Co-movements and Interactions between Segments of Parallel Markets: The Case of the Czech Republic

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Abstract:

In the present paper we concentrate on interactions, co-movements and the sharing of information signals between the organized (and parallel) markets in the Czech Republic. In particular, the lead-lag relationship between the Prague Stock Exchange (PSE) and the RMS (over the counter system) is studied to identify the leaders and followers in the information transmission process.

The analysis shows that the PSE holds the leading position in the the main market of actively traded stocks, but the RMS dominates on segments with lower liquidity. These links did not exist during the early history of both markets, and they have become stronger as time proceeds. The analysis of the intra-market relations also confirms that liquid segments play a leading role in both the PSE and the RMS.

Due to the fact that some links between parallel market segments are missing, we conclude that the PSE and the RMS do not yet behave as a fully integrated market.

Abstrakt:

Tento článek studuje interakce a informační toky mezi paralelními kapitálovými trhy v České republice. Speciálně je studován vztah dominance mezi Burzou cenných papírů Praha (PSE) a RM-Systémem (RMS), abychom určili, který trh dominuje v informačních tocích a ovlivňuje vývoj budoucích cen na paralelním trhu.

Provedené analýzy prokázaly vedoucí úlohu hlavního trhu PSE pro aktivně obchované akcie. Na druhé straně se ukazuje dominantní pozice RMS na segmentech trhu s nízkou likviditou. Je zajímavé, že tyto vazby neexistovaly na počátku, a během času zesilují. Analýza interakcí mezi segmenty téhož trhu opět potvrdila, že segmenty s vyšší likviditou mají vedoucí pozici na obou trzích.

Nicméně mezi některými segmenty PSE a RMS neexistují dostatečné vazby, a tím pádem zamítáme hypotézu, že by se tyto paralelní trhy (PSE a RMS) chovaly jako jeden integrovaný trh.

Keywords: co-movements of financial markets, emerging markets, Granger causality, integration of emerging markets, lead-lag relationship.

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1. Motivation

A new phase of transition towards a market economy began in Central and Eastern Europe. Basically, all countries in the region face a common challenge: the task of developing and providing effective, market-oriented governance. In particular, this means building and supervising financial institutions and capital markets. So far experience has shown that this is a difficult and long term task. However, the experiences of the "front-running" CEE countries, specifically the Czech Republic, provide valuable lessons for other transition economies.

The birth of capital markets in Central and Eastern Europe has so far been strongly influenced by privatization programmes. Contrary to the standard ways of creating a capital market (through applying a range of regulations and rules in order to allow for a step-by-step expansion of the new financial market), the Czech Republic's capital market was developed in a different way. The newly emerged capital market was flooded with about one thousand equities coming from the first wave of voucher privatization in 1993.

Voucher privatization in the Czech Republic resulted in the highest ratio of stock market capitalization to GDP in the region and in a highly heterogeneous population of shareholders with different characteristics and trading needs. Although the Czech voucher scheme was very successful in terms of speed and transparency, the Czech capital market is one of the worst in the region if judged by its transparency, settlement, minority-shareholder protection rights and legal framework. The fact that shares have been traded simultaneously on two parallel markets, as well as very heavily off-market, has been one of the most significant barriers to market transparency. Agents operating in this complex environment see many risks that would not exist in standard capital markets.[1] The price of a single security could be (and in the beginning, indeed, was) very different on different exchanges (e.g., the Prague Stock

[1] Although the Czech capital market has the highest market capitalization in Central and Eastern Europe, the PSE has quite low liquidity. Between 75 to 90 per cent of all share transactions have been made off-market in the Center for Securities where any two individuals can transfer securities without being subject to any regulations.

Exchange (PSE) versus the RMS, an over-the-counter-system), offering possible arbitrage opportunities. [2]

It was shown (see Filer, Hanousek (1997) and Hanousek, Filer (1997)) that the first tier of the PSE *per se* exhibits some degree of market efficiency (weak and semi-strong forms). In addition, Němeček (1997) found few opportunities for insider trading of liquid stocks on the first two tiers of the PSE. Many authors observed trends and arbitrage opportunities between these markets (see Laštovička at al. (1994), among others), but a quantitative study of the interactions of these markets has not yet been done.

Therefore, in this present paper we concentrate on the interaction and linkages between the organized markets in the Czech Republic. We assume that new information entering one capital market should be carried over to the other one. This process, however, could be very different depending on the liquidity of a given security, the general availability of information about the economic situation of the firm, and the structure of agents holding a given asset. An interesting question is whether two parallel emerging markets which offer basically the same securities but have different institutional design could behave as one fully integrated market. The lead-lag relationship between the PSE and the RMS is studied here to identify the leader and follower in the information transmission process. This lead-lag relationship can be attributed to several factors: transaction costs, differences in settlement and institutional design, and non-synchronous trading. While strong bilateral links support the hypothesis of market integration, unilateral links lead to market segmentation and arbitrage opportunities.

Because disclosure and capital requirements vary across the tiers of the PSE, the lead-lag relationship is studied using market indices of the PSE tiers.[3] Autoregressive models of the

[2] Trading is governed by the Stock Exchange and Securities Law which was adopted in 1992. Both the PSE and the RMS started trading during the first half of 1993.

interrelations between different tiers of the PSE and the RMS should help explain the ways in which a new signal is absorbed by the market(s) and the role of the market segment (i.e., its transparency, liquidity, and the composition of the traders).

The paper is organized as follows. The next section consists of basic facts, notation and data description. In section 3, the Granger-causality is applied to the market indices to study the relationships between each tier of the PSE and the RMS, respectively, their evolutions over time, as well as the intra-market relationships between segments of each market. The fourth section contains concluding remarks.

2. Basic Facts

The Prague Stock Exchange

The Prague Stock Exchange (PSE), an electronic-type exchange, was re-opened on April 6, 1993, after a 55 year closure.[4] In the beginning, trading on the PSE was held one day per week and only 7 securities were traded, most of which were government or corporate bonds. By July 13, 1993, after the introduction of stocks from the first wave of voucher privatization, the number of securities increased to 961. On November 4, 1993, and March 14, 1994, respectively, trading was increased to two and then three days per week. Since September 19, 1994, trading occurred five days a week. Stocks from the second wave of voucher privatization have been traded since March 1, 1995, when the number of securities reached 1,699.

The actual trading on the central market of the PSE is fully automated (by the so-called Automated Trading System, an order-driven system). This means that prices and market indicators are set, orders are matched and transactions are carried out with full computer

[3] Hanousek and Nemeček (1997) present a complementary model of the lead-lag relationship for individual stocks with and without transaction costs.

support. Every morning, during the morning auction, buy and sell orders are cleared.[5] The goal of the clearing procedure is to maximize the number of shares traded. The results of the morning auction (trading at a fixed price) are made available to the general public at 11:00am. Depending on its trading group, a given security can then be traded in the subsequent afternoon session at a fixed or variable price. Trading at a fixed price means that any afternoon transaction has to be done at the price set during the morning auction. Most liquid stocks are traded in the variable-price continuous auction which opens with the price set in the morning session. Trade settlement is done in the form of the delivery of securities versus payment, processed in T+3 days.

The RMS (electronic over-the-counter exchange)

In May 1993, the RMS (*Registrační Místa System*, i.e., "Registration Places System"), a separate over-the-counter exchange opened. The RMS was essentially an extension of the registration offices' infrastructure, which carried out the voucher-bidding process. The license for organizing a securities market was issued to the RM-System on March 19, 1993, and actual trading began on May 24, 1993. Unlike the PSE, it is not based on the membership principle. Any individual can directly access the market organized by the RMS through one of more than one hundred entry places spread over the whole Czech Republic which allow on-line access to the central RMS work place.[6]

During 1994, the RMS changed from holding so-called "periodic" auctions (accumulated orders were cleared during two or three week periods) to holding continuous auctions. The continuous auctions started on February 2, 1994, with trading held only one day per week. On

[4] Its founding shareholders were 12 Czech monetary institutions and five broker firms. At the end of 1996 the PSE had 109 members, 32 of which were bank-type members and 77 broker-type companies. About one fourth of all members were those with foreign capital participation.

[5] The order may have a limit price specified, i.e., a maximum price for buying and a minimum price for selling order. If the limit price is not specified, it is a simple market order.

March 2, 1994, April 19, 1994, and July 11, 1994, trading was extended to two, three and four days a week, respectively. Since September 5, 1994, trading has taken place every weekday.

In the RMS auction, the buy and sell orders are matched and trade is executed by means of computer algorithm. The auction price is set to maximize the volume of trade, given an admissible set of buy and sell orders during a given auction round. If there are several prices leading to the same volume of trade, the arithmetic mean is used. In the continuous auction, a trading day opens with the auction of those orders not satisfied during the last trading day, including those received after the market closed. Then, a sequence of auction rounds is executed during normal trading hours. Any event changing the demand and supply patterns (for example, the arrival of a new transaction) initiates a new auction round. The transfer of securities and money ("delivery versus payment") resulting from the completed trade takes place immediately — the settlement is done in time T+0. For a detailed timetable of trading on the PSE and the RMS, see Hanousek and Němeček (1997).

Comparison of the PSE and the RMS

Trading on both markets started in the first half of 1993. Contrary to the standard ways of creating a capital market (through applying a range of regulations and rules in order to allow for a step-by-step expansion of the new financial market), the Czech Republic's capital market was developed in a different way. The newly established PSE and RMS markets were flooded by about one thousand equities coming from the first wave of voucher privatization in 1993. Another set of about seven hundred equities entered the market after the end of the second wave of voucher privatization in March 1995. Voucher privatization also resulted in a highly heterogeneous population of shareholders with different characteristics and trading needs. While institutional investors (represented for example, by mutual funds managers) prefer to

[6] The network of the RM-System share shops located throughout the country totaled 155 in 1996 (208 in 1995,

trade on the PSE, individual shareholders generally prefer to trade on the easy-to-access RMS. Note that the trading volume on the PSE dominates (approximately 4:1) the trading volume on the RMS. See Table 1.

Table 1. The trading volume on registered capital markets (US$ billion)

Trading volume (US$ billion)**	1993*	1994	1995	1996
PSE	0.3	2.16	7.36	14.47
RMS	0.1	0.15	1.03	3.68

* April-December (PSE), July-December (RMS)
** Average exchange rates

The high number of securities with their very different frequencies and volumes of trade, market capitalizations, varying information disclosures, and the non-transparency of the market in general resulted in the first restructuring of the PSE. The new segmentation of the PSE started on September 1, 1995, when the PSE market was split into three main tiers.[7] The listing requirements for each trading group are summarized in Table 2.

Table 2. The Listing Requirements for the PSE (1996)

Trading Group	Requirements			Segment notation
	Disclosure	Liquidity*	Capital**	
Tier one	Quarterly	> 300,000	Public offer > 200 mill. Registered capital > 500 mill.	A1, A2
Tier two	Semi-annually	N/A	Public offer > 100 mill. Registered capital > 250 mill.	B2
Tier three	Annually	N/A	N/A	C2, C3

All figures are in CZK
* Average volume per session (last five months)
** Capital requirements vary for firms (public offer) and for investment trusts and units (registered capital)

Group A1 and A2 denote securities traded on the first tier at variable and fixed (afternoon-auction) prices, respectively. Group B2 and C2 represent securities from the second and third tiers, respectively. Finally, group C3 denotes those securities from the third tier which have very low liquidity and are traded twice a week in the fixed-price afternoon auction. The above

242 in 1994, 333 in 1993).
[7] The PSE calls its tiers "the Main, Secondary, and Free Markets" which could be misleading so we keep the notation of the First, Second, and Third Tiers, or trading group 1 to 3.

mentioned segments, A1 to C3, vary considerably in terms of both market capitalization and liquidity, as documented in Table 3.

One can note several expected trends for both the PSE and the RMS. Particularly, A1 and A2 have been gaining in terms of market capitalization and liquidity. In other words, as the market emerged, the segments with the highest disclosure requirements comprise the most attractive and liquid stocks. The ratio of trading volume of PSE/RMS fell from 4.1 to 3.5, still showing significant dominance of the PSE over the RMS. It is interesting that figures for the trading volumes on less transparent (and liquid) segments of the PSE are getting closer to the RMS figures.

Table 3: Characteristics of the particular trading groups

Date	A1	A2	B2	C2	C3	On RMS only**
April 1995						
# of stocks (04/03/95)	7	36	48	568	1050	256
Avg. daily volume of trade on PSE *	15831	11529	4002	28032	2333	-
Avg. Daily Volume of Trade on RMS *	1991	2384	789	8060	715	1146
Ratio of Volume of Trade PSE/RMS	7.95	4.84	5.07	3.48	3.26	-
% of market cap. on PSE	39.52%	23.53%	9.08%	22.98%	4.89%	-
% of market cap. on RMS	38.20%	22.43%	8.57%	22.04%	5.47%	3.29%
February 97						
# of stocks (02/18/97)	8	37	52	564	1030	399
Avg. daily volume of trade on PSE *	61144	37267	17501	49554	1392	-
Avg. daily volume of trade on RMS *	9415	11176	4468	17947	1003	4264
Ratio of volume of trade PSE/RMS	6.49	3.33	3.92	2.76	1.39	-
% of market cap. on PSE	44.57%	29.25%	10.46%	13.68%	2.04%	-
% of market cap. on RMS	43.30%	28.31%	10.11%	13.27%	2.09%	2.92%

* All figures are in thousands of CZK

** A group of stocks not traded at the PSE.

Data description

We omit data from the very embryonic stage of both markets and concentrate on the time span from April 3, 1995 to December 20, 1996. Thus, we analyze the period starting after the

bulk of shares from the second wave of voucher privatization entered the market (we allow for a one-month "settle-down period") and ending before the first major withdraw of shares on the PSE took place.[8]

The daily data on individual stocks as published by the PSE and the RMS were used to create market price indices for each segment of the PSE: A1, A2, B2, and C2.[9] All shares of a given segment were incorporated in the index base and were assigned a weight proportional to their market capitalization. For the sake of simplicity we assume that the index base remained unchanged.[10] Therefore, the index for each segment of the PSE and the RMS is defined as follows:

$$I(t) = \frac{M(t)}{M(0)} 1000 \qquad (1)$$

where

M(t) and M(0) are the market capitalization of the base at time t and "0", i.e., at the initial starting period.[11] As a starting period we chose April 3, 1995, four weeks after the last major transfer of shares to organized markets.

[8] The following criteria were applied: volume of trades, market capitalization, number of day traded per year. By September 1997, 1303 companies were withdrawn from the PSE in the following steps: March 1997 – 100 stocks, April 1997 – 391 stocks, June 1997 – 509 stocks, September 1997 – 303 stocks.

[9] We have to exclude segment C3 from our analysis because of its different frequency of trading on the PSE. Basically, until October 1995, segment C3 was traded daily, then it was traded twice a week, and finally since January 1997, it has again been traded daily.

[10] There were few changes in the base during the period studied, and our results were robust with respect to the chosen base.

[11] This definition complies with the methodology of the International Finance Corporation which is mostly used for creating market indices in emerging markets.

3. Interrelation between markets: Granger-causality test

Since Granger (1969) introduced his definition of 'causality', the test of Granger-type causality has been applied quite frequently in empirical works, including studies on (international) market links. The methodology of testing for the existence of linkages between markets is quite standard; see Agmon(1972), Hiemstra and Jones (1994), Hsiao (1981), Joy et al.(1976), Kwan et al. (1995), Smith et al. (1993), among others. A similar approach has been used to test interrelations between the cash markets and stock index futures; see Chan (1992), Kawaller et al. (1987) and Shyy et al. (1996), among others.

We say that '$\{x_t\}$ causes $\{y_t\}$', if the present value y_t can be predicted significantly better when past values of x_t are included in all relevant information. Usually the notion of 'causality' in economic systems is limited to linear relations between observed time series. The Granger causality is then tested via an autoregressive representation

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \begin{bmatrix} a(L) & b(L) \\ c(L) & d(L) \end{bmatrix} \begin{pmatrix} x_t \\ y_t \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \delta_t \end{pmatrix}, \tag{2}$$

where L denotes the lag operator. For a review of alternative tests, see Geweke et al. (1983).

Because disturbances are serially uncorrelated, the test for the direction of causality between $\{x_t\}$ and $\{y_t\}$ can be turned into a standard test of whether $b(L)=0$ and/or $c(L)=0$.[12] The testing can proceed only if some restrictions on the autoregressive form (3) are specified before the actual estimation. Particularly, the length of autoregression should be identified prior to the estimation of (3). We applied Hsiao's (1981) two-step approach to determine the length of the lag structure. The causal relationships between the related segments of the RMS and the PSE were examined in the context of the following models:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{k1} \alpha_i \Delta X_{t-i} + \sum_{i=1}^{k2} \beta_i \Delta Y_{t-i} + \varepsilon_t \tag{3}$$

[12] The test of the hypothesis '$\{x_t\}$ causes $\{y_t\}$' is equivalent to the test of the restriction $b(L)=0$. Similarly, the opposite direction of causality can be tested via the restriction $c(L)=0$.

$$\Delta Y_t = \chi_0 + \sum_{i=1}^{k3} \chi_i \Delta Y_{t-i} + \sum_{i=1}^{k4} \delta_i \Delta X_{t-i} + \nu_t \qquad (4)$$

where X_t and Y_t denote price indices of the particular segment of the RMS and the PSE, respectively.

For each segment of the market (A1, A2, B2, and C2), *k1*, *k2*, *k3* and *k4* were determined by a search method over a range of lag lengths from 1 to 5. Settlements are done in time T+0 and T+3, respectively. If the market is efficient, then there is no reason to expect a market response longer than 3 lags. Nevertheless, because prices of a particular stock could change by a maximum of ± 5 percent between subsequent trading sessions on the PSE and by a maximum of ±10 percent on the RMS, we allow a longer time for price adjustment.[13]

In order to capture the dynamics of the linkages between these newly emerging markets, we split our sample into three sub-samples: 4/95 to 12/95, 1/96 to 6/96 and 7/96 to 12/96. The "optimal lengths" were estimated applying standard information criteria — Akaike (1969), Hannan and Quinn (1979), Schwarz (1978).

To test for a lead-lag relationship between corresponding segments of the PSE and the RMS, we should estimate the autoregressive models (4) and (5) with the number of lags representing "true" size or memory of the model. Several studies exists comparing the accuracy of information criteria for estimating the length of the model. See, for instance, Hannan and Quinn (1979).[14] Note that it is necessary to test whether both series are cointegrated; see the standard methodology developed by Engle and Granger (1987). We did several robust checks, using the number of lags specified by different information criteria.[15] Moreover, we have also used four and five lags of both dependent and independent variables in the tests for market linkages. The results obtained were not sensitive to the model

[13] The floor and ceiling limits could affect the length of the autocorrelation; it takes a few sessions to incorporate rapid changes into the price, especially for the segments with low liquidity.
[14] In our case, the Hannan-Quinn and Schwarz-Bayes criteria tend to estimate a shorter length of the model compared to the Akaike criterion.

specification. The tests for linkages between the same segments of the PSE and the RMS are conducted as follows:

$H_0 : \beta_i = 0$ for all i (i.e., no link from the PSE to the RMS)

and

$H_0 : \delta_i = 0$ for all i (i.e., no link from the RMS to the PSE).

Table 5 summarizes our results. These results clearly document the process of increasing market integration over time with almost no intermarket links in 1995 and with significant interactions in the second half of 1996.

Nevertheless, even after two years from the last major share transfer (and four years since establishing the capital markets), the PSE and the RMS do not yet behave as a fully integrated market. Moreover, the tests provide evidence in favor of our prior expectation that in segments containing liquid and attractive stocks, the PSE dominates the RMS; for the less liquid and transparent stocks, just the opposite is true.

Table 5. Test of the linkages between the corresponding segments of the PSE and the RMS.

Segment	04 – 12/95	01 – 06/96	07 – 12/96
A1	No link	PSE => RMS a	PSE => RMS a
A2	PSE => RMS a	PSE => RMS a	PSE => RMS a RMS => PSE b
B2	No link	RMS => PSE a	RMS => PSE a
C2	No link	RMS => PSE a	RMS => PSE a

In accordance with standard methodology, we verified the cointegration of the time series studied and the lack of residual autocorrelation in all models.
a and b denote significance at 1% and 5% levels, respectively. For more details see Table A.1 in the Appendix.

[15] Thorton and Batetten (1985) show the sensitivity of the causal relationships to a chosen number of lags.

This phenomenon raises another related question: Are the segments with missing links affected indirectly, say by "a signal" coming from the entire parallel market? This question leads to the following models:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{k1} \alpha_i \Delta X_{t-i} + \sum_{i=1}^{k3} \phi_i \Delta Z_{t-i} + \varepsilon_t \quad (5)$$

$$\Delta Y_t = \chi_0 + \sum_{i=1}^{k4} \chi_i \Delta Y_{t-i} + \sum_{i=1}^{k6} \varphi_i \Delta Z_{t-i} + \nu_t \quad (6)$$

where X_t and Y_t denote the price indices of the RMS and the PSE, respectively, and Z_t covers all price indices from the parallel market.

Similarly, testing for market linkage in this case means testing the following:

$H_0 : \phi_i = 0$ for all i (i.e., no link from the whole PSE to a given segment of the RMS)

and

$H_0 : \varphi_i = 0$ for all i (i.e., no link from the whole RMS to a given segment of the PSE).

We have tested these hypotheses for the time span 01/96 to 12/96. Results of the tests show that segment A1 of the PSE (representing the blue chips traded in the variable-price auction) is not affected by any segment of the RMS. This statement is also true for segment A2; firms on the first tier traded at a fix price.[16] Similarly, segments B2 and C2 on the RMS are not influenced by price changes on the PSE.

Recent studies of emerging markets (see for instance Morck et al. (1997)) pointed out that young markets usually indicate very low firm-specific risk. Basically, many emerging markets have a tendency to rise and fall as a whole. It is interesting to test to what extent we could observe this phenomena in the segments of the PSE and the RMS. In particular, if all stocks in

[16] Note that for the second half of 1996, we already detected a bilateral relationship; see Table 5.

emerging markets are inclined to move in the same direction, which market segment is the leading one? Therefore, we also test a lead-lag relationship in the following specification:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{k1} \alpha_i \Delta Y_{t-i} + \sum_{i=1}^{k2} \beta_i \Delta W_{t-i} + \varepsilon_t , \qquad (7)$$

where Y_t represents a price index of the RMS (PSE), and W_t contains all remaining price indices from this market. Testing for the inter-segment linkages within the same market leads to the following hypothesis:

$H_0 : \beta_i = 0$ for all i (i.e., the studied segment is not affected by the other parts of the market).

The results comply with our expectations: the shocks from more transparent and more liquid segments should contain relatively more firm-specific risk; therefore, moves in these segments can not be explained by price changes in the other tiers. Moreover, we expect that because foreign investors mainly trade stocks from the first two segments of the market (A1 and A2), price changes in these segments could indicate a general "change in investors' mood" and hence would affect prices in the other segments.[17] The results are presented in Table 6.

[17] It should be noted that linkages from the segments with higher liquidity to those less liquid are likely to be magnified by the differences in the average probability of nontrading. These differences imply positive autocorrelations between current returns on a lower-liquidity segment and lagged returns on a higher-liquidity segment due to nonsynchronous trading. This is caused by the lagged incorporation of common information signals into prices of less frequently traded stocks.

Table 6. Inter-segment Links: January 1996 to December 1996.

Segment	PSE	RMS
A1	No link	No link
A2	No link	A1=>A2[b]
B2	A1=>B2[a] A2=>B2[a] C2=>B2[b]	A1=>B2[a] A2=>B2[a] C2=>B2[b]
C2	A1=>C2[a] A2=>C2[a] B2=>C2[a]	A1=>C2[b] A2=>C2[b] B2=>C2[b]

a and b denote significance at 1% and 5% levels, respectively.

Indeed, A1 and A2 segments of the PSE are not affected by any other segment with lower liquidity. The opposite is true for the bottom of the market: segments B2 and C2. Results for the RMS were similar, with the exception of segment A2. The hypothesis of a linkage is not rejected on the 5 per cent significance level. We would assign this discrepancy between the PSE and the RMS to the different population of traders. While the PSE is based on the membership principle and serves mainly the trading needs of institutional investors, the RMS is a free-access over-the-counter system with significant participation of individual investors. For detailed results see Table A.2 and Table A.3 in the Appendix (Note, very high R^2 on the PSE segments B2 and C2 indicates high predictability of changes on the segments with low liquidity).

4. Conclusions

The interactions between similar markets, in particular a lead-lag relationship, are of general interest. Many financial studies used cash and option markets to study the extent to which different transaction costs, institutional design, technical condition, etc., affect the lead-lag relationship. If the co-existing parallel markets are efficient, then arbitrage will maintain a correct pricing relationship. As a complement to other studies we used the fact that two parallel equity markets exist in the Czech Republic, and we studied similar issues of market linkage in these emerging markets.

Thus, this present paper has provided the first insight into the (creation of) interactions, co-movements and sharing of information signals between the organized markets in the Czech Republic. The empirical results indicate that new information appearing on the market regarding continuously traded stocks (segment A1) of the PSE strongly dominates the corresponding segment of the RMS. On the other hand, the RMS dominates other segments with lower liquidity.

In particular, we find unidirectional causality for the segment of continuously traded stocks (A1) running from the PSE to the RMS, showing that the price of "blue chips" is primarily determined by the demand/supply of institutional investors on the PSE. For liquid stocks (segment B2), we detected causal relationships in both directions.[18] On the other hand, because of low liquidity, the so-called "free market" (segment C2) reflects primarily the supply side of the RMS (individual investors). In other words, the RMS serves as a source of shares to be subsequently traded on the PSE or off-market (This process continues to further concentrate share ownership). The existing intra-market linkages also confirm the leading role which liquid stocks play in incorporating common information signals into stock prices.

[18] This pattern was first determined for the second half of 1996. Prior to that time, we detect only links from the PSE to the RMS.

However, because of missing links between some market segments, we conclude that the PSE and RMS do not yet behave as one integrated market. This market inefficiency is due partly to the various institutional barriers like transaction costs and settlement procedures, partly to the differences in the population of traders (with institutional investors trading primarily on the PSE and individual investors on the RMS), and partly to the process of ownership concentration through trading on the RMS.

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Appendix Numerical results associated with Tables 5 and 6.

In the Appendix we present the results of models (5) – (7), in which we chose the number of lags (i.e., *k1, k2, k3* and *k4*) equal to five. As usual, the hypotheses are tested using the standard F-test of restricted versus unrestricted models.

Table A.1 The linkages between the parallel segments of the PSE and the RMS

Segment	Time period	A link from the PSE to the RMS			A link from the RMS to the PSE		
		R^2 restr.	R^2 unrestr.	F-statistics	R^2 restr.	R^2 unrestr.	F-statistics
A1	04-12/95	.07	.11	1.04	.17	.19	.27
	01-06/96	.10	.54	20.32 a	.01	.03	.55
	07-12/96	.10	.65	36.57 a	.16	.19	.73
A2	04-12/95	.30	.62	4.78 a	.23	.41	2.24
	01-06/96	.02	.37	12.79 a	.08	.11	.48
	07-12/96	.16	.40	9.18 a	.24	.31	2.56 b
B2	04-12/95	.23	.29	.70	.53	.53	.85
	01-06/96	.06	.11	1.07	.85	.87	4.00 a
	07-12/96	.10	.20	3.01 b	.67	.70	2.29 b
C2	04-12/95	.25	.27	.19	.75	.75	.43
	01-06/96	.09	.11	.55	.87	.91	9.18 a
	07-12/96	.07	.15	1.98	.70	.77	6.48 a

a and b denote significance at 1% and 5% levels, respectively.

Table A.2 The inter-segment linkages of the PSE (1996)

Segment (1)	Segment (2)	A link from (1) to (2)			A link from (2) to (1)		
		R^2 restr.	R^2 unrestr.	F-statistics	R^2 restr.	R^2 unrestr.	F-statistics
A1	A2	.19	.22	1.77	.05	.08	1.60
	B2	.75	.77	4.45 a	.05	.06	.57
	C2	.81	.83	3.15 a	.05	.06	.22
A2	B2	.75	.79	9.33 a	.19	.20	.21
	C2	.81	.83	3.24 a	.19	.21	.94
B2	C2	.81	.83	4.87 a	.75	.77	2.74 b

a and b denote significance at 1% and 5% levels, respectively.

Table A.3 The inter-segment linkages of the RMS (1996)

Segment (1)	Segment (2)	A link from (1) to (2)			A link from (2) to (1)		
		R^2 restr.	R^2 unrestr.	F-statistics	R^2 restr.	R^2 unrestr.	F-statistics
A1	A2	.13	.17	2.39 b	.09	.10	.74
	B2	.08	.14	3.40 a	.09	.12	1.48
	C2	.05	.11	3.17 a	.09	.12	1.71
A2	B2	.08	.16	4.00 a	.13	.16	1.81
	C2	.05	.10	2.33 b	.13	.13	.44
B2	C2	.05	.10	2.37 b	.08	.13	2.32 b

a and b denote significance at 1% and 5% levels, respectively.