD exchange rate and the Czech stock market index is greater than the correlation coefficient of 0.576 between the nominal effective exchange rate and the Czech stock market index. The German and US share price indexes with 2005 as the base year are both selected to

represent the foreign stock market index. Although the Czech Republic and Germany are closely linked economically and financially, the US stock market is expected to have some impacts on the Czech and other stock markets in the world. The euro area government bond yield is chosen to represent the foreign interest rate. Except for the expected inflation rate and the domestic real interest rate with negative values, other variables are measured in the logarithmic scale. The quarterly sample ranges from 2002.Q1 to 2010.Q2. The data for the money supply are not available before 2002.Q1.

Graph 1 presents the scatter diagrams between the Czech stock market index and selected explanatory variables. As shown, the Czech stock market index generally has a positive correlation with the US and German stock market indexes, a negative correlation with the government borrowing/GDP ratio, the CZK/USD exchange rate and the euro area government bond yield, and a bell-shaped relationship with the M2/GDP ratio. The scatter diagram for the relationship between the Czech stock market index and the CZK/USD exchange rate suggests that depreciation of the Czech koruna would cause the stock market index to decline whereas appreciation of the Czech koruna would increase the Czech stock market index. According to the fitness of the scatter diagrams, the correlation between the Czech stock market index and the German stock market index is greater than the correlation between the Czech stock market index and the US stock market index.

Table 1 presents the estimated regressions and related statistics. Figures in the parenthesis are t-statistics. The GARCH model is employed because the error variance is a function of the lagged squared error and the lagged error variance. The base model is reported in Version I. Approximately 97.3% of the variation in the Czech stock market index can be explained by the ten right-hand side variables. All the estimated coefficients are significant at the 1% or 5% level. The Czech stock market index is positively affected by real GDP, the German stock market index and the US stock market index, is negatively influenced by the government borrowing/GDP ratio, the real interest rate, the CZK/USD exchange rate, the expected inflation rate and the euro area government bond yield, and has a quadratic relationship with the M2/GDP ratio. Based on equation (5), the critical value of the M2/GDP ratio that maximizes the Czech stock market index is estimated to be 60.0%, implying that the Czech stock market index has a positive (negative) relationship with the M2/GDP ratio if the M2/GDP ratio is less (greater) than 60.0%. If the squared M2/GDP ratio is deleted from the estimated regression in Version I, the coefficient of the M2/GDP ratio is negative and insignificant at the 10% level, and a misleading conclusion that increased money supply does not affect the Czech stock market index may be drawn.

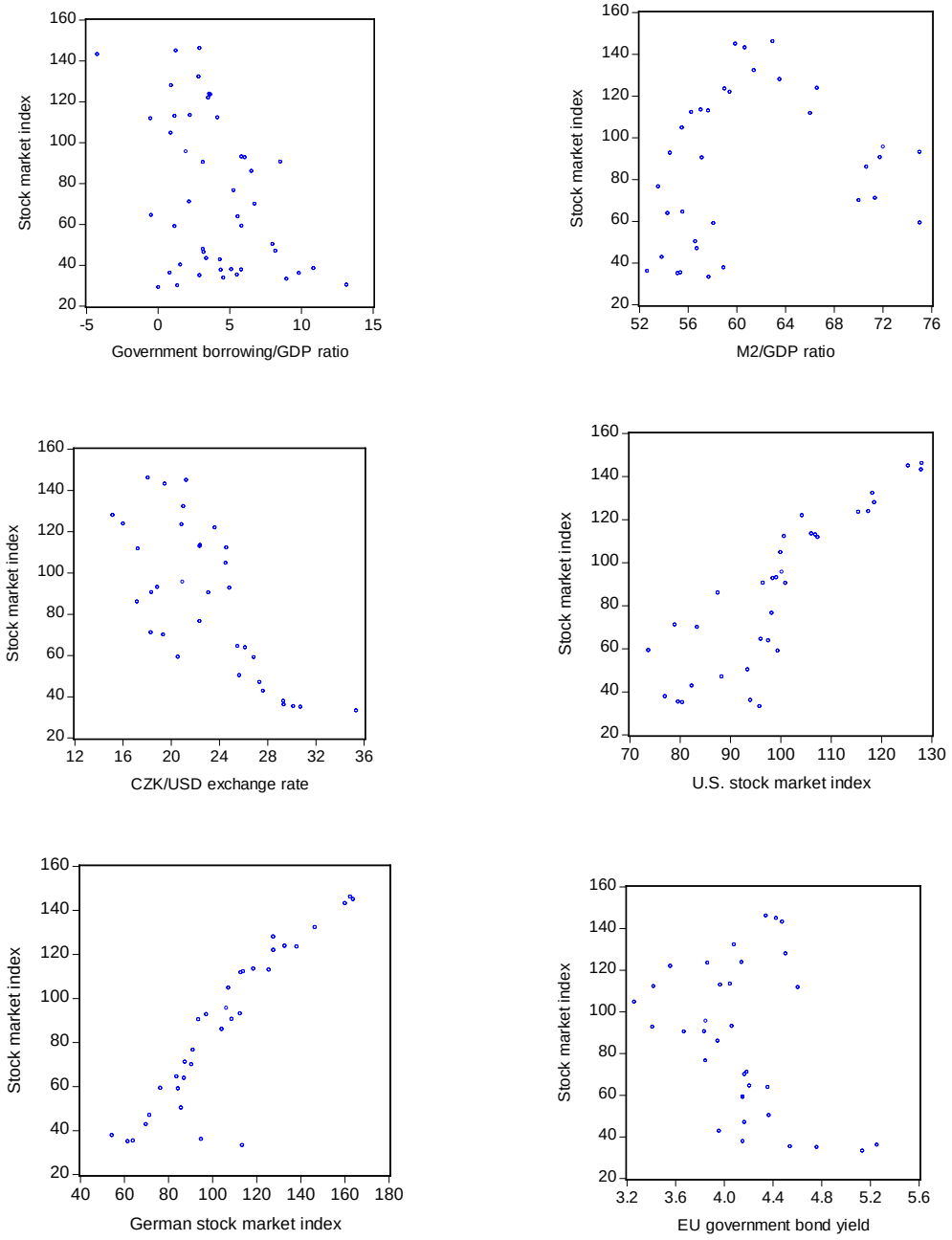


**Figure 1.** *Scatter diagrams*

Table 1

**Estimated regressions of the Czech stock market index**

| | I | II | III |
|---|---|---|---|
| Real GDP | 0.993<br>(4.230) | 1.348<br>(3.141) | 0.891<br>(3.192) |
| Government borrowing/GDP ratio | -0.017<br>(-11.440) | | -0.013<br>(-3.535) |
| Government debt/GDP ratio | | -0.057<br>(-0.178) | |
| M2/GDP ratio | 26.977<br>(2.245) | 38.943<br>(3.263) | |
| (M2/GDP ratio)^2 | -3.295<br>(-2.268) | -4.743<br>(-3.273) | |
| M1/GDP ratio | | | 18.069<br>(3.719) |
| (M1/GDP ratio)^2 | | | -2.444<br>(-3.724) |
| Real interest rate | -0.084<br>(-4.148) | -0.106<br>(-3.401) | -0.063<br>(-2.546) |
| CZK/USD exchange rate | -0.473<br>(-4.013) | -0.423<br>(-1.861) | -0.283<br>(-2.407) |
| Expected inflation rate | -0.238<br>(-4.054) | -0.311<br>(-2.593) | -0.163<br>(-1.967) |
| German stock market index | 0.467<br>(7.821) | 0.333<br>(2.427) | 0.502<br>(4.631) |
| US stock market index | 0.868<br>(6.245) | 1.166<br>(5,889) | 0.897<br>(5.840) |
| Euro area government bond yield | -1.094<br>(-8.285) | -1.015<br>(-6.708) | -0.984<br>(-6.808) |
| Constant | -60.291<br>(-2.490) | -88.193<br>(-3.318) | -38.889<br>(-4.379) |
| Estimation method | GARCH | GARCH | GARCH |
| Adjusted R-squared | 0.973 | 0.963 | 0.977 |
| AIC | -2.218 | -1.755 | -2.297 |
| SC | -1.590 | -1.127 | -1.623 |
| F-statistic | 91.929 | 67.252 | 103.300 |
| Sample period | 2002.Q1-<br>2010.Q2 | 2002.Q1-<br>2010.Q2 | 2002.Q1-<br>2010.Q2 |
| N | 34 | 34 | 34 |

**Notes:** Figures in the parenthesis are t-statistics. AIC is Akaike information criterion. SC is Schwarz information criterion.

According to estimated coefficients, the Czech stock market index is more sensitive to a percent change in real GDP, the U.S. stock market index, or the euro area government bond yield than other variables. For example, a 1% change

in the euro area government bond yield, real GDP, and the US stock market index would change the Czech stock market index by -1.094%, +0.993%, +0.868%, respectively. In comparison, a 1% increase in the German stock market index would result in 0.467% increase in the Czech stock market index. If the CZK/USD exchange rate rises 1% or if the Czech koruna depreciates 1% versus the US dollar, the Czech stock market index would decline by 0.473%.

To determine whether the above regression results may be spurious, the ADF test on the regression residuals is applied. Based on the Schwarz information criterion, a lag length of zero is selected. The value of the test statistic is estimated to be -6.774, which is greater than the critical value of -2.637 in absolute values at the 1% level. Hence, the regression outcomes are not spurious, and these time series variables have a long-term stable relationship.

In comparison, the results in this paper are similar to the findings of Samitas and Kenourgios (2007), Wang and Moore (2008) and part of Horobet and Dumitrescu (2009) in terms of the relationship between the Czech stock market index and the domestic interest rate, the foreign interest rate, real GDP, and the eurozone stock market index. However, the results are different from the findings of Hanousek and Filer (2000), Grambovas (2003) and part of Horobet and Dumitrescu (2009) in terms of the relationship between the Czech stock market index and the German stock market index, the Dow Jones Industrial Average, appreciation of the koruna, the CPI, M1 money supply, and the domestic interest rate. Different results may be due to different model specifications, estimation methodologies, measurements of the variables, sample periods, and other possible factors.

Several different versions are estimated. When the government debt/GDP ratio replaces the government borrowing/GDP ratio (Version II), its negative coefficient is insignificant at the 10% level, and the quadratic relationship between the Czech stock market index and the M2/GDP ratio continues to hold. An analysis of the relationship between the Czech stock market index and the debt/GDP ratio indicates that the correlation coefficient is calculated to be a very small value of -0.060 mainly because both the positive and negative relationships are found and may cancel out each other. If the M1/GDP ratio and the M1/GDP ratio squared replace the M2/GDP ratio and the M2/GDP ratio squared (Version III), its coefficients are significant at the 1% level. The critical value for the M1/GDP ratio that maximizes the Czech stock market index is estimated to be 40.3%. Because M2 money supply is a broader measure of the monetary aggregate, the critical value for the M2/GDP ratio may have more policy implications.

## 4. Summary and conclusions

This paper has examined the relationship between the Czech stock market index and selected macroeconomic variables based on a sample during 2002.Q1 – 2010.Q2. More real GDP, a lower government borrowing/GDP ratio, a lower real interest rate or expected inflation rate, a higher US or German stock market index, or a lower euro area government bond yield would increase the Czech stock market index. The Czech stock market index and the M2/GDP ratio exhibit a bell-shaped relationship. A higher M2/GDP ratio would increase (reduce) the Czech stock market index if it is less (greater) than 60.0%. If fiscal policy is represented by the government debt/GDP ratio, its negative coefficient is insignificant at the 10% level. When the money supply is represented by the M1/GDP ratio, the critical value of the M1/GDP ratio is estimated to be 40.3%.

There are several policy implications. To maintain a healthy stock market, the authorities would need to pursue economic growth, fiscal discipline, moderate increase in the money supply, a relatively low interest rate or inflation rate, and the appreciation of the Czech koruna. The finding of a quadratic relationship between the Czech stock market index and the M2/GDP ratio has significant policy implications. Increased money supply to accommodate increased GDP would be conducive to the stock market as long as the M2/GDP ratio stays within the critical value of 60.0%. Too much money supply causes higher inflation expectations and is harmful to the stock market. Although the coefficient of the government debt/GDP ratio is insignificant, we should not rule out a possible negative relationship in the future when more sample observations become available. Appreciation of the Czech koruna would help the Czech stock market index because its positive impacts on increased international capital inflows, lower import costs and lower prices outweigh its negative impact on reduced exports. It appears that the impact of the US stock market index on the Czech stock market index is greater than the impact of the German stock market index on the Czech stock market index. Hence, any study which does not include the US stock market index would miss a key variable in regression analysis. The authorities need to monitor the external factors such as the German stock market index, the US stock market index and the euro area government bond yield in order to forecast their impacts when any change occurs.

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