ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 62 157 Number 6, 2014
http://dx.doi.org/10.11118/actaun201462061509

INTERMARKET TECHNICAL RESEARCH OF THE U.S. CAPITAL MARKETS AND THE CZECH STOCK MARKET PERFORMANCE

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Abstract

VYCHYTILOVÁ JANA. 2014. Intermarket Technical Research of the U.S. Capital Markets and the Czech Stock Market Performance. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 62(6): 1509–1519.

Globalization of the capital markets increasingly leads the investors to understand the fundamentals and technicals of asset cross-correlations and the global asset allocation seems to be an important task. The paper measures product momentum correlations between the four leading global benchmarks Standard & Poor's stock index, Thomson Reuters/Jefferies CRB index, 30-Year U.S. Treasury Bond Price index and Dollar Index and between these indices and the Czech stock PX index. Empirical results illustrate that statistically significant correlations between U.S. indices existed over some past period at the 95.0% confidence level. In addition, the significant relation between indices Standard & Poor's stock index, Thomson Reuters/Jefferies CRB index and the Czech stock market PX during the past fifteen years has been detected. These conclusions were reached from an analysis of monthly data in the United States and the Czech Republic, from January 1999 to April 2014. The empirical results offer beneficial applications not only for investors to diversify their risk but also for policy-makers to allocate resources more efficiently.

Keywords: cross-asset allocation perspective, asset market linkages, attributes of cross-market movements and capital market fluctuations

INTRODUCTION

The risk-averting investor uses risk management techniques to reduce risk and increase expected returns by allocating investments among various types of financial instruments. The optimal diversified portfolio combines assets that do not all move in the same direction at the same time in the reaction to the market forces.

Any individual investor or institutional investment department cannot diversify and allocate assets appropriately without taking cross-asset market linkages into consideration. Markets move very rapidly and within a short time span due to market efficiencies and impact of global externalities. The cross-market research then provides a comprehensive picture of how the main world financial markets perform and interrelate. It is important for investors to know asset return linkages during non-crisis and crisis periods.

In recent years there has been growing attention to verify international capital markets relationships among traditional asset classes including stock, bonds, currencies and commodities. According to increasing globalization, when is even more obvious how the financial markets really connected are, it is challenging to study market interactions worldwide and evaluate the degree of the co-movements at the statistical significant level.

In this context it is essential to analyse the global cross-market correlations and cross-asset correlations in a relation to the Czech stock market during different periods of time including the crisis period retrospectively.

Attributes of the Traditional Cross-asset Correlations

Globalization of the capital markets increasingly leads the investors to understand

both the fundamentals and technicals of cross-asset correlations. Empirical results confirm that globalization has been increasing in recent years. North American and European markets are observed to be much more strongly connected among themselves compared to the integration with the other geographical regions (Eryiğit, 2009; Hon, Strauss and Yong, 2004; Didier, Love and Martínez Pería, 2012).

According to J. P. Morgan (2011, p. 1), cross-asset correlations almost doubled over the past ten years as a result of elevated macro volatility. Globalization of capital markets, new risk-management and alpha-extraction techniques have driven the secular increase of cross-asset correlations.

A major argument for investing internationally is that it increases profit opportunity while providing risk diversification. According to Odier and Solnik (1993), optimal hedging policy varies with the investor's nationality, with the percentage of foreign assets in his portfolio and with the asset classes included in the portfolio. They propose benefits of investing internationally depend on three conditions, namely, cross-country correlations, market volatilities and future changes in currency risks. According to Shin and Park (2012), efficiency of the realized variance of an asset is improved by taking advantage of another asset whose return is cross-sectionally correlated with that of the asset and is less sensitive to market microstructure noises permitting higher frequency sampling than the original asset.

Huand and Chen (2014) argue that in terms of financial stability, a relatively small market may not benefit from market linkage and market opening is essentially a double-edged sword. Ehrmann *et al.* (2011) estimate the financial transmission between money, bond and equity markets and exchange rates within and between the U.S. and the euro area and find that asset prices strongly react to other domestic asset price shocks, but that there are also substantial international spillovers, both within and across asset classes. Authors also highlight the dominance of U.S. markets as the main driver of global financial markets and state US financial markets explain, on average, around 30% of movements in euro area financial markets, whereas euro area markets account only for about 6% of U.S. asset price changes.

Cevdet Aydemir (2008) states the periods of high risk aversion are associated with high market correlations and high market volatility. Leonidas and Italo de Paula (2012) show how the markets tend to behave similarly during times of high volatility and how the correlation between them has been growing for the past decades and conclude that high volatility of markets is directly linked with strong correlations between them. Choe *et al.* (2012) also agree that there is a significant relationship between cross-market co-movement and time varying volatility and conclude that a high level of cross-market correlation during a crisis is mostly due to the high level of cross-market co-movement resulting from the intertemporal risk-return adjustment.

Shiller and Beltratti (1992) discuss annual real stock prices have shown little correlation with changes in bond yields between years 1918–1989 in the United States. Papavassiliou (2014) argue that the return correlation between the stock and bond asset classes has increased during the crisis phases. Yang, Zhoe and Wang (2009) studied stock-bond correlation by analysing monthly return data between years 1855–2001 for the U.S. and UK and their results imply higher stock-bond correlations tend to follow higher short rates and higher inflation rates. Bansal, Connolly and Stivers (2010) show a high-stress regime exhibits a much higher stock volatility, a much lower stock-bond correlation, and a higher mean bond return. They state during the high stock market stress, the diversification benefits of combined stock-bond holdings tend to be greater.

According to Hartmann, Straetmans and De Vries (2004), the simultaneous crashes between stock markets are much more likely than between bond markets. Chui and Yang (2012) evidence the positive extreme stock-bond correlation in U.S. and UK, while in Germany investigate the negative stock–bond correlation is negative. They suggest macroeconomic news, the business cycle, and the stock market uncertainty all significantly affect the median stock-bond futures correlation. Lee, Huang and Yin (2013) agree that there are indeed various patterns of dynamic relationships among stock, insurance and bond markets in the developed countries; however the direction of causality appears to differ across countries.

Reboredo, Rivera-Castro and Zebende (2014) provide evidence of both contagion and interdependence between oil prices and the U.S. dollar exchange rate, when by using detrended cross-correlation analysis detected negative dependence that increased after the onset of the global financial crisis. Treepongkaruna and Wu (2012) find that currency and stock markets react somewhat heterogeneously to various rating announcements and that stock markets are more responsive to rating news than currency markets. According Dungey and Martin (2007), the cross-market links between currency and stock markets are important while spillovers have a relatively larger effect on volatility than contagion, but both are statistically significant.

According to Gao and Liu (2014), the commodity futures can be a good instrument for risk diversification because they do not share common volatility regimes with U.S. stocks, which is in line with the segmented market view and the correlations between the U.S. stocks and the commodity futures do increase in periods in which both are volatile. Authors support risk diversification between commodity futures and stocks. Büyükşahin and Robe (2012) agree that the correlation between

the rates of return on commodities and stocks rises amid greater participation by speculators generally.

Büyükşahin, Haigh and Robe (2010) investigated whether commodities are in sync with traditional financial assets by sing daily, weekly and monthly data over 18 years and they found compared to the 1991–2002 period, both short- and long-term relationships between passive commodity and equity investments are generally weaker after 2003. Even though the correlations between equity and commodity returns increased sharply in the fall of 2008, during a time of extraordinary economic and financial turbulence, they remained lower than their peaks in the previous decade.

According to Sayyed (2012), a significant relationship between gold price, stock and bond market exist and author proposes that the recent worldwide financial crisis and instability such as recession and deficit problems in the Euro zone and the U.S. have increased the precautionary demand for gold in Southeast Asian countries, at least over the last five years.

Piplack and Straetmans (2010) show through the correlation analysis similar positive correlations between stocks and bonds as well as stocks and T-bills over time. They state that the gold turns out to be only mildly correlated with the rest of the assets in the sample set. Kenourgios, Christopoulos and Dimitriou (2013) investigated the contagion effects stocks, bonds, commodities, shipping, foreign exchange and real estate by comparing average conditional correlations among markets across the stable and crisis periods and their results show increasing linkages among those asset markets and show the existence of a contagion mechanism among the assets.

Chan *et al.* (2011) examine the relationships between returns over U.S. stocks, Treasury bonds, commodities (oil and gold) and real estate assets. Authors confirm the existence of two distinct regimes called a "tranquil" regime with periods of economic expansion, and a "crisis" regime with periods of economic decline. During the tranquil regime they evidenced of a flight from gold to stocks, while during the crisis the contagion between stocks, oil and real estate has been evidenced and furthermore, the strong evidence of a flight from stocks to Treasury bonds has been proved.

Research Limitations

The goal of this paper is to examine intermarket linkages between variables Standard & Poor's stock index, 30-Year U.S. Treasury Bond Price index, Thomson Reuters/Jefferies CRB commodity index and U.S. Dollar index during the past fifteen years in the relation to the Czech PX price index of the Prague Stock Exchange blue chip issues.

MATERIALS AND METHODS

A research about capital market linkages has been conducted on the basis of results of foreign studies and our own knowledge of this issue (Aboura and Chevallier, 2014; Papavassiliou, 2014; Reboredo, Rivera-Castro and Zebende, 2014; Ehrmann, Fratzscher and Rigobon, 2011; Piplack and Straetmans, 2009; Choe *et al.,* 2012; Dungey and Martin, 2007).

The research about financial transmission between money, bond, stock and commodity markets within and between the U.S. and the Czech Republic uses the historical data file containing the monthly adjusted closing prices (dividend yields are not considered in calculation) of those four global market indices:

1) Standard & Poor's stock index (SPX).
2) 30-Year U.S. Treasury Bond Price index (USB).
3) Thomson Reuters/Jefferies CRB index (CRB).
4) Dollar Index (DI), in a relation to the Czech stock PX index (PX).

These indexes appropriately represent four traditional categories of capital assets classes:

1) stocks,
2) bonds,
3) commodities and
4) currencies.

The Standard & Poor's stock index includes 500 leading companies in leading industries of the U.S. economy and represent overall stock trends in my estimations. The 30-Year U.S. Treasury Bond Price Index has been used to demonstrate the bond market. The Thomson Reuters/Jefferies CRB index is comprised of 19 commodities sorted into four commodity groups:

1) petroleum based products,
2) liquid assets,
3) highly liquid assets,
4) diverse commodities; and represent the overall commodity market trends.

The fourth currency sector is demonstrated by Dollar Index that value the United States dollar relative to a basket of foreign currencies.

The U.S. indices' monthly closing prices have been obtained from the available online historical databases (Yahoo Finance, 2014; Bloomberg, 2014; Investing.com, 2014) with the sample period from January 1999 to April 2014. The Czech stock PX index' monthly closing prices have been obtained from the Prague Stock Exchange (2014), with the same sample period from January 1999 to April 2014. Internal data are not included in the examination. The aim was to analyse how the U.S. markets as the main driver of global financial markets (Ehrmann *et al.*, 2011) explain asset prices movements in the Czech stock market during the past fifteen years, and study the linkages between U.S. stock, bond, currency and commodity markets during the various economic phases including the crisis phase.

In this research, five hypotheses were set, based on the basic fundamental premises saying all capital markets are interconnected -domestically

and globally; no market exists in isolation; the single market analysis should include an analysis of other markets; and there are expectations of functional asset market relationships between markets that can be explored (Murphy, 2004; Katsanos, 2009).

P1. Bond (*USB*) and commodity (*CRB*) markets were negatively correlated during the analysed period.

P2. Currency (*DI*) and commodity (*CRB*) markets were negatively correlated during the analysed period.

P3. Stock (*SPX*) and bond (*USB*) markets were positively correlated during the analysed period.

P4. The stock (*SPX*) and currency (*DI*) markets were positively correlated during the analysed period.

P5. The U.S. financial indices (*SPX, USB, CRB, DI*) were correlated with the Czech stock market index (*PX*) during the analysed period.

According to Ang and Timmermann (2012), in empirical estimates, the means, volatilities, autocorrelations, and cross-covariances of asset returns often differ across regimes in a manner that allows regime-switching models to capture the stylized behaviour of many financial series including fat tails, heteroskedasticity, skewness, and time-varying correlations while regime switches also lead to potentially large consequences for investors' optimal portfolio choice. In this research, the strength and the direction of the relation between each pair of indices during the different time frames have been examined through a Pearson product moment correlation coefficients (1) in this research in accordance to Leonidas and Italo de Paula (2012) and Wang *et al.* (2013). The statistical significance of the estimated correlations has been tested with p-value statistics. Calculations have been performed in Statgraphics Centurion XV.

$$r = \frac{\left(n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)\right)}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]}}. \quad (1)$$

In this research p-value below 0.05 indicate statistically significant non-zero correlations at the 95.0% confidence level and leads to reject the null hypothesis Significance level was set as $\alpha = 0.05$. To compare the various financial assets, the monthly relative performances were calculated by using the horizontal analysis:

$$r^{i}_{t/t-1} = \frac{P_i(t) - P_i(t-1)}{P_i(t-1)}, \quad (2)$$

where "r" means a monthly relative performance and "*P*" is the indices' monthly closing price adjusted for dividends and splits. The data set in this work contains a total of 915 measured monthly values, which were obtained for the last 184 months. Empirical verification of the relationships between each pair of indices is applied to a panel data. This paper assesses the linkages between the most important U.S. financial asset classes (stocks, bonds, currencies and commodities) with the relation to the Czech stock market during the past fifteen years, including volatile periods of financial turmoil (i.e., the U.S. sub-prime crisis and European debt crisis).

RESULTS

The linkages among traditional asset classes are shown in Tabs. I–V. The p-value tests the statistical significance of the estimated correlations at the 95.0% confidence level.

The correlation between the four U.S. financial indices and the Czech stock market index shows Tab. VI.

Tab. I is shown the development of the bond-commodity linkage using indices Thomson Reuters/ Jefferies CRB and 30-Year U.S. Treasury Bond Price index during the past fifteen years period.

In this research, the statistically significant negative dependence between bonds and commodities has been found by using multivariate methods during the entire past fifteen period (p-value = 0.0179). Even though the directions of the bond-commodity linkage varied in researched years, negative correlations prevailed over the positive. The negative bond-commodity correlations were statistically significant in 2010 (p-value = 0.04) and in Σ period (p-value = 0.0179). The hypothesis P1 is therefore accepted only for these periods. Tab. II shows the development of the currency-commodity linkage with using indices Dollar Index and Thomson Reuters/Jefferies CRB for estimating PPMC correlations during the analysed period.

The statistically significant relations were identified between indices Dollar Index and Thomson Reuters/Jefferies CRB. The statistically significant negative currency-commodity correlations in accordance with the hypothesis P2 were identified in years 1999 (p-value = 0.01); 2006 (p = 0.01); 2007 (p-value = 0.01); 2011 (0.00); 2012 (0.02) and in in Σ period (p-value = 0.0133). In 2009 statistically significant positive correlation was detected (p-value = 0.01), contrary to the hypothesis P2. Dependences between stock and bond markets are shown in Tab. III.

The stock-bond dependence was not statistically significant for the overall period (p-value = 0.9056), and indicated a more complicated relation. In this research non-zero correlations between indices Standard & Poor's stock index and 30-Year U.S. Treasury Bond Price index has been found. Statistically significant correlations were identified in years 2006 (p-value = 0.02; positive r) and 2012 (p-value = 0.01, negative r). According to p-values the hypothesis P3 is accepted in 2006 and rejected in 2012. P-values have not confirmed the significant relations in other years.

In Tab. VI are shown relations between Standard & Poor's stock index and Dollar Index representing

I: *The development of the bond-commodity linkage*

P1: Are bond and commodity markets negatively correlated?								
USB-CRB	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Correlation coefficient	–0.13	0.04	–0.43	–0.28	–0.06	0.06	–0.11	–0.41
2. P-value	(0.70)	(0.91)	(0.16)	(0.38)	(0.85)	(0.85)	(0.73)	(0.19)
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1. Correlation coefficient	0.15	–0.32	0.15	–0.59	–0.53	–0.31	–0.22	–0.23
2. P-value	(0.64)	(0.31)	(0.64)	**(0.04)**	(0.07)	(0.32)	(0.49)	(0.77)
Σ (01/99–04/2014)	r= –0.1749; p-value = **0.0179**							

Source: Own source

II: *The development of the currency-commodity linkage*

P2: Are currency and commodity markets negatively correlated?								
DI-CRB	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Correlation coefficient	–0.71	–0.22	–0.38	0.05	0.07	0.03	–0.42	–0.73
2. P-value	**(0.01)**	(0.49)	(0.23)	(0.87)	(0.19)	(0.93)	(0.18)	**(0.01)**
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1. Correlation coefficient	–0.69	–0.11	0.69	–0.09	–0.91	–0.68	–0.30	–0.85
2. P-value	**(0.01)**	(0.73)	**(0.01)**	(0.77)	**(0.00)**	**(0.02)**	(0.34)	(0.15)
Σ (01/99–04/2014)	r= –0.1827; p-value = **0.0133**							

Source: Own source

III: *The development of the stock-bond linkage*

P3: Are stock and bond markets positively correlated?								
SPX-USB	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Correlation coefficient	–0.16	0.30	–0.06	0.01	0.14	–0.16	0.41	0.66
2. P-value	(0.65)	(0.34)	(0.86)	(0.98)	(0.67)	(0.62)	(0.19)	**(0.02)**
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1. Correlation coefficient	0.05	–0.11	0, 08	0.18	–0.31	–0.72	0.21	–0.85
2. P-value	(0.89)	(0.74)	(0.82)	(0.57)	(0.33)	**(0.01)**	(0.52)	(0.15)
Σ (01/99–04/2014)	r= –0.0088; p-value = 0.9056							

Source: Own source

IV: *The development of the stock-currency linkage*

P4: Are stocks and U.S. Dollar Index positively correlated?								
SPX-DI	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Correlation coefficient	0.07	–0.30	0.01	0.15	–0.30	–0.47	0.32	0.39
2. P-value	(0.83)	(0.34)	(0.96)	(0.63)	(0.34)	(0.13)	(0.30)	(0.20)
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1. Correlation coefficient	–0.06	0.58	0.01	–0.48	0.46	0.78	–0.29	–0.96
2. P-value	(0.85)	(0.04)	(0.99)	(0.11)	(0.13)	**(0.00)**	(0.36)	**(0.04)**
Σ (01/99–04/2014)	r= 0.0389; p-value= 0.6009							

Source: Own source

the stock-currency linkage. The development of the linkage has been changed during the past fifteen years and the direction positive/negative differs over the years. The hypothesis P4 is accepted only for years 2008 (p-value = 0.04) and 2012 (p-value = 0.00), when positive correlations have been found and rejected for the first quarter 2014 when negative correlation has been detected (p-value = 0.04).

According to these estimates presented in Tab. I–IV, the currency-commodity linkage seemed to be the most statistically significant linkage in the reported period, with the most p-values confirming the significant relations.

V: *The cross asset markets linkages during summary phases*

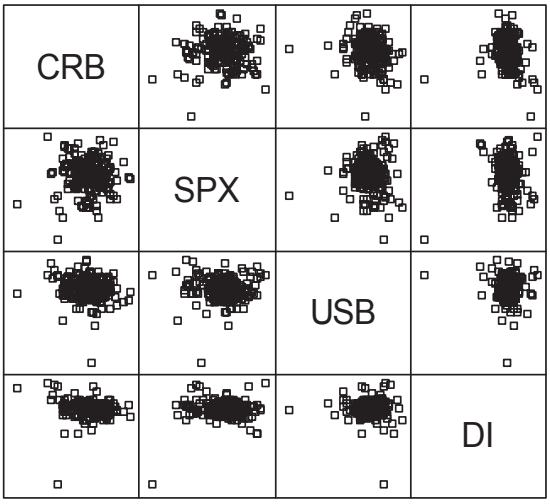
P1–P4 Σ		1999–2003	2004–2008	2009–2014	1999–2014
1.USB-CRB	r	–0.1275	–0.1892	–0.2344	–0.1749
	p-value	(0.3359)	(0.1477)	(0.0623)	**(0.0179)**
2.DI-CRB	r	–0.2235	–0.1499	–0.2374	–0.1827
	p-value	(0.0889)	(0.253)	(0.0589)	**(0.0133)**
3.SPX-USB	r	0.0666	–0.0141	–0.1019	–0.0088
	p-value	(0.6161)	(0.9146	(0.4229)	(0.9056)
4.SPX-DI	r	–0.1329	0.4082	–0.2007	0-0389
	p-value	(0.3156)	**(0.0012)**	(0.1117)	(0.6009)

Source: Own source

VI: *The development of the U.S. markets – Czech stock market linkage*

P5: Are U.S. financial indices correlated with the Czech stock market index?					
		1999–2003	2004–2008	2009–2014	1999–2014
1.CRB-PX	r	0.0349	0.4257	0.306	0.2218
	p-value	(0.7932)	**(0.0007)**	**(0.0139)**	**(0.0026)**
2.SPX-PX	r	0.2351	0.4011	0.0731	0.146
	p-value	(0.0731)	**(0.0015)**	(0.5661)	**(0.0486)**
3.USB-PX	r	0.0161	–0.151	–0.0728	–0.04
	p-value	(0.9035)	(0.2493)	(0.5673)	(0.591)
4.DI-PX	r	–0.0461	0.0904	–0.0315	0.0042
	p-value	(0.729)	(0.4923)	(0.8046)	(0.9548)

Source: Own source



1: *The multivariate graph 01 January 1999–01 April 2014*
Source: Own source

The cross-asset market correlations between Standard & Poor's stock index, 30-Year U.S. Treasury Bond Price index, Thomson Reuters/ Jefferies CRB index and Dollar Index during the various summarized periods are shown in Tab. V and visualized by the PerfChart in Fig. 2. The non-zero correlations were found in those phases. These statistically significant correlations at the 95.0% confidence level were identified:

1) USB-CRB, 1999–2014, negative correlation (p-value = 0.0179, r = –0.1749);
2) DI-CRB, 1999–2014, negative correlation (p-value = 0.0133, r = –0.1827); and
3) SPX-DI, 2004–2008, positive correlation (p-value = 0.0012, r = 0.4082).

P-values have confirmed the significant relations in these periods.

Fig. 1 shows the multivariate graph that gives interesting view into the market indices. This correlation matrix summarizes the correlations between each pair of market indices between whole

2: *PerfChart: SPX, CRB, DI, CRB; 01 January 1999–01 April 2014*
Source: Own source

researched period. Each pair of indices is plotted twice, once with the first variable on the X-axis and once with it on the Y-axis and summarizes which indices are most strongly correlated with which others.

The development of the dependence between four U.S. financial indices (1) Thomson Reuters/ Jefferies CRB index, 2) Standard & Poor's stock index, 3) 30-Year U.S. Treasury Bond Price index, 4) Dollar Index) and the Czech stock market index during the four phases is illustrated in Tab. VI.

The hypothesis P5 is accepted for the CRB-PX linkage in the period 2004–2008 (p-value = 0.0007), 2009–2014 (p-value = 0.0139), 1999–2014 (p-value = 0.0026) and for the SPX-PX linkage in the period 2004–2008 (p-value = 0.0015) and 1999–2014 phase (p-value = 0.0486). Other correlations were non-zero but statistically insignificant.

DISCUSSION

According to Wang *et al.* (2013) the statistical properties of the U.S. stock market cross-correlation measured by the Pearson's correlation coefficient at the sample data from January 2005 to August 2012 are more remarkable. Furthermore, the largest market shocks and economic crises often lead to a large co-movement effect and interaction effect in the financial markets.

According to results of Hon, Strauss and Yong research (2004) the international stock markets, particularly in Europe, responded more closely to U.S. stock market. According to results of my research, the Czech stock market index was substantially correlated with the U.S. stock and commodity markets indices in the past fifteen years.

My survey pointed to a relatively statistically insignificant respond of the Czech stock market index to U.S. currency and bond markets indices.

According to results of Didier, Love and Martínez Pería (2012) the higher comovement in stock market returns exhibited in relation to U.S. stock market returns during the phase 2007–2008 in 83 countries.

The results of my research showed the statistically significant cross-correlations between indices Standard & Poor's stock index and the Czech stock market PX index between years 2004–2008 and extended the conclusions of Didier, Love and Martínez Pería (2012). These conclusions are compatible with the conclusions about increased correlations during the volatile and crisis phase of Büyükşahin, Haigh and Robe (2010), Choe *et al.* (2012) and Cevdet Aydemir (2008).

The statistically significant negative correlation between the Dollar Index and Thomson Reuters/ Jefferies CRB index in 1999, 2007, 2011, 2012, and in the summarized phase 1999–2014 has been identified in this research. These finding

corresponded with findings of Reboredo, Rivera-Castro and Zebende (2014), Katsanos (2009) and Murphy (2004).

The significant negative dependence between indices 30-Year U.S. Treasury Bond Price and Thomson Reuters/Jefferies CRB index in 2010 and in the summarized phase 1999–2014 has been detected. Even though the direction of the bond-commodity linkage varied in the researched years, the negative correlations prevailed over the positive. These conclusions of this research are compatible with Katsanos (2009) and Murphy (2004) opinions and were partially confirmed with opinions of Kenourgios *et al*. (2013).

A surprising finding was a fact that only in 2006 the significant correlation between indices Standard & Poor's stock index and 30-Year U.S. Treasury Bond Price has been found. This finding corresponds with findings of Shiller and Beltratti (1992).

Furthermore, the statistically significant positive correlation between indices Standard & Poor's stock index and the Dollar Index in 2008 and during the phase 2004–2008 has been detected. These finding confirmed opinions of some authors such as Dungey and Martin (2007), and on the contrary did not confirm opinions of others authors such as Papavassiliou (2014). The verification of the linkage will be a subject of other research.

CONCLUSION

The research about U.S. stock, bond, currency and commodity markets movements and about their relation to the Czech stock market has showed interesting findings.

It has been proved by using correlation analysis that even though the correlations between traditional assets are not perfect, the statistically significant relations existed over some past periods at the 95.0% confidence level.

In this research the currency–commodity linkage has been indicated as the most significant linkage from all researched linkages with the most p-values confirming the significance of the relation during the researched periods.

The research proved the statistically significant negative correlation between the Dollar Index and Thomson Reuters/Jefferies CRB index in 1999, 2007, 2011, 2012, and also in the summarized period from January 1999 to April 2014. Otherwise, the statistically significant positive correlation between these indices has been detected in 2009.

This research confirmed the significant negative dependence between indices 30-Year U.S. Treasury Bond Price and Thomson Reuters/Jefferies CRB index in 2010 and also in the summarized phase 1999–2014. It has been found that even though the direction of the bond – commodity linkage varied in researched years, the negative correlations prevailed over the positive.

Empirically, the significant positive correlation between indices Standard & Poor's stock index and 30-Year U.S. Treasury Bond Price has been found in 2006. The negative correlation between these indices has been detected in 2012.

It has been proved the development of the stock – currency linkage differed during the past fifteen years. The research detected the statistically significant positive correlation between indices Standard & Poor's stock index and the Dollar Index in 2008 and in the summarized period from 2004–2008.

The significant relation between indices Standard & Poor's stock index and the Czech stock market PX index between years 2004–2008 and 1999–2014 has been identified.

In addition, this research confirmed the significant relation between indices Thomson Reuters/Jefferies CRB index and the Czech stock market PX index between phases 2004–2008, 2009–2014 and 1999–2014. Other correlations were non-zero but statistically insignificant.

Results of this cross – asset market research could be an inspiration for individual investors as well as for policy makers because results showed how the traditional asset classes interrelated during the different periods including crisis period.

Further research could be directed towards testing the causality between indices.

SUMMARY

The aim of this article was to examine the development of the relationship between stock, bond, currency and commodity markets within and between the U.S. and the Czech Republic and to quantify statistically significant cross-market correlations during the different periods including the crisis period retrospectively.

The research about the traditional asset classes relations presented by the leading global benchmarks Standard & Poor's stock index, Thomson Reuters/Jefferies CRB index, 30-Year U.S. Treasury Bond Price index and the Dollar Index as well as about their relation to the Czech stock PX index has been conducted on the basis of results of foreign studies and authors' own knowledge of this issue. This research used the indices' monthly closing prices with the sample period from January 1999 to April 2014 and on the sample of estimated 915 monthly relative market returns. Internal data were not included into the examination. The strength and the direction of the relation between each pair of indices have been examined within Pearson product moment correlation coefficient. The statistical significance of the estimated correlations has been tested with p-value statistics.

It has been proved the substantially correlations between the traditional assets existed over some past period. The currency–commodity linkage has been indicated as the most important linkage with the greatest number of p-values confirming the relations' significance during the researched periods. It has been found that even though the direction of the bond-commodity linkage varied in researched years, the negative correlations prevailed over the positive. Empirically, the statistically significant correlation between indices Thomson Reuters/Jefferies CRB and Dollar Index has been evidenced in 1999, 2006, 2007, 2009, 2011 and 2012; between indices Standard & Poor's stock index and 30-Year U.S. Treasury Bond Price in 2006 and 2012; between indices U.S. Treasury Bond Price and Thomson Reuters/Jefferies CRB in 2010 and 1999–2014; and finally between indices Standard & Poor's stock index and the Dollar Index in 2012 and 2004–2008. In addition the significant co-movement of indices Standard & Poor's stock index, Thomson Reuters/Jefferies CRB index and the Czech stock market PX index in phases 2004–2008, 2009–2014, 1999–2014 has been proved. Other correlations were detected as non-zero but statistically insignificant.

Acknowledgement

This paper was supported by Project No. IGA/FaME/2013/014: 014 Trading in Financial Markets Using Market Profile.

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