

**Institutional Trading, Trading Mechanisms and Equity Market
Integration: Essays on the Polish Stock Market**

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Chapter 1: Introduction

The launch of financial reforms in Central and Eastern Europe (CEE) at the beginning of the 1990s stimulated increased interest of investors and academics in the newly-born stock markets of this region. Two main streams in the extant empirical financial literature on these markets include testing the established asset pricing models (Hanousek and Filler (1997), Ratkovicova (1999), Charemza and Majerowska (2000)) and studies on integration of the CEE markets into the global market environment (Linne (1998), Jochum, Kirshgässner and Platek (1999), Gilmor and McManus (2000)). Most of these studies, however, consider a group of the CEE markets, stressing their commonalities and discarding the fact that though these markets started at approximately the same time, due to the different starting conditions and reform paths, nowadays they differ considerably in terms of size and significance for domestic economies (Schröder (2000)).

In the present thesis, we focus on the Polish stock market, as it is considered to be an example of consistent and successful financial market reforms. After the first decade of reforms, Warsaw Stock Exchange (WSE) turned into the leading trading venue in the CEE region due to the higher number of listed securities, higher growth rates and more sophisticated infrastructure than in the neighboring markets. In terms of market capitalization WSE is now comparable with the smaller Exchanges of Western Europe, like Vienna Stock Exchange (Köke and Schröder (2002)). There are, however, several important features pertaining to the institutional and regulation aspects of the Polish stock market that may impact formation of equity prices, which nevertheless failed to attract the interest of the researchers so far. Some of these features are common with other emerging markets, which makes the results of our study interesting to a broader international audience.

This thesis consists of four separate self-contained essays. They extend four streams of the empirical literature on the developing European stock markets: investment behavior of institutional investors; impact of institutional demand on individual and aggregate stock prices; effects of trading mechanism regulation on stock return autocorrelation and volatility; predictability of stock returns due to long-run relationships between developing European and mature markets. Some of the results of the present research appear to challenge findings documented in

the previous literature and question the extant policies, thus suggesting areas for future research.

The first essay entitled “Institutional Traders’ Behavior in an Emerging Stock Market: Empirical Evidence on Polish Pension Fund Investors” addresses the launch of pension funds as the new type of institutional investor on the Polish stock market in the result of the pension system reform of 1998. The important change in the composition of the institutional traders is difficult to be underestimated since it has resulted in the appearance of the most important group of institutional investors in terms of the value of the assets (Mech (2001), Stanko (2003)). Previous studies of institutional investors indicate that institutions may be engaged in herding and positive feedback trading, investment behavior that may have destabilizing impact on asset prices (Lakonishok, Shleifer and Vishny (1992)). Recent evidence on institutional trading in mature stock markets suggests that these types of trading activities are exercised by pension funds to a lesser extent than by other institutions, like mutual funds and insurance companies (Jones, Lee and Weis (1999), Badrinath and Wahal (2002)). We do not expect it, however, to hold in the case of Polish pension funds. The main reason behind this hypothesis stems from the specifics of the Polish pension fund industry and a strict regulation of pension fund investment activity, in form of peer-based evaluation benchmarks, quantitative investment limits and a penalty structure. As far as we are aware, this essay represents the first analysis of the so-called ‘Latin-American’ type of pension fund market characterized by stricter investment rules than the so-called ‘Anglo-Saxon’ and ‘Continental’ types, scrutinized in the earlier studies. In the analysis we utilize a measure of herding and positive feedback trading suggested by Lakonishok, Shleifer and Vishny (1992) widely used in the earlier studies. This enables us to compare our findings for the sample of Polish pension funds with the findings documented in the extant literature.

In line with our expectations, we find that Polish pension funds display considerably greater extent of herd-like behavior and more often pursue feedback trading strategies than their counterparts in mature markets. Herding and positive feedback trading are especially pronounced in stocks from the extreme performance groups, e.g., extreme winners and extreme losers. Whereas funds in mature stock markets tend to herd into small stocks, Polish pension funds also

herd into the stocks of larger companies, which is attributed to the strict performance evaluation of the pension funds.

One of the outcomes of herding is identical portfolio compositions of herding institutions resulting in sub-optimal risk-sharing. Analysis of the pension fund portfolios does suggest a high concentration of the pension fund assets in a limited number of large and highly liquid assets. These findings are in line with the conclusion of Blake, Lehmann and Timmermann (2002) that peer-based performance measures stimulate mimicking of the investment decisions of market leaders. Though we do not detect that trading by the pension funds exerts significant influence on the future individual stock prices and thus there seem to be no pronounced destabilizing effect from pension fund trading, our findings question the effectiveness of the present investment regulation from the point of view of the optimal asset allocation by pension funds and wealth maximization of the pension fund trustees in the long-run.

The second essay entitled “Stock Market Prices and Institutional Trades: Evidence on Trading by Pension Funds in Poland” is stimulated by the on-going debate in the Polish stock market press about the price pressures exerted by the pension funds. It formally estimates the impact of the demand by pension funds on aggregate stock returns (Brycki and Karpinski (2002), Karpinski (2002b), Karpinski (2003)). In the spirit of Warther (1995) and Goetzmann and Massa (2003) it scrutinizes the market-wide response to trading by pension funds. Using a framework similar to Froot et al. (2001) structural vector autoregression model it tests for the contemporaneous relation between the movements of the two most important stock market indices WIG and WIG20 and monthly flows from pension funds. As expected, the findings indicate that there is a significant positive relation between the flows and two main market indices’ concurrent returns, showing that trading by pension funds does exert pressure on contemporaneous aggregate market prices. However, this relationship does not appear to be present in the following months suggesting that pension fund trading does not influence future stock returns, at least on a monthly basis. Findings for the stock returns of medium capitalization companies, listed in MIDWIG index are similar, suggesting no asymmetry in the reaction of smaller companies to pension fund trading.

Analyzing flows from the largest and smaller pension funds, we find that these are flows from the market leaders that drive contemporaneous stock market returns. This result reflects the growing concentration in the pension fund market and substantiates concerns of impending liquidity attenuation of the WSE, once again highlighting undesirable outcomes of the strict investment regulation at the aggregate market level. Echoing the results of the previous essay, there is no indication that institutional trading has a significant impact on the future stock market prices.

The third essay, “Price Limits on a Call Auction Market: Evidence from the Warsaw Stock Exchange”, focuses on a specific regulation of the trading mechanism of the Polish stock market. Namely, it analyses price impact of the limits imposed on daily stock price movements. Price limits are widely used by the stock exchanges around the world for at least a subset of stocks. The motivation behind their imposition is to mitigate overreaction during the turbulent periods and ensure smooth and efficient asset prices (Ma Rao, and Sears (1989a), Ma, Dare, and Donaldson (1990), and Huang, Fu, and Ke (2001)).

In order to ensure the stability of the market and decrease its vulnerability to excessive price swings, Polish stock market regulators impose price limits in the call auction segment of the WSE, where trading takes place once per day. Up to our knowledge, this study constitutes the first attempt to analyze price limits’ impact in the call auction market. The motivation behind it is that since call auctions with a low number of clearings per day inherently offer time-out periods to investors, we do not expect price limits to fulfil their functions and to counter overreaction and panic in this market structure. Utilizing the AR-GARCH framework in the spirit of Shen and Wang (1998) and Veld-Merkoulova (2003), we investigate the effects of price limits in terms of their impact on return volatility and the autocorrelation of the stocks listed in the call auction segment of the WSE. Indeed, our empirical findings show that price limits result in excess volatility and strong continuation of price movements on the next trading day. This indicates that price limits only delay the adjustment of prices to equilibrium levels. Our results therefore question the necessity of price limits in the call auction system of the WSE.

The fourth essay entitled “Polish Equity Market Integration with the Emerging European and Developed Markets: A Cointegration Analysis with

Shifting Regimes” analyzes Polish stock market along two other emerging markets of Hungary and Czech Republic and investigate their long-run linkages with the US, UK, German and French stock markets. Previous studies that analyzed predictability of the CEE stock returns using information from other emerging and mature markets assumed stable long-rung relationships between the stock market indices and failed to find significant evidence of predictability using information from other markets. We utilize more flexible framework that accounts for the time-varying nature of market linkages. Namely, we use the Gregory-Hansen test (1996) that does not impose the stringent assumption of stable relationships. This enables us to obtain much stronger evidence supporting long-run linkages displayed by all Central European (CE) markets than was previously reported (Jochum, Kirchgässner and Platek (1999), Gilmor and McManus (2002)).

Our findings confirm the presence of long-run relationships between the emerging stock markets of Central Europe. Furthermore, using two-regime vector-error correction models, we find that CE markets display equilibrium relations with their mature counterparts that persist after controlling for structural change. Our results provide a strong indication that the Polish and the other two CE markets have become more integrated with the global stock markets, which suggests reduced diversification opportunities for the foreign investors seeking to diversify in these markets.

Chapter 2: Institutional Traders' Behavior in an Emerging Stock Market: Empirical Evidence on Polish Pension Fund Investors

2.1. Introduction

The increasing dominance of institutional investors on stock markets world-wide has stimulated public and academic discourse on the influence their trading exerts on asset prices. This interest is due to the common belief that institutional investors, being to a greater extent engaged in herding and feedback trading behavior than individual traders, may contribute to the destabilization of stock prices.¹ Nevertheless, previous studies of institutional behavior show that the actual extent of herding and positive feedback trading by institutions proved to be surprisingly modest.² These investigations scrutinize trading behavior conditional on the type of the institution, with the particular emphasis on the performance of mutual funds.

Though recent investigations report the growing importance of pension funds for the domestic stock markets (Davis (1997), Davis and Steil (2000)), only few studies focus on the investment behavior of pension fund managers. Lakonishok, Shleifer, and Vishny (1992) investigate holdings of more than 700 US pension funds and conclude that pension fund herding and positive feedback trading in large stocks is very modest. Somewhat more pronounced evidence of positive feedback trading was revealed for smaller stocks, but even in this case, its extent is far from enough to exert any destabilizing influence on individual stock prices.

A recent study by Badrinath and Wahal (2002) examines pension funds along with a broad range of institutions of the US market including mutual funds, investment advisors, insurance companies, commercial banks, and trusts. They document that pension fund managers are to a lesser extent engaged in feedback

¹ For theoretical models explaining herding and feedback trading by institutions, see Scharfstein and Stein (1990), Roll (1992), Froot, Scharfstein, and Stein (1992), Hirshleifer, Subrahmanyam, and Titman (1994), and Sentana and Wadhvani (1992).

² See, e.g., Grinblatt, Titman, and Wermers (1995), Wermers (1999), Borensztein and Gelos (2000).

trading than others, with the link between past returns and taking a position in stocks being more pronounced in small firms. Jones, Lee, and Weis (1999), using a sample similar to Badrinath and Wahal, report that pension funds managers act as feedback traders especially on the buy side and mostly in small stocks with high past performance. Blake, Lehmann, and Timmermann (2002), find clustering in the UK pension fund performance and conclude that pension fund managers are likely to herd around the fund with the median outcome.

The empirical studies mentioned above concentrate on pension funds of the so-called ‘Anglo-Saxon’ type, while omitting ‘Continental’ and ‘Latin American’ types of pension fund industries adopted in developed countries of continental Europe, and emerging economies of Latin America and Central Europe.³ This omission is important due to salient differences in investment regulations shaping these three types of pension fund markets. The ‘Anglo-Saxon’ type is characterized by dominance of loose ‘prudent-man’ investment rules. Pension funds of the second type face quantitative limits on their investment, which are not, however, binding and rather reflect conservative investment preferences of their participants. The ‘Latin American’ type is the strictest among the three types mentioned. In the latter system pension funds face substantial restrictions of the investment freedom, like limits on the amount of funds to be invested in particular types of assets and foreign assets, and obligation to guarantee their participants pre-defined levels of returns.

Blake, Lehmann, and Timmermann (2002) state that investment rules may affect institutional trading translating into differing patterns of investment behavior implemented by pension funds. This consideration warrants further inquiry into investment behavior of pension funds operating in different regulatory environments. For this reason, we extend the existing empirical literature on institutional trading behavior by analyzing pension funds that are subject to a different, more stringent, investment regulation than funds examined in the earlier studies. While issues related to operating of Latin American pension funds became subject to a discussion, pension fund markets of the Central

³ For a description of the different types of pension systems please see Davis (1997).

European countries have drawn so far less attention.⁴ Up to our knowledge, this study is the first attempt to formally analyze investment behavior by pension funds in the region.

Due to existing particularities of the legal environment of Polish pension funds, which was created after Latin American type of regulation, we may gain additional insight into the herding and positive feedback trading by pension funds that act in a dynamically developing emerging stock market. In the present study we address the following questions. First, to what extent are Polish pension funds engaged in herding and feedback trading and is it comparable to the degree of herding found in the previous studies on pension funds? Second, are there any differences in the extent of herding and feedback trading with regard to particular groups of stocks categorized in terms of size, past performance and industry? Third, is there any relationship between the excess demand of pension funds and contemporaneous stock returns? Our findings should be of interest to pension fund participants, whose future pensions are directly influenced by investment decisions of pension fund managers and regulators of markets where similar investment legislation is implemented.

The rest of the chapter is structured as follows. The next section describes the Polish pension reform and pension fund market. The statistical methodology used to assess the extent of herding and feedback trading is outlined in section 2.3. Section 2.4 describes the data set used in the study. Empirical findings are represented in section 2.5. Finally, section 2.6 concludes.

2.2. Pension Funds in Poland

Heavy fiscal burden resulting from the flows of the old pay-as-you-go pension system, aggravated by growing demographic pressure, called for a reform of the existing Polish system of pension insurance.⁵ The new three-pillar pension

⁴ For the analysis of the pension reform in Latin America see Simonetti (2000), and Yermo (2000).

⁵ By the mid 1990s, the level of deductions from personal incomes soared to 45 % and the amount of pensions to be paid reached 15 % of Polish GDP.

system was launched in 1999.⁶ It consists of the reformed pay-as-you-go government-run system represented by the Zakład Ubezpieczeń Społecznych (ZUS), the system of open pension funds run by private managing companies, and privately funded pension security schemes. The first two pillars are compulsory, the third one is voluntary and aims to provide above-the-minimal standard of living by promoting long-term private savings through different types of investments.⁷

Polish pension funds are defined-contribution funds, which implies, that amount of future pensions accumulated in this pillar depends solely on returns on invested assets.⁸ Employees transfer 7.3 % of their gross salary through the ZUS to the pension funds, which invest it mostly in domestic financial instruments.⁹ Due to regular, significant cash flows, open pension funds were expected to trigger an upturn in the national stock market and boost its liquidity and trading volume.

In the second quarter of 2002, 17 pension funds were operating in the Polish stock market with assets under management totalling 25 billion zlotys and with additional seven billion zlotys still to be transferred to the funds' accounts by the ZUS.¹⁰ In terms of capital under discretionary management, pension funds outweigh mutual funds and insurance companies, whose assets total only three billion and twelve billion zlotys, respectively, constituting an influential group of institutional investors on the Polish stock market.

By the middle of 2002 open pension funds' investments into stocks listed on the WSE amounted to 30 % the assets under management or eight billion zlotys. They are predominantly concentrated in the large capitalization stocks that

⁶ The pension systems of Latin American countries served as a model for the new Polish one.

⁷ For a detailed description of the three pillars see Hadyniak and Monkiewicz (1999) and Mech (2001). Our discussion refers primarily to the second one.

⁸ For an analysis of distinctions between defined-contribution and defined-benefit pension funds, see Davis (1997).

⁹ Only at the end of 2001 two of the pension funds realized the possibility provided by law to invest in foreign assets (Karpinski (2002a)).

¹⁰ The average exchange rate of Polish zloty to US dollar in June 2002 was 4.06.

are listed in the blue-chip index, WIG20, and usually belong to the Top 5 in their industries (Karpinski (2002b)). Funds' holdings amounted to 17 % of stocks that are in the free-float, and their participation in the capitalization of the WSE already surpasses 5 % (www.igte.com.pl).¹¹ Pension funds thus turned into the protagonists of the national stock market, able to affect asset prices and cause their abrupt swings.¹² Due to potential unexploited by the pension funds to invest up to 40 % of their portfolios into stocks, market observers voice concern of impending liquidity attenuation in the Polish stock market (Brycki and Karpinski (2002)).

The pension fund industry in Poland is highly concentrated, which is typical for developing countries whose pension systems followed the same track of reforms (Hadyniak and Monkiewicz (1999)). Among all funds, the four largest (Commercial Union, ING Nationale-Nederlanden Polska, PZU Złota Jesień, and AIG) dominate the market. By the end of June 2002 they had attracted 74 % of the all funds' assets and 63 % of the participants.

Investment activity of the pension funds in Poland is subject to strict regulation, which is typical for the 'Latin American' type of funds. The Law on Organisation and Operation of Pension Funds (1997) imposes restrictions on asset allocation in each financial instrument. In particular, the proportion of funds invested in shares is limited to 40 % of the total fund portfolio.¹³ Moreover, funds are required to guarantee a minimum rate of return on their investments, with failure to achieve it being punished by penalties. The Polish law defines the mandatory minimum rate of return as the rate of return lower by 50 % than the weighted average rate of all funds established for a given period, or a rate of return four percentage points lower than the aforesaid average, whichever is

¹¹ One particularity of the Polish stock market is that the company's stocks being in the free float do not exceed 37 %, while the majority of stocks are owned by long-term (mostly foreign) investors.

¹² As it was said by one of the money managers in an interview to one of the most popular Polish newspapers "I have earned my biggest money by trying to predict what pension funds are going to do" (Brycki and Karpinski (2002)).

¹³ Additional 20 % may be invested in shares indirectly via holdings in mutual funds.

lower. Eventually, a lower rate of return should be made up from the pension fund's own funds. If its own assets will not suffice to cover the difference, funds will be withdrawn from the special government managed guarantee fund. A minimum required return is calculated and announced on a quarterly basis for the previous two-year period.

Polish market observers agree that the heavy concentration in the pension fund industry and the regulatory requirements translate into alike portfolio compositions and similar financial results among Polish pension funds. These outcomes mainly stem from the regulation that requires offset of losses faced by fund's participants from fund's own assets, when it falls short of the minimum required rate of return. This influences managers' incentives making them loath to experiment with the assets' selection and impelling them to emulate each other's investment decisions. Such regulatory provisions are considered to favor reduced competition and intensified herding behavior among Polish pension funds.

2.3. Herding and Feedback Trading Measures

To evaluate herding we utilize the measure suggested by Lakonishok, Shleifer, and Vishny (1992) which is one of the most widely used herding measure in the empirical finance literature. It estimates herding as a degree of correlated trading among investors. Since it is more probable to reveal herding inside a homogenous group of investors that are directly competing for customers and are identically evaluated, than in a random sample of institutions, it is usually calculated for a group of identical institutions. The Lakonishok-Shleifer-Vishny measure gauges their average tendency to end up on the same side of the market in a particular stock and in a particular time period. The measure for stock i in period t is defined as:

$$H_{i,t} = |p_{i,t} - p_t| - AF_{i,t} \quad (2.1)$$

with $p_{i,t} = B_{i,t} / (B_{i,t} + S_{i,t})$. $B_{i,t}$ ($S_{i,t}$) denotes the number of investors in the group that buy (sell) stock i in period t . p_t is the average of the $p_{i,t}$ s over all stocks that were traded in period t and measures the number of investors buying in a given period relative to the number of investors active in period t .

The adjustment factor in equation (2.1), $AF_{i,t}$, is defined as the expected absolute difference between $p_{i,t}$ and p_t :

$$AF_{i,t} = E(|p_{i,t} - p_t|), \quad (2.2)$$

where E denotes the expectation operator. $AF_{i,t}$ is calculated under the null hypothesis that $B_{i,t}$ follows a binomial distribution with the parameter p_t . The inclusion of the adjustment factor prevents the bias in $|p_{i,t} - p_t|$ for stocks that are traded by a low number of investors. In our empirical application the herding measures computed for each stock are averaged first across different sub-groups of stocks and then across periods. Under the assumption of normality, positive values of these averaged herding measures that are different from zero will constitute evidence in favor of herd behavior.

Despite its popularity, the Lakonishok-Shleifer-Vishny measure has several shortcomings (Bikhchandani and Sharma (2000)). First, the measure limits the ability to differentiate between herding and a rational response of investors to publicly available information, thus failing to account for changes in fundamentals. Second, since it is not possible to trace intertemporal trading behavior with the Lakonishok-Shleifer-Vishny measure, it is also not possible to determine whether a particular investor persists to herd. Third, taking only the number of investors active and disregarding the value of stocks they trade threatens to omit herding which can in fact be present. Finally, as shown in Jones, Lee, and Weis (1999), the expected value of $H_{i,t}$ may be negative, since for low activity stocks the adjustment factor, $AF_{i,t}$, may take large values.

Feedback trading, which is a particular case of herding, presumes that past stock returns affect current investors' demand. Positive feedback trading refers to acquiring stocks that were past winners and selling those that are past losers. Positive feedback trading strategies were paid much attention in the academic literature since they were believed to aggravate price destabilization (Lakonishok, Shleifer, and Vishny (1992)). To estimate the extent of positive feedback trading we use the measures applied by Jones, Lee, and Weis (1999), which include slight modifications to those initially suggested in Lakonishok, Shleifer, and Vishny.

The so-called numbers ratio measure, $nratio_{i,t}$, is defined as:

$$nratio_{i,t} = B_{i,t} / (B_{i,t} + S_{i,t}) - p_t, \quad (2.3)$$

where, as in (1), $B_{i,t}$ is the number of institutions that purchased stock i in period t and $S_{i,t}$ denotes the number of investors which sold the stock. p_t is the average proportion of the investors that increased their holdings in a given stock during a given period. The modification by Jones, Lee, and Weis consists in subtracting p_t from the ratio of the number of buyers to the total number of institutions active in a stock in a given period. Thus, this measure estimates the relative demand as a fraction of investors moving in the same direction that is in excess of the average.

The dollars ratio measure, $dratio_{i,t}$, is calculated as:

$$dratio_{i,t} = \$B_{i,t} / (\$B_{i,t} + \$S_{i,t}) - \$p_t, \quad (2.4)$$

where $\$B_{i,t}$ ($\$S_{i,t}$) is zloty amount of the stock i bought (sold) by the investors in period t and $\$p_t$ denotes the average proportion of the institutional holdings increases in a given period, also denominated in zlotys.¹⁴ The *nratio* and the *dratio* measures can be viewed as complementary. While the *nratio* measure provides an indication about the number of investors that increased their holdings in a particular asset during a given period, regardless of the extent of the ownership changes, the *dratio* measure focuses instead on the zloty amounts of the shares being traded. Higher absolute values of *nratio* and *dratio* measures reflect stronger investors' demand or supply for a given stock. We calculate values of these two measures and average them across different groups of stocks categorized by size and past returns, trying to shape trading patterns in terms of stock characteristics.

Additionally, Lakonishok, Shleifer, and Vishny (1992) used a measure of excess institutional demand, $exdemand_{i,t}$, computed as:

$$exdemand_{i,t} = (\$B_{i,t} - \$S_{i,t}) / MVE_{i,t}, \quad (2.5)$$

¹⁴ We follow the original name of the dollars ratio feedback trading measure, as introduced in Lakonishok, Shleifer, and Vishny (1992). However, since the reported values of pension fund holdings are expressed in the national currency, Polish zloty, the values of $\$B_{i,t}$ ($\$S_{i,t}$) are also expressed in zlotys.

where $\$B_{i,t}$ and $\$S_{i,t}$ are as defined above and $MVE_{i,t}$ denotes the market value of stock i in period t . $MVE_{i,t}$ serves as a scaling factor which enables us to distinguish the effect of the excess demand on moving stock prices. Positive values of $exdemand_{i,t}$ for a group of stocks indicate that the group is in excess demand, and negative values indicate excess supply. Computed values are again averaged across groups clustered by the degree of excess demand (supply) and past period returns. The available data enables us to perform this grouping only for the stocks in excess demand (in which investors are net buyers), since the low number of stocks in excess supply (in which investors are net sellers) precludes such segmentation.

2.4. Data Description

In this study we use data on pension funds' ownership relying on reports about the structure of their portfolios. According to the Decree of the Polish Council of Ministers of July 3, 2001, on the financial reports on joint security portfolio, investment funds are obliged to provide annual and semi-annual reports covering information about portfolio structures, including the name of the stocks and their proportion of total fund holdings. Pension funds are required to disclose these data to the public to keep current and potential investors informed about the level of risk exposure of the funds' investments.

Our hand-collected data set relies on the semi-annual and annual reports for 17 pension funds that existed during the period from 1999 to 2001. Semi-annual reports provide information on the value of the assets that exceed 1 % of the portfolio, while annual statements supply the data on all stocks that are being held. The ownership reports contain the name, the value, and the proportion of each asset in the portfolio at the end of the year.¹⁵ We end up with the sample that contains 363 stock-periods.

Relying on the yearly pension funds' ownership data, it is possible to estimate the value of purchases (sales), $B_{i,t}$ ($S_{i,t}$), of stock i in period t by

¹⁵ The pension fund portfolios besides corporate stocks also include stocks of the National Investment Funds, treasury bills and bonds.

subtracting the holdings in the current period from the holdings in the previous period.¹⁶ The data on institutional ownership are supplemented by data on daily stock prices and stock capitalization, obtained directly from the WSE. The values of holdings are reported in Polish zlotys.

To describe pension funds portfolios by the past performance of the stocks owned, we consider holdings of all pension funds as if it were one universal fund and classify the stocks into five quintiles based on their past period performance. The procedure is repeated for every period for which the data are available. When quintile compositions are known, we are able to calculate how much from each performance group is being purchased, sold, or held by all pension funds.

It follows from the results reported in Table 2.1 that pension funds holdings in the extreme quintiles are distributed almost evenly. 43 % of funds' assets are allocated into stocks from the top two performance quintiles and 46 % of the assets are allocated into the two quintiles including stocks with the poorest performance (columns 1, 2 and 4 and 5). Moreover, it is also shown that funds are much more disposed towards purchasing stocks with excellent past performance which amounts to about 80 % of total buys (column 1 and 2). At the same time funds try to dampen the proportion of extreme losers (column 5). Sells in the worst performance quintile size to 37 % of total sells whereas buys equal only to 8 %. Thus, funds are intensively selling extreme losers and buying extreme winners. This apparent discrepancy between the past performance of the assets that are being purchased and sold may serve as preliminary evidence on feedback trading.

¹⁶ However, since we do not possess information about the trades of the pension funds during a year, we are not able to account for possible changes in ownership that take place throughout the period.

Table 2.1: Holdings of Pension Funds by Past Performance

	Past Performance Quintile				
	1 (best)	2	3	4	5 (worst)
Quintile Holdings as % of Total Holdings	20	23	14	27	19
Purchases in Quintile as % of Total Purchases	39	39	5	9	8
Sales in Quintile as % of Total Sales	10	27	12	14	37

Note: Total holdings are aggregated holdings of all pension funds as of one universal fund and then are assigned into quintiles according to the past performance of the assets. 1 indicates the quintile including stocks that performed the best in the past period and 5 indicates the quintile including stocks that performed the worst.

2.5. Empirical Results and Comparison with Previous Literature

2.5.1. Empirical Results on Herding

The main findings on herding in the sample of Polish pension funds are represented in Table 2.2. The first column in Panel A provides the values of the Lakonishok-Shleifer-Vishny herding measure computed across all stocks owned by pension funds. The number 0.146 implies that if it is assumed that 50 % of the ownership changes were increases, then 64.6 % of all investors were changing their position in a stock in one direction and 35.4 % in the opposite direction. Panel A also provides values of the herding measure for stocks partitioned by the total number of investors trading these stocks. As expected, the Lakonishok-Shleifer-Vishny statistic attains its highest value of 0.165 for the stocks traded by a substantial number of institutional traders (more than 15). The measures in Panel B suggest that among the actively traded stocks, i.e., stocks traded by more than

ten investors, institutions herd more into stocks from extreme size quintiles (the largest and smallest firms), where size is defined in terms of capitalization.¹⁷

Table 2.2: Herding Measures by Trading Activity

Panel A: Herding Measures				
All	Number of Active Institutions			
Stocks	> 5	> 10	> 15	
0.146	0.109	0.115	0.165	

Panel B: Herding Measures for Actively Traded Stocks				
Size				
1 (largest)	2	3	4	5 (smallest)
0.147	0.065	0.116	0.062	0.119

Note: The mean of the Lakonishok-Shleifer-Vishny statistics across periods for a given group of stocks are presented. In Panel B, 1 indicates the quintile including stocks with the largest capitalization and 5 indicates the quintile including stocks with the smallest capitalization. For details see section 2.2.

The values of the herding measures reported in Table 2.2 are rather high in comparison with analogous statistics for pension funds in mature markets. The magnitude of herding revealed by Wermers (1999) is 0.034 while Lakonishok, Shleifer, and Vishny (1992) as well as Jones, Lee, and Weis (1999) obtained even smaller values of 0.027 and 0.016, respectively. An explanation for such substantial herding found in the sample of Polish pension funds could stem from the above-mentioned regulation design of the funds' performance evaluation. Since the minimum required rate of return is computed as a weighted average of the rates of return achieved by all pension funds, the high concentration of the

¹⁷ The "small" nature of our data base implies high standard errors of the measures. Therefore, we rely solely on the point estimates without reporting their standard errors.

pension funds market results in a heavy influence of the returns attained by the largest institutions.

Moreover, the quarterly frequency at which the minimum required rate of return is calculated and announced provides pension fund managers with the additional incentive to undertake short-term investment strategies to be sure not to fall behind their peers. Therefore, smaller pension funds, aiming not to underperform their larger counterparts and to avoid penalties imposed by regulation in case of their failure to achieve the minimum required return, simply track large pension fund investment behavior.

Our results support the findings of Blake and Timmermann (2002) stating that, under relative performance evaluation, investors are striving not to underperform their peers with the median outcome. When the evaluation benchmark is set to a weighted average, the safest investment strategy is the strategy followed by the market leaders. These findings also lend empirical substance to the widespread belief that smaller pension funds in the Polish stock market are imitators of the actions of the larger ones. Among the consequences of herd-like behavior are identical financial outcomes, reduced competition among the Polish pension funds, and higher opportunity costs arising from giving up long-term investment strategies that might provide funds with more substantial capital accumulation.¹⁸

Since it is likely that investors may be more involved in herding in particular groups of stocks, we proceed with the analysis of herding for stocks classified by size, past performance, and industry. These results are shown in Table 2.3. Panel A demonstrates that when divided by size, the two highest values of the Lakonishok-Shleifer-Vishny herding measure (0.182 and 0.146) correspond to the two smallest size quintiles. However, the relationship is not monotonic. Herding in the largest stocks, although smaller, still amounts to a value of 0.133.

¹⁸ For the discussion of pension fund evaluation measures and their influence on fund performance see Blake and Timmermann (2002) and Blake, Lehmann, and Timmermann (2002). For an analysis of the performance of Polish pension funds see Stanko (2003).

Table 2.3: Herding Statistics by Firm Size, Past Performance, and Industry

Panel A: Firm Size Quintile				
1 (largest)	2	3	4	5 (smallest)
0.133	0.085	0.144	0.182	0.146

Panel B: Past Performance Quintile				
1 (best)	2	3	4	5 (worst)
0.147	0.162	0.132	0.098	0.146

Panel C: Industry				
Banking	Computer Services	Metal Production	Pharmaceuticals	Construction
0.128	0.140	0.114	0.098	0.163

Note: The mean of the Lakonishok-Shleifer-Vishny statistics across periods for a given group of stocks are presented. In Panel A, 1 indicates the quintile including stocks with the largest capitalization and 5 indicates the quintile including stocks with the smallest capitalization. In Panel B, 1 indicates the quintile including stocks that performed the best and 5 indicates the quintile including stocks that performed the worst in the previous period. For details see section 2.2.

The literature provides two types of explanations that justify a higher degree of herding in small stocks compared to larger stocks. Depending on the motivation behind investment decisions, it distinguishes between intentional and unintentional herding. Intentional herding arises due to the lack of analyst coverage and publicly available information about small firms, which prompts investment managers to pay more attention to the actions of other investors (Bikhchandani and Sharma (2000), Lakonishok, Shleifer, and Vishny (1992)). Unintentional herding arises when investors, not deliberately emulating other's behavior, undertake identical investments when facing similar decision problems.¹⁹ For example, investors may seek to dispose of small poorly

¹⁹ For theoretical models assuming unintentional herding see Banerjee (1992), Scharfstein and Stein (1990), and Froot, Scharfstein, and Stein (1992).

performing stocks due to evaluation concerns. This so-called “window dressing” phenomenon was brought forth by Lakonishok et al. (1991). Such behavior is more distinct in smaller rather than in larger stocks, since the latter are held by many investors.²⁰

Additionally, we analyse herding intensity conditional on past return performance. The findings reported in Panel B show that herding is high for the two groups of extreme winners with herding measures being equal to 0.147 and 0.162. Fund investors also seem to follow herd-like behavior in extreme losers. This performance quintile also demonstrates a rather high magnitude of herding (0.146). It is difficult, however, to discern a monotonic relationship conditional on the past performance history.

In Panel C we provide results for stocks classified by industry, since one may expect a higher degree of herding for stocks that belong to certain branches. This hypothesis is attributed to the sentiments that investors may share regarding particular industries, associated with uncertainty about their profits and cash flows. From the data set on pension fund holdings we determined the five industries in which institutions allocate their funds more often. These industries are banking, computer services, metal production, pharmaceuticals, and construction branches. In fact, computer services and construction stocks demonstrate a higher magnitude of herding (0.140 and 0.163) relative to stocks that belong to banking, metal production, and pharmaceuticals branches (0.128, 0.114, and 0.098).

Finally, Table 2.4 presents herding statistics aggregated across both past return performance and size of stocks. All stocks held in the pension fund portfolios were first divided into five size quintiles, which then were assigned into four performance quartiles. This stock partitioning is motivated by the consideration that, e.g., there can be an overlap between the small actively traded and poorly performing firms. The results from Table 2.4 imply that herding in the largest size quintile is more pronounced among the extreme performance groups

²⁰ Selling extreme losers is probably the most widely used, though by no means unique form of window dressing. To other forms of window dressing also refer slowing down the pace of selling winners and buying losers (Lakonishok et al. (1991)).

(the stocks that performed the best and the worst) for which herding measures reach 0.165 and 0.144, respectively. Notably, small stocks from the medium performance groups also demonstrate a considerable degree of herding reaching 0.221 and 0.222. For the smallest stocks herding pattern resembles the one for the largest ones. Namely, investors tend to herd into the outermost performance quartiles. It should be noted that patterns in trading behavior are more apparent in terms of size of the assets rather than in terms of their performance, making it difficult to discern any monotonically changing pattern in the dual size-performance classification.

Table 2.4: Herding Measures by Size of Stocks and Past Performance

Past Performance Quartiles	Size Quintiles				
	1 (largest)	2	3	4	5 (smallest)
1 (best)	0.165	0.062	0.147	0.199	0.164
2	0.090	0.112	0.149	0.221	0.070
3	0.093	0.176	0.151	0.222	0.137
4 (worst)	0.144	0.093	0.070	0.142	0.121

Note: The mean of the Lakonishok-Shleifer-Vishny statistics across periods for a given group of stocks are presented. For details see section 2.2.

2.5.2. Empirical Results on Feedback Trading

Finding a relationship between investor demand and past stock performance will provide evidence in favor of the presence of feedback trading. To assess the extent of institutional feedback trading we use the dollars ratio and the numbers ratio discussed in section 2.2. The findings are shown in Table 2.5 where we use the same dual partitioning of stocks in terms of their size and past history as in Table 2.4. The dollars ratio measures in Panel A clearly indicate that pension funds aspire to sell stocks of the smallest companies (column 5) and especially those that were performing poorly in the previous period. The overall minimum value (-0.407) corresponds to the worst performance quartile of the smallest stocks. This finding is consistent with the general view that due to the higher level of uncertainty attributed to smaller firms fund managers for

evaluation reasons are more disposed to imitate actions of other market participants.

Table 2.5: Demand of Pension Funds by Size and Past Quarter Returns

Panel A: Dollars Ratio Measures					
Past Period Performance	Size				
	1 (largest)	2	3	4	5 (smallest)
1(best)	0.233	0.204	-0.061	0.029	-0.104
2	0.120	-0.017	0.170	0.015	-0.084
3	0.238	0.121	-0.082	0.072	-0.111
4 (worst)	0.230	0.134	0.032	-0.120	-0.407

Panel B: Numbers Ratio Measures					
Past Period Performance	Size				
	1 (largest)	2	3	4	5 (smallest)
1(best)	0.061	0.025	-0.100	0.057	0.054
2	0.161	0.096	0.177	0.038	0.009
3	0.253	0.256	0.063	-0.015	0.087
4(worst)	0.013	0.149	0.059	0.141	0.023

Note: The mean of the dollars ratio and the numbers ratio statistics across periods for given stock groups are presented. For details see section 2.2.

The insufficient liquidity of the Polish stock market could be a further reason for the unwillingness of the pension funds to hold small losers. Since small stocks are characterized by especially low liquidity and pension fund holdings are usually large relative to the market, to exit a position in a stock may require for a fund considerable amount of time.²¹ Thus, fears of inability to quickly correct unprofitable investment decisions may provide the pension funds with an additional incentive to sell small poorly performing stocks. Notably, only

²¹ Selling a stock completely may require a pension fund to participate in up to twenty trading sessions. Sometimes the needed number of trading sessions may come to several dozens (Karpinski (2003)).

for the stocks of the largest firms (column 1) the dollars ratio measure takes positive values for all levels of past period return and at the same time achieves the second overall maximum amounting to 0.233. It suggests that the largest stocks are being excessively demanded by pension funds.

The herding discovered in the two extreme size-performance groups in section 2.5.1 manifests itself through positive feedback trading in large winners and small losers. At the same time, a contrarian type of behavior is more prevalent in large losers and the smallest winners. These findings are consistent with the results from Table 2.1 described in section 5.4 and show a distinct inconsistency between performance characteristics of purchased and sold stocks. Our results are also in line with the evidence on feedback trading documented by Jones, Lee, and Weis (1999) for the US market.

The results on the numbers ratio measures are presented in Panel B. Numbers ratio values of 0.161 and 0.253 show that institutions are apt to buy stocks from the largest size quintiles with moderate past period performance but are reluctant to buy small stocks (0.057 and 0.054). The fraction of the institutions buying is considerably less in the fifth size group, being especially low in the worst performance quartile (0.023). The small positive values of the numbers ratio for the fifth size quintile in Panel B that correspond to the larger in absolute terms negative values of the dollars ratio measure in Panel A may reflect large sells by a few funds, possibly indicating high concentration of the Polish pension fund industry.

2.5.3. Current Returns and Excess Institutional Demand

The excess demand measure outlined in section 5.2 enables us to uncover the effects of herding and positive feedback trading that are unrelated to past stock returns. For this purpose contemporaneous size-adjusted stock returns are grouped based on past period returns and values of the excess demand measure. The available data permits us to perform this grouping only for the stocks being in excess demand (in which investors are net buyers). The low number of stocks in excess supply (in which investors are net sellers) does not allow us to perform such segmentation.

If negative (positive) contemporaneous returns coincide with poor (good) past performance regardless of the value of the excess supply (demand) measures, then changes in the returns can be attributed exclusively to momentum. If stocks with extreme negative (positive) returns correspond to the largest excess supply (demand) measure no matter how well they performed in the past, this will indicate that contemporaneous returns are driven solely by institutional demand. The results in Table 2.6 illustrate that stocks experiencing large excess demand demonstrate a positive size-adjusted return of 2.23 % contrary to the stocks in which pension funds are net sellers. In this case, they exhibit high negative returns of – 30.77 %. However, the negative contemporaneous returns documented for groups of stocks with moderate and small excess demand show that feedback trading is not crucial in explaining posterior returns movements.

When stocks in excess demand are categorized by their past performance, institutional trading appears to trigger positive returns of 1.95 % in the worst past performers, thus indicating that in this case institutional trading surpasses momentum. Medium excess demand stocks display considerable positive returns of the best and average past performance groups, while small excess affects only stocks with average past performance. Absence of the apparent link between the extent of institutional demand and posterior stock performance casts doubts on the conjecture that returns of the stocks experiencing excess demand are driven by institutional traders in the next period.

Table 2.6: Contemporaneous Size-Adjusted Returns by Past Returns and Levels of Excess Demand and Supply

Firms in Excess	Past Period Returns				Firms in Excess	
	Demand	All Firms	1 (best)	2		3 (worst)
Large Excess		2.23	7.95	- 2.82	1.95	- 30.77
Medium Excess		- 0.17	2.50	5.39	- 10.76	- 19.16
Small Excess		- 2.03	- 2.32	3.20	- 7.73	- 4.06

Note: The stocks are first divided into two groups conditional on whether they are in excess demand or excess supply based on the values of measure (5). Next, they are assigned according to the extent of the excess demand (supply). Stocks in excess demand and also grouped by their past period performance. The procedure is repeated every period. The figures displayed show the value of the current returns averaged across the assets in the group and the periods.

The effect of feedback trading on the stocks being in excess supply appears to be more pronounced and strengthening momentum. Stock returns of this group, which demonstrate negative current returns for all levels of excess supply, are decreasing with the increase in supply. These results show that positive feedback trading appears to reinforce a momentum effect in returns of the damped stocks and sometimes even to exceed it. Jones, Lee, and Weis (1999) report similar findings for the US market. They also uncover a clear relationship between past stock performance and institutional demand only for the stocks being excessively sold.

2.6. Conclusion

In this essay, we investigate the degree to which pension fund investors follow herd-like and feedback trading behavior as well as its effects on price formation in the emerging stock market of Poland. Since Polish pension fund managers, contrary to their mature counterparts, face substantial restrictions of the investment opportunities, we examine the extends of herding and positive feedback trading displayed by pension funds in this regulatory environment.

The application of the widely used measure suggested by Lakonishok, Shleifer, and Vishny (1992) enables us to compare the degree of herding and positive feedback trading between the Polish and developed stock markets. The values of the point estimates found for Polish pension funds are higher than values of herding measures reported in studies of institutions acting in mature markets. These outcomes are primarily attributed to specific regulatory provisions, i.e. relative performance evaluation, penalties' structure, and the extent of concentration in the Polish pension fund industry.

Our findings provide evidence in favor of the presence of substantial herding by Polish pension fund investors, especially for small size stocks and stocks of particular industries, like computer service and construction. Conditional on the past return performance, herding is detected for both past winners and past losers. We also find that pension fund managers in Poland are apt to track positive feedback trading strategies, being actively engaged in selling stocks of smaller firms that performed poorly in the previous period and acquiring well-performing stocks with large capitalization. We do not find, however, that herding and positive feedback trading by the institutions has a significant effect on Polish stock prices.

Chapter 3: Stock Returns and Institutional Trades: Evidence on Trading by Pension Funds in Poland

3.1. Introduction

The rapid upsurge of the value of institutional assets over the last two decades centered the interest of researchers on the price effects of institutional demand. Numerous studies find that increasing institutional ownership and preferences displayed by institutions towards stocks with certain characteristics resulted in tangible price pressures influencing subsequent stock returns (Falkenstein (1996), Gompers and Metrick (1999)).

Nofsinger and Sias (1999), Jones, Lee, and Weis (1999), and Wermers (1999) show that stocks purchased by institutions outperform those which they sell in the subsequent quarters. Detected trends in prices do not revert, suggesting that institutional trading has a permanent rather than a temporary price effect and thus facilitates price discovery. Absence of reversals in daily return series is reported by Chan and Lakonishok (1996) for stocks displaying a high price and earnings momentum. Chan and Lakonishok (1993) find that both purchases and sales by institutional money managers exert pressure on daily security prices. The authors attribute detected persistence in price movements as the investors' response to the new information. Gompers and Metrick (1999) find that institutional holdings help to predict stock returns. They point to the institutional holdings that mounted during 1980-1996 and were mostly located in large and highly liquid stocks. A shift in the ownership composition towards large securities drove a significant increase in prices and returns of large stocks relative to those of small stocks, substantial enough to explain the disappearance of the small-stock premium (Chan et al. (2000)).

Extant literature shows that shocks in institutional demand affect not only prices of individual stocks but also cause market-wide fluctuations. According to Warther (1995), there is a positive relation between monthly mutual fund flows and subsequent stock market returns. Goetzmann and Massa (1999) report that contemporaneous daily S&P500 returns and index fund flows are strongly related.

As far as we know, extant empirical evidence on institutional trading is limited to the mature stock markets (Warther (1995), Cai, Kaul and Zheng (2000), Sias, Starks and Titman (2001), Goetzmann and Massa (2003)). However, institutional peculiarities of emerging stock markets supply an additional venue

for the analysis of price-ownership relation. In the present essay we centre our attention on the developing Polish stock market.

The Polish stock market constitutes especial interest for this type of study due to the unique detail that has greatly shifted institutional composition. As a result of the reform of the national pension system, privately managed pension funds entered the Polish stock market in 1999. Pension funds are regularly supplied with huge amount of assets transferred from several millions of individuals insured in a new pension system. As a result, already in 2002 their assets significantly outweighed those possessed by other types of institutional investors, like mutual funds and insurance companies. Pension fund investments are highly concentrated in a relatively low number of stocks because of stringent investment regulation. Against this background, there is a lot of speculation in the Polish stock market press about the pressure exerted by the pension funds on security prices (Brycki and Karpinski (2002), Karpinski (2002b), Karpinski (2003)).

The aim of the present essay is two-fold. Firstly, it addresses the question how a thin Polish stock market reacts to a massive inflow of liquidity from the pension funds estimating the response of the two main stock market indices to the monthly flows from the pension funds. Secondly, as noted in Del Guercio and Tkac (2002) relatively little is known about pension funds' trading. While herding by pension fund managers is scrutinized in Lakonishok, Shleifer, and Vishny (1992), and also, along with the other institutions, in Jones, Lee, and Weis (1999), and Badrinath and Wahal (2002), the market-wide response to trading by pension funds has not been examined. Therefore, the present research extends empirical literature on the relation between institutional demand and stock market returns by focusing on pension fund investors. Against this background, in this essay we answer the following questions: 1) Do pension fund flows affect concurrent and future market returns? 2) Is this effect (if any) temporal or permanent? 3) Do past and present market movements influence pension fund flows? Our results should be of interest for investors and regulators of markets with the similar asset concentration across institutional investors, primarily for the emerging markets that followed a similar track of the reforms.

Our findings provide evidence in favor of a strong positive relation between the flows from Polish pension funds and contemporaneous stock market

returns, thus lending support to the popular belief that pension funds in Poland exert a strong influence on the stock prices. Shocks in pension fund demand cause persistence in the returns of the two stock market indices, WIG and WIG20. The four largest funds appear to be responsible for this price effect. We also reveal that stock market returns in turn influence institutional demand. Our results, however, are likely not to support the other popular view that pension funds are apt to act as positive feedback traders, at least at monthly frequency; this issue, however, calls for a separate investigation.

The remainder of the chapter is organized as follows. The following section describes the role of the pension funds on the Polish stock market. Section 3.3 presents the data used in the study and the methodology. Empirical results are described in Section 3.4. Finally, Section 3.5 contains the summary and concluding remarks.

3.2. Pension Funds and the Polish Stock Market

Pension funds in Poland were introduced in April 1999, in the result of the national pension system reform.²² Insurance by a pension fund is obligatory within the new pension system. Polish pension funds are defined-contribution open funds. Employees must transfer 7.3 % of their gross salary monthly through the Social Insurance Institution (SII) to the funds, which invest it mostly in domestic financial instruments. To ensure safety of the future pensions, the investment activities of the pension funds are subject to strict regulation. The Law on Organization and Operation of Pension Funds (1997) imposes restrictions on asset allocation in each financial instrument. In particular, the proportion of funds invested in shares is limited to 40 % of the total fund portfolio.

Mid 2003, 17 pension funds were operating in the Polish stock market with assets under management totalling 9.7 billion US dollars or 9 % of the WSE capitalization. Such a substantial value of assets turned pension funds into an influential group of institutional investors on the Polish stock market. In terms of capital under discretionary management, they already outweigh mutual funds and

²² For a detailed description of the new Polish pension system, see Hadyniak and Monkiewicz (1999) and Mech (2001).

insurance companies, whose assets total only one billion and three billion US dollars respectively.

Mid 2003, open pension funds' investments into stocks listed on the WSE amounted to about 30 % of their assets or 2.5 billion US dollars. They are predominantly concentrated in the large capitalization stocks that are a part of the blue-chip index, WIG20, and usually belong to the Top 5 in their industry (Karpinski (2002a)). Funds' holdings amounted to 17 % of stocks that are in the free-float (www.igte.com.pl).²³ Since pension funds still do not exploit their potential to invest up to 40 % of their portfolio into stocks, market observers voice concern of impending liquidity attenuation in the Polish stock market (Brycki and Karpinski (2002)).

The pension fund industry in Poland is highly concentrated, which is typical for developing countries whose pension systems followed the same track of reforms (Hadyniak and Monkiewicz (1999)). Among all funds, the four largest (Commercial Union, ING Nationale-Nederlanden Polska, PZU Złota Jesień, and AIG) dominate the market. By the end of June 2003 they had attracted about 70 % of the all funds' assets and 60 % of the insured individuals. Pension funds are believed to be able to affect asset prices and cause their abrupt swings (Brycki and Karpinski (2002), Karpinski (2002b), Karpinski (2003)). In this study we formally investigate reaction of the main stock market indices.

3.3. Data and Methodology

In the present study we follow the so-called 'macro-approach' that contrary to the 'micro-approach' focused on the responses of individual stock returns to the institutional demand, concentrates on the impact on aggregate level of stock returns. Since the data on inflows and outflows from pension funds to the stock market are not available, we utilize the data on stock holdings of individual pension funds to calculate a proxy for the net flows from the funds into the Polish stock market. Data on the composition of individual pension fund portfolios at a

²³ One particularity of the Polish stock market is that the company's stocks being in the free float do not exceed 37 %, while the majority of stocks are owned by long-term (mostly foreign) investors.

monthly basis was retrieved from the web-page of Polish financial portal HOGA (www.emerytura.hoga.pl). It spans the period from June 1999 to June 2003 and includes the data for 17 pension funds.²⁴ The data comprises the value of the total portfolio of each pension fund at the end of each month expressed in Polish Zlotys and a percentage fraction of each category of assets in the portfolio. The assets in the pension fund portfolios are categorized into stocks, bonds and bills issued by the Treasury and National Bank of Poland, stocks of the National Investment Funds, bank deposits and bank securities, and other bonds.

In addition to the data on pension fund portfolio composition we use the data on daily closing prices for Polish stock market indices WIG, WIG20 and MIDWIG, and data on the WSE capitalization and trading volume. The data on the market capitalization and trading volume measured as turnover was extracted from WSE Monthly Bulletins. Data on daily closing prices for Polish stock market indices was obtained from PARKIET, the official electronic newspaper of the WSE (www.parkiet.pl). It covers the period from 1 June 1999 to 31 June 2003. We used these daily price data to calculate monthly returns of the two indices. The returns are calculated as logarithmic difference:

$$R_t = \ln P_t - \ln P_{t-1}, \quad (3.1)$$

where P_t and P_{t-1} denote values of the stock market index at the end of month t and $t-1$ respectively.

²⁴ During 1999-2003 the number of operating pension funds fluctuated between 16 and 21. In 2001 four smaller funds were absorbed by the larger ones. It happened due to their failure to gain a significant share of the market because of the late marketing campaign rather than to inferior investment skills and poor performance. Though it would be desirable to include the data for all funds that existed during the period of the study, we believe that our sample is unlikely to be subject to the survivorship bias since the assets of the four liquidated funds accounted for only 2.6 % of the total assets in the pension fund market (the three of the funds accounted for less than 1 % and one fund accounted for about 1.6 % of all pension fund assets).

The proxy for net flows is defined as a proportional growth in the value of pension funds' stock holdings, adjusted for the market growth. We follow the approach of Chevalier and Ellison (1995), and define net flows in period $t+1$ as:

$$Flows_{t+1}^* = \frac{Stock\ Holdings_{t+1} - Stock\ Holdings_t}{Stock\ Holdings_t} \frac{Market\ Value_{t+1}}{Market\ Value_t}, \quad (3.2)$$

where $Stock\ Holdings_{t+1}$ and $Stock\ Holdings_t$ denote aggregate holdings of stocks across all pension funds in month $t+1$ and t respectively. Aggregate stock holdings are evaluated as a sum of pension fund assets invested into stocks (excluding stocks of the National Investment Funds) at the end of the month, using the information from the reports on monthly portfolio composition. To account for the market growth, we adjust our net flows measure by the increase in the value of stock market capitalization, $\frac{Market\ Value_{t+1}}{Market\ Value_t}$, where $Market\ Value_{t+1}$ and $Market\ Value_t$ denote the total value of the market expressed in Polish Zlotys at the end of the month $t+1$ and t respectively.

Due to a sharp increase in the value of flows from pension funds in the second half of 1999 because of the enormous funds transferred to them from the ZUS, in our estimation we include only observations starting from January 2000, thus ending up with the sample containing 42 observations. Table 3.1 presents selected descriptive statistics for the flows.

Table 3.1: Summary Statistics for Pension Fund Flows

Statistics	Value	p-Value
Mean	0.07	0.00
Standard Deviation	0.11	-
Skewness	1.18	-
Kurtosis	4.48	-
Jarque-Bera Test	13.56	0.00
Autocorrelation at lag 1	0.27	0.08
Autocorrelation at lag 3	-0.02	0.35
Autocorrelation at lag 6	0.08	0.29

In order to account for the correlation structure in the flows series, following the approach by Warther (1995) and Remolona, Kleiman and

Gruenstein (1997) we segment it into expected and unexpected components by modeling it as an autoregressive process. After performing the Lagrange multiplier test for first-order autocorrelation in residuals, we select an AR (3) specification for modeling flows.²⁵ Using the obtained AR (3) coefficients, we estimate expected flows as the expected value from the AR model. Unexpected flows are estimated as a one-step-ahead prediction error. Due to the lack of space, tables are not reported here, but they are available upon request.

To investigate the relation between returns on the Polish stock market pension fund investments, we follow the approach proposed by Goetzmann and Massa (2003), which is similar to Froot et al. (2001) structural VAR and estimate the following model:

$$\begin{bmatrix} R_t \\ Flows_t \end{bmatrix} = \begin{bmatrix} \alpha_R \\ \alpha_F \end{bmatrix} + \begin{bmatrix} \beta_F Flows_t \\ \beta_R R_t \end{bmatrix} + \begin{bmatrix} \gamma \lambda^{RF}(L) & \gamma TV_{t-1} \\ \delta \lambda^{FR}(L) & \vartheta \lambda^{FF}(L) \end{bmatrix} + \begin{bmatrix} \varepsilon_R \\ \varepsilon_F \end{bmatrix}, \quad (3.3)$$

where R_t is return of the WIG, the WIG20 or the MIDWIG in month t . $Flows_t$ denotes net, unexpected or expected flows.²⁶ $\lambda^{RF}(L)$, $\lambda^{FR}(L)$ are distributed lag operators on lagged returns and $\lambda^{FF}(L)$ is the distributed lag operator on flows. TV_{t-1} denotes (logarithm of the) lagged trading volume at the stock market, measured as turnover. ε_t is an error term.²⁷

Model (3.3) is estimated equation by equation, using White (1980) heteroscedasticity-consistent covariance matrix. The model is estimated separately for each type of flows, i.e., index returns R_t are first modeled as a function of net, then of unexpected and finally of expected flows. By using the MIDWIG returns,

²⁵ Monthly dummies for January and December were included to check for possible biases, but they turned out to be insignificant.

²⁶ Before conducting the regression analysis, we assure the stationarity of the returns and unexpected flows series by performing Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) unit root tests. Both tests' results reject the null hypothesis of unit root at the 1 % significance levels. Critical values of MacKinnon were used.

²⁷ We limit the model by the above mentioned explanatory variables because of the relatively small sample size and stemming from it problems with the low number of degrees of freedom.

we aim to figure out whether pension fund flows affect prices of large and smaller stocks in a different way. The lagged value of the trading volume TV_{t-1} is included to account for the so-called volume effect (Boudoukh, Richardson and Whitelaw (1994)) which presumes that of high trading activity is followed by a decrease in the extent of autocorrelation.

3.4. Empirical Results

3.4.1. Market Returns on Flows

Results reported in Table 3.2 indicate a positive and significant relation between the net flows from pension funds and contemporaneous returns on the main market index WIG. This is in line with the views expressed by the market observers with regard to the sound influence that trading by pension funds exerts on prices at the WSE, and stemming from its tendency of smaller investors to emulate investment decisions of the pension funds. The results displayed in Table 3.2 also suggest the higher predictive power of the unexpected flows relative to the expected flows with respect to index returns, which conforms to the previous evidence reported by Warther (1995). They indicate that the previous market information is quickly incorporated in the stock prices, thus the forecasts of prices based on this information are not possible.

A similar pattern is observed for the blue-chip index WIG20 (Table 3.3). In case of the WIG20 the values of the coefficient of concurrent net flows is even higher and are statistically significantly different from the values of the respective coefficient for WIG. The higher impact of pension fund trading on stocks listed in the WIG20 reflects the fact that almost three fourths of their investments in stocks is allocated in the assets that are constituent parts of this index.

Table 3.2: WIG Returns on Concurrent and Lagged Flows

Variable	Coefficient (t-Statistic)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.34 ^a (3.65)	0.27 ^a (2.75)	0.25 ^b (2.38)	0.35 ^a (4.02)	0.32 ^a (3.26)	0.34 ^a (3.17)	0.14 (0.76)	0.03 (0.19)	-0.03 (-0.14)
Lag 0	0.64 ^a (11.54)	0.62 ^a (10.76)	0.62 ^a (10.22)	0.64 ^a (11.45)	0.63 ^a (10.54)	0.64 ^a (10.50)	0.35 (0.75)	0.16 (0.35)	0.02 (0.05)
Lag 1	0.00 (0.02)	0.03 (0.46)	0.02 (0.25)	0.20 ^a (3.56)	0.20 ^a (3.21)	0.19 ^a (2.94)	0.06 (0.29)	-0.90 ^b (-2.08)	-0.88 ^b (-2.01)
Lag 2	-	-0.09 ^c (-1.86)	-0.09 (-1.53)	-	-0.03 (-0.53)	-0.05 (-0.76)	-	0.12 (0.64)	-0.06 (-0.14)
Lag 3	-	-	-0.03 (-0.60)	-	-	-0.04 (-0.74)	-	-	-0.14 (-0.72)
Turnover	-0.04 ^a (-4.03)	-0.03 ^a (-3.01)	-0.03 ^a (-2.59)	-0.04 ^a (-4.09)	-0.04 ^a (-3.31)	-0.04 (-3.22)	-0.02 (-0.87)	0.00 (-0.03)	0.01 (0.39)
Adj. R ²	0.77	0.77	0.77	0.79	0.79	0.77	0.03	0.13	0.17
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.30	0.27

Notes: Sample: 2000:01 2003:06. ^a, ^b, ^c – significant at 1, 5, and 10 % level of significance respectively.

Table 3.3: WIG20 Returns on Concurrent and Lagged Flows

Variable	Coefficient (t-Statistics)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.44 (3.80)	0.34 ^a (2.78)	0.32 ^b (2.46)	0.43 ^a (3.99)	0.40 ^a (3.29)	0.43 ^a (3.21)	0.20 (0.84)	0.04 (0.18)	-0.04 (-0.15)
Lag 0	0.83 (11.94)	0.78 ^a (10.80)	0.78 ^a (10.30)	0.80 ^a (11.48)	0.79 ^a (10.64)	0.81 ^a (10.50)	0.49 (0.81)	0.23 (0.40)	0.08 (0.14)
Lag 1	0.06 (0.94)	0.04 (0.53)	0.03 (0.41)	0.26 ^a (3.62)	0.26 ^a (3.35)	0.25 ^a (3.11)	0.24 (0.95)	-1.07 ^c (-1.97)	-1.04 (-1.89)
Lag 2	-	-0.11 ^c (-1.73)	-0.10 (-1.31)	-	-0.02 (-0.29)	-0.04 (-0.47)	-	0.13 (0.54)	-0.03 (-0.05)
Lag 3	-	-	-0.03 (-0.51)	-	-	-0.04 (-0.50)	-	-	-0.20 (-0.81)
Turnover	-0.06 ^a (-4.27)	-0.04 ^a (-3.11)	-0.04 ^a (-2.72)	-0.05 ^a (-4.11)	-0.05 ^a (-3.39)	-0.05 ^a (-3.30)	-0.03 (-1.01)	0.00 (-0.06)	0.01 (0.34)
Adj. R ²	0.79	0.79	0.77	0.78	0.77	0.76	0.00	0.02	0.16
Prob(F-Stat)	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.33	0.31

Notes: Sample: 2000:01 2003:06. ^a, ^b, ^c – significant at 1, 5, and 10 % level of significance respectively.

Using standardized values of the coefficients, it is estimated that increase in the net flows by one standard deviation will cause an increase in WIG by about 0.07 points and in WIG20 by about 0.09 points.

The market returns react to expected and unexpected components of the flows in a different way. That is, unexpected flows, or shocks in pension fund demand, seem to cause persistence in the price movements in the next month, whereas in case of expected flows there is a weak indication of price reversals (Table 3.2 and Table 3.3). The overall effect of pension fund demand captured by the coefficient of net flows is insignificant in case of both indices. The insignificance of the lagged net flows may be explained by the possibility that they serve as a proxy for the expected flows (Warther (1995)). The past trading volume is highly significant and negative in case of both indices. This result implies that returns autocorrelation decreases after periods of active trading and supports presence of the volume effect in the Polish stock market.

Return-flows relation is similar in case returns of smaller companies listed on the WSE, evaluated by returns of MIDWIG that includes 40 companies listed in the main markets but not included into WIG20 (Table 3.4). The expected flows do not have any explanatory power for contemporaneous index returns, as is the case for the larger companies. However, there is a weak indication that pension fund flows may facilitate price discovery as the sign of the coefficient of the first lag of net flows is positive and weakly significant.

Table 3.4: MIDWIG Returns on Concurrent and Lagged Flows

Variable	Coefficient (t-Statistics)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.14 (1.19)	0.19 ^c (1.89)	0.13 (1.32)	0.17 ^c (1.86)	0.22 ^b (2.40)	0.18 ^b (1.95)	0.00 (0.02)	0.04 (0.27)	-0.02 (-0.15)
Lag 0	0.32 ^a (4.56)	0.41 ^a (6.74)	0.37 ^a (6.78)	0.39 ^a (6.73)	0.39 ^a (6.94)	0.38 ^a (7.10)	0.48 (1.46)	0.42 (1.25)	0.14 (0.42)
Lag 1	-0.02 (-0.38)	0.11 ^c (1.87)	0.05 (0.83)	0.21 ^a (3.44)	0.18 ^a (3.13)	0.15 ^a (2.54)	-0.31 ^b (-2.23)	-0.54 ^c (-1.70)	-0.58 ^c (-1.91)
Lag 2	-	-0.01 (-0.11)	-0.06 (-1.15)	-	0.00 (-0.01)	0.03 (-0.51)	-	0.23 (1.61)	-0.35 (-1.17)
Lag 3	-	-	-0.08 ^c (-1.72)	-	-	-0.11 ^a (-2.12)	-	-	0.00 (0.00)
Turnover	-0.02 (-1.34)	-0.03 ^b (-2.11)	-0.02 (-1.44)	-0.02 ^c (-1.87)	-0.03 ^b (-2.44)	0.02 ^b (-1.98)	0.00 (-0.09)	-0.01 (-0.31)	0.01 (0.42)
Adj. R ²	0.36	0.60	0.66	0.59	0.63	0.66	0.12	0.14	0.19
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.26	0.19

Notes: Sample: 2000:01 2003:06. ^a, ^b, ^c – significant at 1, 5, and 10 % level of significance respectively.

As it was mentioned above, the pension fund industry in Poland is highly concentrated in terms of assets under discretionary management, with the four largest funds accounting for more than 70 % of assets in the industry. Our data set, which contains flows to the stock market from each of the funds, allows us to account for this high concentration. We do it by splitting aggregate flows measures into two components: flows from the four largest funds ((Commercial Union, ING Nationale-Nederlanden Polska, PZU Złota Jesień, and AIG) and flows from the remaining thirteen smaller funds. Next we estimate model 3.3 for flows from the four largest and thirteen smaller funds separately. The results for WIG and WIG20 are reported in Tables 3.5 and 3.6 respectively.

As one can see from Tables 3.5 and 3.6, these are the flows from the largest pension funds that explain contemporaneous WIG returns, as reflected in the significance of the coefficients and higher values of the adjusted R^2 . Results displayed in Panel B of Tables 3.5 and 3.6 demonstrate that returns of WIG and WIG20 not affected by the flows from the bundle of smaller funds.

Table 3.5: WIG Returns and Flows from the Four Largest Pension Funds

Panel A: Flows from the Four Largest Funds									
Variable	Coefficient (t-Statistics)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.32 ^a (3.29)	0.30 ^a (2.97)	0.29 ^a (2.95)	0.34 ^a (3.71)	0.30 ^a (2.97)	0.29 ^a (2.60)	0.13 (0.71)	0.08 (0.44)	0.02 (0.10)
Lag 0	0.57 ^a (10.61)	0.57 ^a (10.48)	0.56 ^a (10.17)	0.56 ^a (10.51)	0.55 ^a (10.03)	0.55 ^a (9.68)	0.50 (0.71)	0.30 (0.44)	0.12 (0.17)
Lag 1	0.07 (1.21)	0.07 (1.27)	0.06 (1.02)	0.15 ^a (2.62)	0.13 ^b (2.32)	0.12 ^b (2.09)	0.19 (0.69)	-1.17 ^c (-1.77)	-1.17 ^c (-1.78)
Lag 2	-	-0.02 (-0.46)	-0.08 (-1.42)	-	-0.07 (-1.22)	-0.07 (-1.29)	-	0.06 (0.23)	-0.25 (-0.38)
Lag 3	-	-	0.03 (1.61)	-	-	-0.04 (-0.80)	-	-	-0.30 (-1.11)
Turnover	-0.04 ^a (-3.65)	-0.04 ^a (-3.28)	-0.04 ^a (-3.24)	-0.04 ^a (-3.78)	-0.04 ^a (-3.03)	-0.03 ^a (-2.64)	-0.02 (-0.89)	0.00 (-0.21)	0.01 (0.31)
Adj. R ²	0.74	0.73	0.75	0.74	0.74	0.73	-0.04	0.00	0.03
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.42	0.31

Panel B: Flows from the Smaller Funds									
Variable	Coefficient (t-Statistics)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.14 (0.80)	0.13 (0.73)	0.11 (0.59)	0.13 (0.70)	0.06 (0.31)	0.06 (0.31)	0.12 (0.70)	-0.04 (-0.20)	-0.07 (-0.32)
Lag 0	0.06 (1.22)	0.03 (0.43)	0.03 (0.49)	0.05 (0.65)	0.07 (1.05)	0.08 (1.02)	0.08 (1.21)	0.77 ^c (1.82)	0.64 (1.19)
Lag 1	-0.01 (-0.33)	-0.02 (-0.74)	-0.02 (-0.74)	-0.05 (-0.70)	-0.06 (-0.82)	-0.05 (-0.75)	0.00 (0.09)	0.02 (0.30)	0.25 (0.49)
Lag 2	-	-0.01 (-0.76)	-0.01 (-0.65)	-	-0.13 ^c (-1.83)	-0.13 (-1.78)	-	0.07 (1.25)	0.07 (0.78)
Lag 3	-	-	0.01 (0.38)	-	-	-0.01 (-0.10)	-	-	0.03 (0.37)
Turnover	-0.02 (-0.86)	-0.02 (-0.76)	-0.01 (-0.63)	-0.02 (-0.74)	-0.01 (-0.34)	-0.01 (-0.33)	-0.01 (-0.78)	0.00 (-0.17)	0.00 (-0.05)
Adj. R ²	0.05	0.03	0.01	-0.04	0.01	-0.02	0.03	0.01	-0.02
Prob(F-statistic)	0.20	0.27	0.38	0.68	0.36	0.52	0.24	0.37	0.50

Notes: Sample: 2000:01 2003:06. ^a, ^b, ^c – significant at 1, 5, and 10 % level of significance respectively.

Table 3.6: WIG20 Returns and Flows from the Pension Funds

Panel A: Flows from the Four Largest Funds									
Variable	Coefficient (t-Statistics)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.39 ^a (3.00)	0.41 ^a (3.01)	0.39 ^a (3.12)	0.42 ^a (3.74)	0.37 ^a (2.96)	0.36 ^a (2.61)	0.17 (0.72)	0.09 (0.41)	0.01 (0.05)
Lag 0	0.74 ^a (10.17)	0.74 ^a (10.09)	0.71 ^a (10.20)	0.71 ^a (10.76)	0.69 ^a (10.26)	0.69 ^a (9.85)	0.68 (0.74)	0.39 (0.45)	0.19 (0.22)
Lag 1	0.12 (1.66)	0.11 (1.49)	0.08 (1.14)	0.19 (2.70)	0.17 ^b (2.40)	0.16 ^b (2.20)	0.50 (1.44)	-1.46 ^c (-1.76)	-1.45 ^c (-1.76)
Lag 2	-	0.03 (0.57)	-0.09 (-1.36)	-	-0.08 (-1.23)	-0.09 (-1.25)	-	0.07 (0.22)	-0.18 (-0.22)
Lag 3	-	-	0.07 ^a (2.75)	-	-	-0.03 (-0.50)	-	-	-0.40 (-1.19)
Turnover	-0.05 ^a (-3.40)	-0.05 ^a (-3.38)	-0.05 ^a (-3.48)	-0.05 ^a (-3.87)	-0.04 ^a (-3.07)	-0.04 ^a (-2.70)	-0.03 (-0.99)	-0.01 (-0.21)	0.01 (0.30)
Adj. R ²	0.73	0.72	0.76	0.75	0.75	0.74	0.01	0.00	0.03
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.42	0.33

Panel B: Flows from the Smaller Funds									
Variable	Coefficient (t-Statistics)								
	Net Flows			Unexpected Flows			Expected Flows		
Constant	0.15 (0.68)	0.13 (0.61)	0.12 (0.53)	0.16 (0.68)	0.07 (0.30)	0.06 (0.25)	0.12 (0.59)	-0.02 (-0.08)	-0.07 (-0.26)
Lag 0	0.09 (1.41)	0.05 (0.56)	0.05 (0.58)	0.06 (0.66)	0.08 (0.94)	0.08 (0.91)	0.12 (1.41)	0.75 (1.39)	0.53 (0.77)
Lag 1	-0.02 (-0.76)	-0.04 (-1.08)	-0.04 (-1.07)	-0.04 (-0.51)	-0.05 (-0.61)	-0.05 (-0.50)	-0.01 (-0.24)	0.01 (0.07)	0.39 (0.58)
Lag 2	-	-0.02 (-0.77)	-0.02 (-0.71)	-	-0.13 (-1.42)	-0.13 (-1.39)	-	0.06 (0.87)	0.06 (0.52)
Lag 3	-	-	0.00 (0.18)	-	-	-0.03 (-0.29)	-	-	0.04 (0.48)
Turnover	-0.02 (-0.77)	-0.02 (-0.67)	-0.02 (-0.59)	-0.02 (-0.75)	-0.01 (-0.35)	-0.01 (-0.30)	-0.02 (-0.70)	-0.01 (-0.23)	0.00 (-0.07)
Adj. R ²	0.13	0.12	0.10	-0.05	-0.03	-0.07	0.12	-0.03	-0.05
Prob(F-statistic)	0.04	0.07	0.13	0.74	0.59	0.73	0.05	0.56	0.67

Notes: Sample: 2000:01 2003:06. ^a, ^b, ^c – significant at 1, 5, and 10 % level of significance respectively.

3.4.2. Flows on Market Returns

As it is demonstrated in the previous section, institutional demand does affect market-wide price movements on the WSE. In this subsection we aim to investigate whether there is a link between market returns and flows from pension funds.

Table 3.7: Flows from the Pension Funds and WIG20 Returns

Variable	Coefficient (t-Statistics)					
	Net Flows		Unexpected Flows		Expected Flows	
Constant	0.02 ^a (2.68)	0.04 ^a (3.44)	0.00 (0.17)	0.05 (14.65)	0.05 (15.32)	0.01 (0.79)
Flows(-1)	0.55 ^a (5.76)	0.36 ^a (3.26)	0.26 (1.53)	0.20 (5.66)	0.20 (9.90)	0.09 (0.52)
WIG	1.19 ^a (13.73)	-	1.17 (13.03)	-	0.00 (-0.14)	-
WIG(-1)	-0.79 ^a (-5.34)	-	-0.72 (-3.44)	-	0.31 (10.73)	-
WIG20	-	0.87 ^a (9.56)	-	0.02 (0.76)	-	0.91 (11.53)
WIG20(-1)	-	-0.37 ^a (-2.58)	-	0.24 (9.21)	-	-0.34 (-1.78)
Adj. R ²	0.82	0.75	0.77	0.79	0.79	0.71
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Sample: 2000:01 2003:06. ^a, ^b, ^c – significant at 1, 5, and 10 % level of significance respectively.

As the results from Table 3.7 demonstrate, it is not only the flows that affect the returns, causality also runs in the opposite direction, reflected in positive and significant coefficients of the contemporaneous stock market indices. Surprisingly, the values of the coefficients of the lagged WIG and WIG20 are significant and negative in case of net and unexpected flows. This result does not reveal positive feedback trading by pension funds.²⁸ However, since the utilized

²⁸ Warther (1995) also fails to detect positive feedback trading in the sample of the US mutual funds, when analyzing their impact on aggregate market returns.

measures for pension fund flows signal predominantly about the flows from the largest pension funds, one may argue that the above finding is not surprising, taking into account the fact that positive feedback trading strategies might be more popular among the smaller rather than larger funds. In addition, using of aggregate stock returns may also be a reason since it is a well known fact that institutions tend to herd into groups of stocks having certain size-performance characteristics, i.e., small stocks with poor past performance, or stocks from certain industries (Lakonishok, Shleifer and Vishny (1992)). Finally, pension funds may not herd at monthly frequency. Therefore we refrain from drawing conclusions about feedback trading since our data is not appropriate enough for analyzing this issue.

3.5. Conclusion

The present chapter investigates effects of trading of pension funds in Poland on the returns on main stock market indices. Our findings might be of interest for the following reasons. Firstly, the previous literature on the price effect of institutional trades is predominantly confined to the investigation of the developed stock markets. Secondly, it focuses on trading by mutual funds and relatively little is known about the pension fund trading. However, as pointed out by several studies, analysis of trading by other types of institutions may bring additional insights since the outcomes of institutional trading with respect to asset prices may differ due to the differences in the investment horizons, clientele profiles, funds' portability etc. Additionally, in the literature on pension funds acting in emerging stock markets, the pricing outcomes of pension fund trading has not been yet investigated.

Our results reveal a strong positive relation between the net and unexpected flows from Polish pension funds and concurrent stock market returns of the two major stock market indices. Increase in the net flows by one standard deviation cause increase in returns in WIG and WIG20 by 0.07 and 0.09 points respectively. When flows are collapsed into the ones from the larger and smaller pension funds, we find that these are flows from the market leaders that drive contemporaneous stock market returns. Our results support the view about the sound impact that pension funds exert on the domestic concurrent stock prices.

However, the results strongly indicate that this price effect do not persist over time, at least at monthly frequency. Our analysis also indicates that stock market returns in turn also influence contemporaneous institutional demand. The findings do not suggest that pension funds pursue positive feedback trading strategies, though this issue calls for a separate investigation. The findings of the present study should be of interest to market participants, as well as to the policy makers of Polish and other emerging stock markets with a similar institutional investor profile.

Chapter 4: Price Limits on a Call Auction Market: Evidence from the Warsaw Stock Exchange

4.1. Introduction

A number of security markets worldwide impose limits on daily asset price movements. Among these markets are very liquid and important exchanges such as Paris Bourse/Euronext and the Tokyo Stock Exchange. A price limit rule restricts daily changes in asset prices by a defined percentage of a previous price. Depending on the regulatory framework in a particular market, trading is either suspended after a limit hit or continues, with subsequent prices fixed either at the limit or within the price limit bounds.

Since price limits directly interfere with asset price resolution, their influence is actively discussed by both practitioners and academic researchers. Price limit advocates consider them beneficial due to the following reasons. First, price limits prevent markets from overreacting by bounding the maximum price change during the trading day. Thus, until trading is resumed, investors may re-assess new information and adjust their beliefs about the asset's fundamental value accordingly. Second, price limits constitute an upper bound for daily volatility and thus reduce the risk that investors bear during turbulent trading days. Therefore, price limit mechanisms are supposed to ensure orderly markets and smooth prices.

However, the implementation of price limits is associated with tangible costs for market participants, which may outweigh their potential benefits. First, prices cannot adjust immediately to their equilibrium in case of large changes in the fundamental asset value because they are restricted by the allowed variation band. A second cost of price limits lies in their interference with liquidity. Since price limits restrict trading beyond certain price ranges and may cause trading halts, some investors are excluded from trading which may cause temporal inefficiency of portfolios and sub-optimal risk-sharing.

Whether the gains from price limit application exceed its costs is scrutinized in a number of studies of equity and futures markets. Evidence on the beneficial influence of price limits is provided by Ma Rao, and Sears (1989a), Ma, Dare, and Donaldson (1990), and Huang, Fu, and Ke (2001). Other studies (Gay, Kale, Kolb, and Noe (1994); Chen (1998)) find no support for systematic overreaction by market participants, thus challenging the expected advantage of price limits. Another strand of the literature, analyzing the impact of price limits

under different price limit regimes on particular markets, casts further doubt on the view that price bounds yield beneficial effects. These investigations document that tighter price limits do not necessarily result in lower volatility levels on the stock markets of Korea (Chung (1991)), Taiwan (Chen (1993); Kim (2001)), and Greece (Phylakitidis, Kavussanos, and Manalis (1999)). A possible reason behind this finding is that price limits, bounding volatility on the limit hit day, merely transfer it to the subsequent day. Abnormally high volatility on the days following a limit move is reported by Kim and Rhee (1997) for the Tokyo Stock Exchange.¹ This volatility spill-over is accompanied by strong price continuation after limit hits, indicating that price limits retard price discovery (Kim and Rhee (1997); Shen and Wang (1998)). The available evidence thus indicates the lack of conformity between proposed and actual effects of price limits.

There are, however, marked differences in market architecture across exchanges and, therefore, price limits do not necessarily have the same effects across markets. The trading process, e.g., as one of the key characteristics of market organization, can be organized as periodic call auctions, continuous auctions, or as continuous dealer markets. The studies cited above all focus on markets where trading takes place continuously or the market clears frequently during operating hours.²⁹ To the best of our knowledge, no study of the impact of price limits on a call auction market with a low number of market clearings per day is available, although this market structure is widely used for at least a subset of stocks traded on various exchanges. In markets with one or two auctions per day, where the period between two consecutive trading sessions is of considerable length, investors are provided with sufficient time to evaluate the importance of any new information. Extensive time-out periods between auctions serve the same purpose as the rationale behind the imposition of price limits that is usually put forward by regulators. Due to a time-out period inherently provided by the discrete market clearing frequency in a call auction, one will not expect that price

²⁹ Similar effects are reported for circuit breakers (Kuhn, Kurserk, and Locke (1991)) and trading halts on the NYSE (Lee, Ready, and Seguin (1994)). Ma, Rao, and Sears (1989b) find lower volatility after limit hitting days; their methodology was, however, subject to heavy criticism (Lehmann (1989), Miller (1989)).

limits will have additional effects on preventing overreaction and panic, and, therefore, there is no reason to assume that price limits offer the proposed advantages to market participants in this market setting.

Empirical evidence on the impact of price limits in such a market setting will be of interest for both market participants, who may suffer from inefficient price formation, and officials of stock exchanges, considering the implementation of similar trading regulation. Therefore, here we investigate the effects of price limits in the call auction segment of the WSE, with trading taking place once per day and with price limits applied to the change of the daily auction price relative to the price on the previous trading day.

We investigate our hypothesis that price limits do not have the positive effects proposed by their proponents in this call auction market by focusing on the following two aspects. First, we do not expect a reduction in volatility after limit moves. On the contrary, if price limits merely hinder price adjustment, volatility will be passed on to the next trading day. Therefore, we examine whether estimated volatility after limit moves is higher than predicted by a model that does not explicitly incorporate price limit hits.

Second, if price limits have no additional effect on preventing overreaction and panic, we do not expect price reversals after limit moves either. Therefore, our second proposition is that price reversals will not occur after limit hits; rather one would observe continuation of price movements.

To examine the first assessment that price limits pass on volatility to the next day, we model daily stock return volatility in a GARCH framework. To capture additional volatility on the day following a limit hit, we include dummy variables in the conditional variance equation. The estimation results yield significant positive parameter values for excess volatility on the first day after limit hits. This indicates that price variability on these days is higher than predicted by a conventional GARCH model that discards the presence of price limits. This finding lends empirical substance to our conjecture that price limits do not moderate volatility but rather transfer it to the next trading day.

We investigate the second assessment that price limit hits are not followed by price reversals by focusing on the serial autocorrelation of daily stock returns. First-order autocorrelation turns out to be positive and highly significant on days following limit hitting days with parameter estimates ranging between .35 and .8.

This finding supports our second hypothesis and enables us to infer that price limits in a call auction market do not succeed in preventing overreaction.

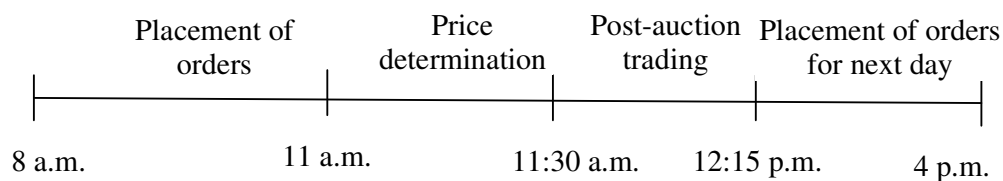
The remainder of this chapter is organized as follows. The next section presents the price limit and trading regulation on the Polish stock market. Section 4.3 describes the data and derives our research hypotheses. The empirical results are presented in Section 4.4: the impact of price limit hits on volatility is investigated in Subsection 4.4.1 and the influence on return autocorrelation in 4.4.2. In Subsection 4.4.3, we identify other potential benefits of price limits and discuss why they are unlikely to apply in the considered market structure. Section 4.5 contains concluding remarks.

4.2. Trading Structure and Price Limits on the Warsaw Stock Exchange

Re-established in 1991, trading on the WSE initially took place in one daily call auction. In July 1996, an order-driven continuous trading system was launched and the most liquid stocks were gradually introduced to this system. These stocks were still traded in the daily call auction in the morning, but an additional continuous trading session took place in the afternoon. In November 2000, a new trading system was launched and all stocks were allocated to either the call auction system or the continuous trading system. Today, most stocks are traded continuously.

Since in our study of the WSE we focus on the influence of price limits on prices of stocks traded exclusively in the call auction system with one daily auction, we confine ourselves here to the outline of the trading procedure in this particular system. The most liquid stocks are additionally traded in the continuous trading system in the afternoon, but as we focus entirely on the effect of price limits in the call auction system, these stocks are excluded from our investigation. The call auction system consists of several phases: a pre-opening phase followed by possible interventions by the specialist, the auction itself, and post-auction trading. The trading day is concluded by the pre-opening order placement for the following trading day. This time schedule of trading of our sample stocks is displayed in Figure 1.

Figure 1: Time schedule of trading in the call auction system



Note: The figure displays the different phases of the call auction system of the WSE. In 1999, the time of order placement in the morning was reduced from three to two hours and all subsequent phases started one hour earlier.

The pre-opening procedure starts after the collection of orders. If there is an order imbalance, the pre-opening phase may be followed by interventions undertaken by the specialist who is appointed by the WSE and assigned to a particular stock. The specialist can intervene by either trading on his own account or by encouraging investors to submit additional offsetting orders.

After the intervention phase, the market price for a security is set. The price is determined under the principles of maximizing turnover, minimizing the demand and supply imbalance, and minimizing the difference between the determined and the reference prices. The reference price for a security is the price fixed in the previous session, i.e., on the previous day. After the call auction price is set, market participants can submit additional orders and trade at this price in a post-auction trading phase, which lasts 45 minutes.

The WSE imposes limits on call auction price fluctuations. According to this price limit rule the stock price may not vary by more than $\pm 10\%$ of the reference price. If a price cannot be determined within these price brackets the following procedure applies. If the imbalance of buy and sell orders (or vice versa) exceeds the ratio 5:1, no trade is executed and a non-transactional price is announced at the upper (lower) price limit in case of a buy (sell) order surplus. If the imbalance does not exceed this ratio, all buy (sell) orders are reduced proportionately and all transactions are executed at the upper (lower) price limit. The WSE categorizes all prices determined in the call auction whether they arise

from a balanced market, or whether demand or supply surpluses prevailed after price determination.³⁰

In some cases, the strict price limit rule is relaxed for a particular stock and the call auction price on this day is unrestricted. This can happen for two reasons. First, the price of a stock may experience price limit hits in the same direction on two or more consecutive trading days. In this case, the specialist may drop the limit rule and the price can adjust to its equilibrium. Second, when trading in a particular stock has been suspended for one or more days, the limit rule is dropped on the first day on which trading is resumed.

4.3. Research Hypotheses and Data

From the description of the periodic call market in Poland presented above it becomes clear that call auction systems with one daily market clearing and price limit mechanisms are essentially substitutional ways to counter panic and overreaction on a market. The call auction structure itself provides time-out periods that allow investors to cool off and re-assess their information. Therefore, we do not expect ex-ante additional benefits arising from the imposition of price limits in the call auction market under investigation. On the contrary, due to the delay of price adjustment, we expect to detect volatility spill-overs to the following day. To test whether price limits dampen volatility, we formulate the following hypothesis: In our empirical investigation, we use this indicator variable to determine price limit hits.

H1₀: On days subsequent to price limit hits, stock returns do not display excess volatility.

against the alternative hypothesis

H1_A: Price limit hits cause excess return volatility on the next trading day.

If price limits prevent overreaction on a market, the price series should display reversal immediately after limit hits. If price limits are not beneficial in the sense that they delay price adjustment to equilibrium, we expect continuation of price movements. In this call auction market, we expect the latter effect to prevail. Therefore, if price limits are successful in mitigating overreaction, then

³⁰ In our empirical investigation, we use this indicator variable to determine price limit hits.

H2₀: On days subsequent to price limit hits, one will not observe price continuation for limit hitting stocks.

We test this hypothesis against the alternative hypothesis

H2_A: Price limit hits induce continuation of price movements on the following day.

We test the two research hypotheses using Polish stock market data. In our empirical study, we use daily stock return and trading volume series that are provided by the WSE. Our sample covers the period from January 1996 to November 2000. We use all stocks that are traded exclusively in the call auction system as described in the previous section.³¹ With the introduction of a new trading system in November 2000, most stocks were transferred to the continuous trading segment that has different price limit restrictions. Therefore, this date naturally constitutes the end of our investigation period.

To be included in our sample, a stock has to meet the following conditions. First, we require at least one year of observations to permit a reliable estimation of model parameters. Second, to estimate the effect of price limit hits for a stock with sufficient accuracy we include only stocks with six or more price limit hits over the estimation window.³² Our final sample contains 92 return series of individual stocks.

To facilitate the presentation of our results, we group the 92 stocks in our sample into three sub-samples. Group 1 contains 30 stocks with the highest number of price limit hits, while 30 stocks with the smallest number of limit hits are assigned to group 3. The remaining 32 stocks with a medium number of price limit hits are classified as group 2.

³¹ Once a stock is introduced to continuous trading, we exclude the following observations from our analysis. The data prior to the transfer to the continuous trading system, however, remain in our sample.

³² When excluding stocks with only few price limit hits, we face a trade-off between a larger number of stocks included in our study and a sufficiently large number of price limit hits in the individual return series. Although the cut-off point at six price limit hits is arbitrarily chosen, this number allows us to use a reasonable number of price limit hits in a sufficiently large sample. Small variations in the cut-off point do not essentially alter our findings.

In the following section, we present results on the impact of price limit hits on volatility and return autocorrelation. We conduct the investigation in two ways. First, we estimate results for all stocks separately and report cross-sectional averages and t-statistics for the overall sample as well as for the three sub-groups. Second, we pool all observations into one sample and estimate results for this one large sample. Since the results are similar in both cases, we report only the cross-sectional averages from individual return series estimations. The pooled regression results as well as the results for individual stocks are available upon request.

4.4. Empirical Results

4.4.1. Volatility

First, we present descriptive statistics of our three groups of stocks as well as of the overall sample. The numbers are shown in Table 4.1.

Our sample stocks hit the price limits on 1.9% of all trading days and the average number of trading days with limit hits varies between 7.1 for group 3 and 24.4 for group 1. Average returns are positive for groups 1 and 2 and negative for group 3, which provides evidence that stocks with more frequent limit hits performed better during our estimation period. Standard deviation and excess kurtosis, indicating fat tails of the return distribution, increase from group 3 to group 1, which is consistent with the fact that the stocks in group 1 hit their price limits more frequently. Finally, the stocks with the highest number of limit hits are most actively traded.

Table 4.1: Descriptive Statistics of the Sample

Stock Group	% Limit Hits	Number of Limit Hits	Return	Std. Dev	Skewness	Excess Kurtosis	Average daily turnover (%)
Group 1	.029	24.4	.024	.042	-.293	6.18 ^a	.524
Group 2	.015	11.5	.026	.038	-.049	1.89 ^a	.264
Group 3	.010	7.1	-.029	.036	-.159 ^a	1.33 ^a	.291
All stocks	.019	14.2	.008	.039	-.165 ^a	3.11 ^a	.358

Note: The table presents descriptive statistics of stocks on the WSE as well as of the entire sample. Group one consists of 30 stocks with the largest number of price limit hits, group 2 of 32 stocks with an intermediate of price limit hits, and group 3 of 30 stocks with a small number of price limit hits. This number is displayed in the second column. The third column reports the average number of limit hits per group in the sample. The last column describes the average daily turnover (in %), defined as the number of shares traded divided by the number of shares outstanding for a particular stock. ^a indicates that the corresponding value is significantly different from zero at the 1% level.

We first investigate the hypothesis that price limits do not increase the expected volatility of returns on the day following limit hits. Therefore, we calculate the impact of price limits on stock return volatility taking into account the serially dependent nature of volatility. Serial dependence, which is a well-known feature of conditional return volatility, is usually captured by GARCH models (Bollerslev, 1986). To explicitly measure volatility on the day following a price limit hit, we include dummy variables for this day in the GARCH framework. Specifically, volatility after price limit hits is captured by the following GARCH(1,1) model:³³

$$r_t = \alpha_0 + \alpha_1 r_{t-1} + \varepsilon_t \quad (4.1)$$

$$\varepsilon_t \sim (0, h_t) \quad (4.2)$$

$$h_t = \omega + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \gamma_1 D_{t-1}^u + \delta_1 D_{t-1}^l + v_t \quad (4.3)$$

The day t return, r_t , of a particular stock depends on the return of the previous trading day plus an error term, ε_t . This error term has zero mean and conditional variance h_t . The conditional variance depends on its value on the previous trading day, h_{t-1} , as well as on the squared lagged residual, ε_{t-1}^2 . Additionally, the conditional variance equation includes dummy variables that explicitly capture the change in conditional volatility attributable to a limit hit. D_{t-1}^u (D_{t-1}^l) equals one if the stock price hits the upper (lower) limit on day $t-1$ and zero otherwise. Thus, the coefficient γ_1 (δ_1) measures the excess volatility on the first day after an upper (lower) limit hit.

First, we estimate a restricted version of (1) to (3) by setting γ_1 and δ_1 equal to zero. The results of this model serve as a benchmark for comparisons with the extended model. Second, we estimate the model with the upper and lower limit hit dummies. This extension explicitly captures excess volatility on the day following a price limit hit.

³³ We determined the optimal lag length of our GARCH specification using the information criteria of Schwartz and Akaike. These measures indicate the GARCH(1,1) specification as optimal for the overwhelming majority of stocks. To allow comparison across stocks, we rely on this specification for all securities in our sample.

We use two measures to evaluate whether volatility on days after a price limit hit is higher or lower than average. First, we analyze the signs of the γ_1 and δ_1 coefficients. If $H1_0$ holds, then γ_1 (δ_1) should not be significantly larger than zero. A positive value of γ_1 implies higher (lower) volatility than expected on the first day after an upper limit hit given the serially dependent nature of volatility. The coefficient δ_1 for lower limit hits is interpreted analogously.³⁴

Second, since the inclusion of the dummy variables may also change the estimated GARCH coefficients, we use the estimated unconditional variance to draw inferences about volatility on days after price limit hits. The unconditional variance of return residuals in a GARCH(1,1) model is given by

$$VAR = \frac{\omega}{1 - \beta_1 - \beta_2} \quad (4.4)$$

where the ω and the two β coefficients are, respectively, the estimated intercept term and the GARCH coefficients of the variance equation (4.3). First, we calculate the measure in equation (4.4) for our restricted benchmark model (γ_1 and δ_1 are both set to zero). Then, we compute the same measure for the model with the dummy variables. In the latter case, equation (4.4) measures the unconditional variance of the return residual series *excluding* excess volatility on the day following a price limit hit. If unconditional variance decreases significantly after excluding the additional volatility attributed to limit hits, we can conclude that excess volatility is present on these days.

³⁴ Note that we have to drop the usual nonnegativity restriction for the coefficients in the conditional variance equation in order to determine whether volatility after price limit hits deviates from volatility in periods without limit hits. The nonnegativity restriction is usually placed on the coefficients to prevent the estimated variance from becoming negative. Our approach is justified by the fact that we apply it solely to historical data and do not use it for out-of-sample forecasts. A similar methodology is used in Cho, Russell, Tiao, and Tsay (2003) and Veld-Merkoulova (2003).

We estimate the two versions of the GARCH model (4.1) to (4.3) described above and present the results from the extended model in Table 4.2. Columns two to four display the results of equation (4.3) of the restricted model, while the coefficients of the unrestricted model are shown in columns five to nine. The model is estimated for each stock separately. The table presents cross-sectional means and t-statistics for the entire sample as well as for the three sub-groups as defined in Section 4.3.

The results shown in the table reveal that the coefficients of the dummy variables are positive and highly significant across the sample. This finding indicates that volatility on days following a price limit hit is higher than predicted by a conventional GARCH(1,1) model that already captures serial dependence in the conditional variance. Coefficients γ_1 and δ_1 are significant across all three sub-groups, with the higher significance levels displayed by the two groups with the larger number of the limit hits.

Table 4.2: Estimation Results of Conditional Return Volatility and the Impact of Price Limit Hits

	ω	β_1	β_2	ω	β_1	β_2	γ_1	δ_1
Group 1								
Coefficient	2.49	.636	.222	2.58	.652	.174	13.97	19.37
<i>t-value</i>	7.32 ^a	20.01 ^a	13.88 ^a	7.39 ^a	20.39 ^a	13.19 ^a	4.26 ^a	4.50 ^a
Group 2								
Coefficeint	2.98	.581	.206	3.06	.591	.174	13.00	16.63
<i>t-value</i>	7.18 ^a	15.99 ^a	14.55 ^a	7.06 ^a	15.59 ^a	12.52 ^a	3.89 ^a	3.79 ^a
Group 3								
Coefficient	2.96	.575	.191	3.00	.584	.171	6.88	9.52
<i>t-value</i>	8.40 ^a	14.44 ^a	13.46 ^a	7.36 ^a	13.90 ^a	11.17 ^a	2.60 ^b	2.67 ^b
All stocks								
Coefficient	2.81	.597	.207	2.88	.609	.173	11.32	15.21
<i>t-value</i>	12.99 ^a	28.32 ^a	23.89 ^a	12.42 ^a	27.77 ^a	21.17 ^a	6.19 ^a	6.29 ^a

Note: The table presents excerpts from the regression results of the GARCH model (4.1) to (4.3). Columns two to four display the results of equation (4.3) of the restricted model ($\gamma_1 = \delta_1 = 0$), while the coefficients of the unrestricted model are shown in columns five to nine. ω is the intercept term, β_1 is the GARCH parameter, and β_2 is the ARCH parameter of the conditional variance equation (4.3). γ_1 and δ_1 are the coefficients of dummy variables that equal one on the day subsequent to an upper and a lower price limit hit, respectively, and zero otherwise. ^a and ^b denote significance at the 1% and 5% level, respectively.

Estimation results in Table 4.2 show that in all sub-samples δ_1 is larger than γ_1 , indicating a possible asymmetric effect of price limits on conditional volatility. This finding suggests that volatility is larger on days after a lower limit hit compared to days after an upper limit hit. The negative correlation between stock returns and volatility is a well-known fact in the finance literature (Pagan and Schwert (1990), Engle and Ng (1993), Bekaert and Wu (2000), Wu (2001)). The differences between the two coefficients could thus reflect a possible asymmetric reaction of conditional volatility to positive and negative shocks. However, cross-sectional t-tests do not reject the hypothesis that γ_1 and δ_1 are, on average, equal across stocks. This finding holds for all three sub-samples, as well as for the entire sample. It suggests that there is no significant asymmetry in the reaction of conditional volatility to price limit hits for the stocks in our sample.³⁵

An explicit test of changes in the unconditional variance is reported in Table 4.3. The measure VAR is defined in equation (4.4) and the indices "0" and "1" indicate the number of lags of the limit hit dummy variables included in the conditional variance equation (4.3). For the model without dummy variables, VAR_0 denotes the unconditional variance in the return series, while for the model with one lag of the dummy variables VAR_1 is the unconditional variance excluding excess volatility on the first day after a limit hit. If price limits successfully mitigate volatility in a call auction, i.e., $H1_0$ holds, then VAR_1 should not be significantly lower than VAR_0 . That means that there is no excess volatility on the day following a limit hit day. To test the significance of the

³⁵ We also utilized the exponential GARCH (EGARCH) model of Nelson (1991) that accommodates asymmetric reaction of conditional volatility to negative shocks. The asymmetry coefficient turns out to be significant for the overall sample, as well as for Groups 1 and 3 indicating larger volatility increases after negative compared to positive shocks. After controlling for this asymmetry δ_1 does not exceed γ_1 anymore and the difference between the coefficients remains statistically insignificant. Results of the EGARCH models are available on request.

difference between VAR_1 and VAR_0 we apply a conventional t-test to the variable $DVAR$, which is defined as $\ln(VAR_1 / VAR_0)$.

Table 4.3: Results of the Impact of Price Limits on Unconditional Return Variance

	VAR_0	VAR_1	$DVAR$	% positive	p-value % positive
Group 1					
Coefficient	21.10	17.88	-.197	.069	<.0001
<i>t-value</i>			-4.16 ^a		
Group 2					
Coefficient	14.25	12.93	-.099	.129	<.0001
<i>t-value</i>			-4.05 ^a		
Group 3					
Coefficient	13.17	12.56	-.45	.103	<.0001
<i>t-value</i>			-2.77 ^a		
All stocks					
Coefficient	16.13	14.42	-.113	.101	<.0001
<i>t-value</i>			-5.79 ^a		

Note: The table presents unconditional variance estimates as defined in equation (4.4) for two formulations of the conditional variance equation (4.3): A model without dummy variables (indexed “0”) and a model with the dummy variables (indexed “1”). $DVAR$ denotes the cross-sectional mean of the change in the unconditional variances defined as $\ln(VAR_1 / VAR_0)$ % positive reports the percentage of stocks for which the estimated coefficient is positive, while the p-value of % positive is the p-value of a test with the null hypothesis that positive and negative coefficients are equally likely across the sample. ^a denotes significance at the 1% level.

Across the sample, VAR_1 is significantly smaller than VAR_0 as indicated by the highly significantly negative $DVAR$ variable. In all three sub-groups, $DVAR$ is significant at the 1% level. Moreover, $DVAR$ is negative for the overwhelming majority of stocks, indicating excess volatility after limit moves.

All results presented in this section soundly reject our first hypothesis that price limit hits do not cause excess volatility on the next trading day. This finding provides the first piece of evidence in favor of our expectation that price limits are not beneficial in a call auction market with one daily auction. We now turn to the second research hypothesis and focus on price movements after limit hits.

4.4.2. Return Autocorrelation

We test our second hypothesis that price limits do not cause price continuation by focusing on the autocorrelation structure of the return series. Following Shen and Wang (1998), we estimate return autocorrelation on the day following a price limit hit using the following two regressions:

$$r_t = \beta_0 + (\beta_1 + \beta_2 D_{t-1}^u + \beta_3 D_{t-1}^l) r_{t-1} + \varepsilon_t \quad (4.5)$$

$$r_t = \beta_0 + (\beta_4 + \beta_5 TO_{t-1} + \beta_6 D_{t-1}^u + \beta_7 D_{t-1}^l) r_{t-1} + \varepsilon_t \quad (4.6)$$

In equation (4.5), we model return autocorrelation as an autoregressive process of the return series. We capture the impact of price limit hits on autocorrelation by including the dummy variables D_{t-1}^u and D_{t-1}^l as defined above. ε_t represents the error term of the regression. The estimated coefficient β_1 gauges first-order autocorrelation if no limit hit occurred on the previous day. In case of a hit of the upper (lower) limit on the previous day, autocorrelation is given by the coefficient sum of β_1 and β_2 (β_1 and β_3).

It has been shown empirically that trading volume may have an impact on return autocorrelation (see Boudoukh, Richardson, and Whitelaw (1994) for an overview). This 'volume effect' presumes a decrease in the extent of autocorrelation after periods of high trading activity. Thus, trading volume may compensate or reinforce the impact of price limits on return autocorrelation. To disentangle this effect, we include turnover, TO_{t-1} , as a proxy of trading volume in equation (4.6), defined as the number of shares traded on day $t-1$ in all phases of the auction system divided by the number of shares outstanding

on the same day. The coefficient β_5 in (6) evaluates the additional impact of volume on autocorrelation in the stock return series.

For $H2_0$ to hold, the coefficients of limit hit dummies ($\beta_2, \beta_3, \beta_6, \beta_7$) should not be significantly positive. Table 4.4 displays the estimation results of equations (4.5) and (4.6). We first estimate the equations using the regular OLS estimation technique. Next, we allow the error term to follow a GARCH(1,1) process and repeat the estimation of equations (4.5) and (4.6).³⁶ Since both methods yield qualitatively identical results, we report the simple OLS estimation results only.

We observe strong continuation in the stock return series after price limit hits reflected in a substantial degree of return autocorrelation. Results of equation (4.5) indicate that after a hit of the upper (lower) price limit the average return autocorrelation in the whole sample measured as the sum of β_1 and β_2 (β_1 and β_3) reaches .618 (.371). Such a considerable extent of serial dependence is found for all sub-groups of stocks with the highest value for the sub-group with the largest number of limit hits (group 1). For this group, return autocorrelation on the day immediately following upper and lower limit hits attains .703 and .585, respectively, while the estimates for group 3 equal .585 and .340. Estimation results of equation (4.6) show that the coefficients of the dummy variables are only slightly reduced when volume is included in the regression, indicating the robustness of our results. Volume, measured as share turnover, exerts a positive influence on return autocorrelation. Correlation is higher on days subsequent to larger trading activity, although this finding is not significant in groups 1 and 2. The additional explanatory power of turnover, however, is rather small as can be seen from the modest increase in the average adjusted R^2 measure as reported in the table.

³⁶ Again, the information criteria indicate optimality of the GARCH(1,1) formulation.

Table 4.4: Estimation Results of the Impact of Price Limit hits on Stock Return Autocorrelation

Group 1	β_1	β_2	β_3	β_4	β_5	β_6	β_7
Parameter	-.051	.754	.636	-.057	7.585	.747	.635
t-value	-2.94 ^a	20.17 ^a	11.81 ^a	-2.76 ^a	1.33	19.42 ^a	11.99 ^a
% positive	.333	1.000	1.000	.333	.633	1.000	1.000
p-value % positive	.068	.000	.000	.068	.144	.000	.000
% significant	.500	1.000	.900	.433	.133	1.000	.867
Adj. R^2	.085			.086			
Group 2							
Parameter	-.094	.712	.340	-.113	6.144	.707	.358
t-value	-5.30 ^a	16.56 ^a	4.53 ^a	-5.21 ^a	1.04	15.56 ^a	4.77 ^a
% positive	.156	1.000	.844	.156	.656	1.000	.875
p-value % positive	.000	.000	.000	.000	.077	.000	.000
% significant	.500	.696	.688	.656	.406	.969	.594
Adj. R^2	.072			.075			
Group 3							
Parameter	-0.050	.585	.340	-.078	19.041	.571	.341

t-value	-2.57 ^b	11.44 ^a	4.54 ^a	-3.24 ^a	2.36 ^b	10.81 ^a	4.48 ^a
% positive	.300	.967	.800	.167	.700	.967	.800
p-value % positive	.029	.000	.001	.000	.029	.000	.001
% significant	.433	.800	.433	.467	.300	.833	.433
Adj. R^2	.033			.038			
<hr/>							
All Stocks							
Parameter	-.066	.684	.437	-.084	10.820	.676	.433
t-value	-6.18 ^a	26.02 ^a	10.40 ^a	-6.47 ^a	2.82 ^a	24.68 ^a	10.55 ^a
% positive	0.63			0.67			
p-value % positive	.261	.989	.880	.217	.663	.989	.891
% significant	.000	.000	.000	.000	.002	.000	.000
Adj. R^2	.478	.942	.674	.522	.283	.935	.630

Note: The table presents estimation results of the models (4.5) and (4.6). The four panels show results for groups 1 to 3 as well as for the entire sample. t-values denote results of cross-sectional t-tests. % positive and % significant report the percentage of stocks for which the estimated coefficient is positive and significant, respectively, while the p-value of % positive is the p-value of a test with the null hypothesis that positive and negative coefficients are equally likely across the sample. ^a and ^b denote significance at the 1% and 5% level, respectively.

Contrary to other markets (Shen and Wang, 1998), we do not find a negative relationship between trading volume and autocorrelation. However, this does not necessarily mean that there is no information content in trading volume. It may be helpful to disaggregate our volume measure into volume realized in the auction phase and volume in post-auction trading. Especially, the latter may contain useful information and contribute to the explanation of autocorrelation in equation (4.6). If market participants expect prices to continue moving in the same direction on days after limit hits, we will observe only small or no volume in post auction trading after the limit hit since all potential sellers prefer selling the stock at the expected higher price on the next trading day. On the other hand, if investors do not expect a certain direction of price movement on the next day, they may want to close down their positions to avoid the increased overnight risk after a limit hit. In this case, we would observe high trading volume. Thus, volume disaggregated into components from different phases of the auction process may contain additional information.³⁷

Due to lack of data from the early years of the WSE, when only aggregated volume series were recorded, we are not able to distinguish between volumes in the different phases of the call auction.³⁸ However, the inclusion of trading volume in equation (4.6) only serves as a robustness check. Moreover, none of our hypotheses are directly related to assumptions about trading volume. Therefore, the relationship between trading volume and autocorrelation should not essentially impact our conclusions.

The findings reported in Table 4.4 are consistent with our assessment that price limits simply distort the price adjustment process to equilibrium since strong positive autocorrelation can be found on the first day after price limit hits.

4.4.3. Discussion

Our empirical findings suggest that price limits in the call auction system of the WSE merely delay price adjustment and cause volatility spill-overs. If the aim of their

³⁷ This issue was raised by an anonymous referee.

³⁸ In personal discussion with WSE officials we obtained estimates for the share of post-auction trading varying from 10% to around one quarter of volume in the auction system.

imposition was to curb overreaction and panic in periods of large price fluctuations, the results indicate that they fail to achieve it. The range of potential benefits of price limits may, however, be wider than this.

Price limits can substitute for higher margin requirements in futures trading, short selling, and credit for the purpose of buying stocks. Moreover, they can limit price manipulation and insider trading by investors with superior information on a stock. While these reasons can justify the implementation of price limits, we doubt that the benefits related to them can realize and thus outweigh the costs of price limit imposition on the WSE.

Price limits can lower transaction costs by substituting for higher margin requirements. This holds for futures trading as shown theoretically by Brennan (1986), Chowdhry and Nanda (1998), and Chou, Lin, and Yu (2000) and supported empirically by Chen (2002), for short selling, as well as for stocks bought on margin (Hardouvelis, 1990; Hsieh and Miller, 1990). Since short positions are usually marked to the market, price limits prevent large changes in margins and, thus, limit the risk of a short position. Therefore, default risk decreases and regulators can decrease transaction costs by allowing lower margins. While this positive function of price limits is intuitively plausible, it cannot be applied to our sample stocks.

First, there are no interdependencies between the stocks used in our study and the futures market. The only futures contracts traded on the WSE that are linked to the stock market are contracts on the WIG 20 index that includes the twenty largest and most liquid stocks. Since these stocks are all traded continuously and are, therefore, not included in our sample, interdependencies between the cash and the futures market do not apply in this case and, therefore, do not justify the implementation of price limits for our sample stocks.

Moreover, the WSE prohibits short selling for almost all stocks (including all of our sample stocks). Thus, price limits in the call auction of the WSE cannot be justified as means of reducing margin requirements for short positions on the spot market either. Finally, buying stocks on margin is very unusual in Poland. In general, brokerage firms do not provide this service to investors. Thus, this rationale can be ruled out as well.

Another potentially beneficial aspect of price limits is the limitation of price manipulation and insider trading. An insider with superior private information on the stock value can make profits at the expense of small uninformed investors. Price limits restrict the potential gains of an insider and the degree of price manipulation and provide time-out periods that make possible the dissemination of information or investigations by regulators. This effect is especially pronounced for less liquid stocks like the stocks in our sample. Since the market is thin for these infrequently traded securities, large orders may lead to large price changes.

The beneficial role in the case of asymmetric information on the WSE is, however, doubtful. First, positive effects of price limits on information distribution are theoretically controversial. As outlined in Chan, Kim, and Rhee (2003), informed traders may be unwilling to trade in the presence of narrow price limits since they are not able to fully exploit their advantage. This may even increase information asymmetry on the market.

Second, due to the specific structure of the call auction system under investigation the necessity of price limits as a protection against insider trading is questionable. Information is efficiently incorporated into securities prices in a call auction especially for illiquid stocks and the losses of small uninformed investors to better informed agents are lower compared to other market structures (Madhavan (1992), Pagano and Röell (1996)).

Finally, the market price is not simply determined by buy and sell orders but computed by a specialist who observes the contents of the order book, may trade on his own account, and can encourage the submission of offsetting orders. Since each trader and his trade can be identified by stock exchange officials *before* the trade is executed, the problem of price manipulation is significantly mitigated since illegal practices can be easier identified and restricted. The imposition of price limits entails severe costs to the market as shown in the previous subsections. The potential benefits as discussed in this section are questionable given the special structure of the market and we doubt that they can compensate for the disadvantages of price limit imposition.

4.5. Conclusion

A number of stock markets in the world restrict daily stock price movements by applying price limit rules. The motivation behind this imposition is to mitigate daily volatility and to prevent markets from overreaction and panic by providing a time-out period that allows investors to cool down. Several investigations have focused on the impact of price limits on markets characterized by continuous trading systems. Their results cast doubt on the suitability of price limits. This study, being the first attempt to extend the empirical evidence to a call auction market with low trading frequency, focuses on the call auction segment of the WSE with one daily auction. Since call auctions provide time-out periods between periodic market clearings, we expect that price limits do not provide additional benefits in terms of reduced volatility and reversed overreaction of stock prices.

Our empirical results sustain this assessment. We document strong evidence of volatility spill-overs to the day after a price limit hit. In our GARCH framework, dummy variables that capture excess volatility on the day following a price limit hit display positive and highly significant coefficients. We also discover strong autocorrelation induced by both upper and lower limit hits. Autocorrelation coefficients on the day subsequent to a limit move are .62 for upper limit hits and .37 for lower limit hits.

Our empirical findings clearly suggest that price limits in the call auction system of the WSE merely delay price adjustment and cause volatility spill-overs. If the aim of their imposition was to curb overreaction and panic in periods of large price fluctuations, the results indicate that they fail to achieve it. Other potential benefits (such as substitutes for higher margin requirements and the protection against insider trading and price manipulation) are also doubtful in this particular trading structure. Our results should be of interest for investors and regulators who are considering the imposition or abolition of price limits on stock markets with similar trading structures.

Chapter 5: Polish Equity Market Integration with the Emerging European and Developed Markets: A Cointegration Analysis with Shifting Regimes

5.1. Introduction

The extent of stock market linkages has attracted increasing attention in recent years. Motivated by the global scale of the October 1987 stock market crash and subsequent Asian and Russian crises of the 1997-1998, voluminous empirical literature examine various aspects of international stock market interrelationships.³⁹ The development of the cointegration methodology by Engle and Granger (1987) and Johansen (1988) gave rise to numerous studies on long-term co-movements between stock markets that suggest important implications for portfolio theory and diversification issues. Earlier investigations into long-run stock markets relations mostly focus on mature markets of Western Europe and the USA, and Asian and Latin American emerging markets.⁴⁰

The developing markets of Central and Eastern Europe have been investigated to a smaller extent. During the 1990s, however, these markets attracted attention of foreign investors as a new venue for diversification and enjoyed an upsurge in the amount of foreign portfolio flows (Lankes and Stern (1998)). Investors' interest in CE markets is warranted by stable performance of their economies, the higher growth rates than in Western Europe, the low valuations, and their upcoming EU accession. Among the CE markets Polish, Hungarian, and Czech markets are considered the most advanced due to

³⁹ For analysis of correlation structure between markets, see Longin and Solnik (1993), Koedijk, Campbell, and Kofman (2002), for investigations of volatility spillovers, see Koutmos and Booth (1995), Ng (2000), for testing of the international asset pricing models see de Jong and Roon (2001), and for studies of contagion refer to IMF (1999), Claessens and Forbes (2001), and Rigobon (2001).

⁴⁰ For studies of cointegration relations between developed European and the US markets see Kasa (1992), Richards (1995), Francis and Leachman (1998), for studies of Asian markets see Arshanapalli and Doukas (1996), Phylaktis (1999), Manning (2002); Latin American markets are analyzed by Choudhry (1997), Arbeláez, Urrutia, and Abbas (2001), and Chen, Firth, and Rui (2002).

higher capitalization, turnover, and number of traded securities (Pajuste, 2001). The extant studies on these markets, however, are not plentiful. Linne (1998) reports some evidence in favor of cointegration between the Central European markets, although no cointegration relationships with the mature markets are found. MacDonald (2001) analyzes the stock indices of Central and Eastern European countries as a group against each of three developed markets (USA, Germany, and the United Kingdom). He documents significant long-run relations for each of the groupings. To the contrary, in the later study, Gilmore and McManus (2003) find no long-term links between the three CE markets and the USA. One needs to stress that the authors focus exclusively on the interactions with the US market, leaving out connections with the important European stock markets. Jochum, Kirchgässner, and Platek (1999) scrutinize the effect of the 1997-98 Russian crises on the long-run relations between Vyshegrad countries (Poland, Hungary, and the Czech Republic), Russia, and the USA. Bivariate cointegration relationships found in the pre-crisis period cease for all but two pairs of markets afterwards due to predominance of the short-run dynamics in the post-crisis period. Relying on the historical performance of the markets and results of the principal component analysis, the authors assume that a change in the long-run relations occurred on September 1, 1997. However, the approach adopted by the authors may suffer from problems arising when assumptions on the data generating process are imposed exogenously.

To summarize, available studies arrive at conflicting conclusions with regard to the presence of long-run links between emerging European stock markets and their mature counterparts. This controversy urges us on to shed more light on patterns of these relations due to their implications for potential diversification benefits. The present essay contributes to the extant literature in two ways. First, we address a common assumption shared by all but one studies referenced above. With the exception of Jochum, Kirchgässner, and Platek (1999) the above-mentioned investigations assume stable long-term relations. However, recent studies have pointed out the time-varying nature of the inter-market relations (Bekaert and Harvey (1995), Gelos and Sahay (2000)). Violation of the stability assumption is especially likely to occur over the long periods, which constitute the focus of cointegration studies. It has important implication for cointegration

analysis since structural breaks deteriorate power of cointegration tests and lead to under-rejection of the null hypothesis of no cointegration Campos, Ericsson and Hendry (1996), and Gregory and Hansen (1996)). For this reason we employ the methodology that accounts for the eventual instability in long-run relations, namely the Gregory-Hansen (1996) procedure. It not only allows for a more general specification of long-term relations than conventional cointegration tests, but also permits to estimate the exact date of the structural change in the relationships rather than arbitrary assume it relying on market history. We compare the results from the traditional cointegration-testing procedures with the findings provided by the new test and analyze whether this methodology helps to uncover any additional long-run relations, potentially overlooked by conventional techniques.⁴¹ Second, we exploit a comprehensive sample that includes daily data for the three most advanced emerging markets in the region and four developed stock markets over a period of almost ten years. Several studies document that CE markets became increasingly correlated with the developed markets in the second half of 1990s (Gelos and Sahay (2000), MacDonald (2001), Gilmore and McManus (2002)). Our sample that covers a period of 1993-2002 allows us to check whether intensification of short-term links has changed a pattern of long-run relations.

Our findings show that once we allow for a more general specification of equilibrium relations, we obtain stronger evidence in support of their presence. Namely, Gregory-Hansen procedure reveals four long-run relations (one within the group of the CE stock markets and three between emerging and developed markets) omitted by regular cointegration test. Our results thus indicate the increased degree of integration of the CE market into global market environments. They imply that previously reported

⁴¹ It was previously asserted in the literature that presence of cointegration, implying price predictability, violates the weak form of market efficiency. However, a number of authors called this statement into question (Dwyer and Wallace (1992), Crowder (1994), Crowder (1996), Engel (1996), Caporalle and Pittis (1998)). Therefore we abstain from drawing conclusions about the extent of efficiency in these markets, and focus on the issue of asset price predictability.

diversification benefits for foreign investors with long horizons in these markets could be somewhat overstated.

The remainder of the chapter is structured as follows. The next section presents the data. Section 5.3 outlines the methodology employed when testing for non-stationarity of the price series and cointegration. The results of unit root tests, bivariate and multivariate cointegration tests as well as estimated cointegration vectors and error-correction models are described in Section 5.4. Finally, Section 5.5 concludes.

5.2. Data

The data set employed in this study comprises daily closing prices for the indices of the three emerging CE markets (Poland, the Czech Republic, and Hungary), three developed European stock markets (the United Kingdom, Germany, and France), and the USA. The data was obtained from the national stock exchanges with the exception for the German stock market, for which it was received from Karlsruher Kapitalmarktdatenbank (University of Karlsruhe, Germany). The rationale for using daily data is based on the notion that weekly or lower-frequency data may lack part of the information on market interactions contained in high frequency series. The sample covers a period of more than nine years, from September 7, 1993 through April 30, 2002, and comprises daily closing prices of the following national stock market indices: Polish WIG, Czech PX50, Hungarian BUX, German DAX, French CAC40, British FTSE100, and American S&P500.⁴² Our final sample includes 1862 observations.

Following the argument of Jochum, Kirchgässner, and Platek (1996), we use indices expressed in the national currencies, thus restricting their changes solely to the movements in the security prices and avoiding the distortion of the cointegration analysis results by numerous devaluations of the exchange rates that took place in the region.

⁴² The starting date of our sample is stipulated by the data availability for the Czech market, which was re-opened the last among his peers, in April 1993. The indices representing the stock markets are selected to guarantee representativeness of the domestic markets and comparability with the previous studies on the CE markets.

Since most of the markets are operating in the same time zone, the problem of trading hours not overlapping does not arise. The USA market is the exception; the price changes in Europe are reflected as of the next day, since trading on European Stock exchanges is over by the time when trading in the American market commences. When a stock exchange is closed due to a national holiday, the price from the last business day is taken.

5.3. Methodology

Prior to testing for cointegration, we determine the order of integration of the market indices and ensure that it is equal across the time series. Augmented Dickey-Fuller (1979) (ADF) and non-parametric Phillips-Perron (1987) (PP) unit root tests are used to test for the non-stationarity of the series. Due to the shortcomings of these tests that are documented in previous investigations, we perform a type of confirmatory analysis, deploying the following testing procedures (Maddala (1995)). First, we apply the test of Kwiatkowski, Phillips, Schmidt, and Shin (1992) (KPSS) that assumes stationarity under the null hypothesis. Second, Perron (1989) and Reichlin (1990) show that in the presence of a structural break traditional testing procedures may erroneously fail to reject the null hypothesis that a series is integrated of higher order. To account for the possibility of a change, we utilize Zivot-Andrews (1992) sequential test for a unit root with the alternative hypothesis of stationarity with a single structural change in the deterministic trend.⁴³

Results of Monte Carlo experiments (Campos, Ericsson, and Hendry (1996), and Gregory and Hansen (1996)) show that when a shift in parameters takes place standard tests for cointegration (like the one of Engle-Granger (1987)) may lose power and falsely signal the absence of equilibrium in the system. Thus, it would be of interest to consider the possibility of the shift in the equilibrium relationship that occurred at an unknown point in time. The Gregory-Hansen (1996) test assumes the null hypothesis of no cointegration against the alternative hypothesis of cointegration with one structural

⁴³ Other procedures that incorporate the possibility of a break at an unknown time under the alternative hypothesis are suggested by Banerjee et al. (1992), and Perron and Vogelsang (1992). We do not intend, however, to make use of all of them here.

break. The timing of the structural change under the alternative hypothesis is estimated rather than selected. Gregory and Hansen suggest three alternative model specifications in the spirit of Zivot and Andrews (1992), accommodating changes in parameters of the cointegration vector under the alternative. A level shift model allows for the change in the intercept only (C):

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha' y_{2t} + e_t, \quad t = 1, \dots, n. \quad (5.1)$$

The second model accommodating trend in data also restricts shift only to the change in level (C/T):

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha' y_{2t} + e_t, \quad t = 1, \dots, n. \quad (5.2)$$

The most general specification allows for changes both in the intercept and slope of the cointegration vector (R/S):

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha_1' y_{1t} + \alpha_2' y_{2t} \varphi_{t\tau} + e_t, \quad t = 1, \dots, n. \quad (5.3)$$

The dummy variable which captures the structural change is represented as:

$$\varphi_{t\tau} = \begin{cases} 0, & t \leq [n\tau] \\ 1, & t > [n\tau] \end{cases}, \quad (5.4)$$

where $\tau \in (0,1)$ is a relative timing of the change point. The trimming interval is usually taken to be $(0.15n, 0.85n)$, as recommended in Andrews (1993). The models (5.1)-(5.3) are estimated sequentially with the break point changing over the interval $\tau \in (0.15n, 0.85n)$. Non-stationarity of the obtained residuals, expected under the null hypothesis, is checked by ADF and PP tests. Setting the test statistics (denoted as ADF^* (Z_a^* , Z_t^*)) to the smallest value of the ADF (Z_a , Z_t) statistics in the sequence, we select the value that constitutes the strongest evidence against the null hypothesis of no cointegration. The asymptotic distribution of the test statistics is free of nuisance parameters and depends only on the number of stochastic regressors. The approximate asymptotic critical values are calculated using MacKinnon (1991) response surfaces.

To check whether application of the refined procedure reveals any additional cointegration relationships, we also implement regular cointegration tests, i.e., we perform Engle-Granger (1987) and Johansen (1988) tests for bivariate for multivariate

setting respectively. The results of the Gregory-Hansen approach could be especially insightful when the null hypothesis of no cointegration is not rejected by the conventional tests. When it is rejected by the Gregory-Hansen test, we receive an important indication that a cointegration relation in fact exists, with the parameters of the cointegration relationship being subject to a change.⁴⁴

After the estimation of the break timings, we re-estimate cointegration vectors allowing for two regimes in stock index relations. For this purpose, we exploit the Fully Modified OLS estimator (FM OLS) suggested by Phillips and Hansen (1990). As shown by Monte-Carlo results this estimator displays properties superior to those of the usual OLS estimator (Phillips and Loretan, 1991). The FM OLS procedure furnishes modification of the dependent variable and the error term from the equilibrium regression estimated by simple OLS to account for endogeneity and serial correlation in the data. The modification takes the following form:

$$\hat{y}_t^+ = y_t - \hat{\omega}_{12} \hat{\Omega}_{11} \Delta x_t \quad (5.5)$$

$$\hat{u}_t^+ = \hat{u}_t - \hat{\omega}_{12} \hat{\Omega}_{11} \Delta x_t, \quad (5.6)$$

where Ω is a long-run covariance matrix, estimated by the Newey-West estimator, partitioned in the following way: $\Omega = \begin{bmatrix} \Omega_{11} & \omega_{12} \\ \omega_{21} & \omega_{22} \end{bmatrix}$. To eliminate serial correlation, the

correction term $\hat{\delta}^+ = \sum_{k=0}^T (u_{1k}^+ u_{21}')$ is constructed, where u_{1t}^+ is estimated as

$\hat{u}_t^+ = \hat{u}_t - \hat{\omega}_{12} \hat{\Omega}_{11} \Delta x_t$. The estimator of the coefficient vector comprises both amendments:

$$\hat{\beta} = (X' X)^{-1} (X' Y^+ - T \hat{\delta}^+). \quad (5.7)$$

⁴⁴ However, as pointed by Gabriel, Silva, and Lopes (1999), the test also possesses power against stable alternatives. A stable cointegration relationship may also cause the rejection of the null hypothesis, thus making interpretation of the estimated break points obscure. Another drawback of the test is that it considers a single structural change, when the alternative of multiple structural breaks is more realistic.

Re-estimated in this way cointegration vectors are subsequently used to evaluate the two-regime error-correction models with one-time shift. It is performed by ordinary OLS, since the obtained coefficient vector is asymptotically equivalent to the estimates obtained by the maximum likelihood. The values of the t-statistics of the error-correction terms serve as additional evidence supporting (rejecting) presence of cointegration.

5.4. Empirical results

5.4.1. Results of Tests for Non-Stationarity

For the sake of brevity, we confine ourselves to an overview of the results of the Augmented Dickey-Fuller, Phillips-Perron, KPSS, and Zivot-Andrews unit root tests. Detailed tables are available upon request. The ADF and PP tests' results indicate that the null hypothesis of a unit root in the stock price levels cannot be rejected for all time series. While a unit root in the first differences of the stock prices is rejected at the 5% significance level suggesting that stock prices follow a process integrated of order one.

According to the results of the KPSS test, the null hypothesis of stationarity is rejected for all price series, supporting the findings of the two previous tests. The Zivot-Andrews test produced results that conform to the outcomes of the other unit root tests, i.e., it failed to reject the null hypothesis of non-stationarity. Since all of the index time series are found to be $I(1)$, we may proceed with the cointegration analysis.

5.4.2. Results of Conventional Cointegration Tests

We start with the presentation of the Engle-Granger and the Johansen cointegration test results in order to compare them later on with the findings of the Gregory-Hansen test. Due to the lack of space, we do not report tables here, but they are available upon request. The Engle-Granger procedure, implemented for the bivariate setting for the CE stock market indices, detects cointegration relationships between Polish and Hungarian markets (in both directions) the between the Czech and Hungarian

ones.⁴⁵ Jochum, Kirchgässner, and Platek (1999) also document the presence of pair-wise relationships between the CE markets. However, long-run links persist only during the global turmoil period in the mid of 1997 and disappear afterwards. Our result lends support to the hypothesis that stock markets in this region are interdependent and implies the possibility of partial stock price forecasts using data from the neighbouring markets. Johansen's (1988) maximum eigenvalue and trace tests carried out for the three CE stock markets show that they are linked by a single common long-run relationship. This, most probably, should be attributed to the growing exposure of these markets to foreign portfolio flows, in which these markets are treated as a single asset and country-specific shocks affect investors' sentiment with regard to the region as a whole.

The analysis also supports the presence of cointegration relationships with the mature markets. Namely, in bivariate setting cointegration vectors exist for Polish markets with USA, German, and UK equity markets. The Czech market display co-movements with the market indices of the same countries. Surprisingly, the Hungarian BUX does not appear to have any relationships with its mature peers.

The Johansen cointegration test implemented in the multivariate setting indicates that the presence of significant cointegration relationships between the three emerging markets and each developed one. These findings are reminiscent of the earlier results of MacDonald (2001), who reports long-run relationships between the CE markets and markets of the USA, Germany, and the UK and imply that the emerging stock markets of Central Europe are driven by both regional and global factors. However, the number of significant long-run relationships does not increase in the multivariate setting, which may be due to the presence of those relationships that are revealed in the bivariate groupings (Linne, 1998).

⁴⁵ When testing for the presence of cointegration between two markets, we verify the hypothesis in both directions, i.e., setting a price series of each market first as a dependent and then as independent variable. We interpret significant results at the 1% and 5% level. The same approach is followed when carrying out the Gregory-Hansen test for cointegration.

5.4.3. Results of Gregory-Hansen Residual-Based Cointegration Test

As stated by Gregory and Hansen, the evidence furnished by their testing procedure is of special value when conventional tests fail to reject the null hypothesis of no cointegration, but the Gregory-Hansen test does not. This implies that structural change is essential for the pattern of long-term stock market co-movements. Table 5.1 presents the results of the Gregory-Hansen test for the emerging markets. The test is performed for models (5.1) to (5.3) (see Section 5.3). The model with significant dummy variable coefficients is used in the subsequent analysis.⁴⁶ The pair-wise test results for all developing markets show that the null hypothesis of no cointegration is rejected in all but one case (Hungary-Czech Republic) at least by one of the tests. The dates of the pair-wise breaks are estimated to be on June 9, 1996, June 12, 1997, May 9, 1997, and September 2, 1996. In most cases, they coincide for all three tests for a given model specification. The relationship between the Czech and Polish markets, not revealed by the Engle-Granger test, was detected by all three tests using the Gregory-Hansen procedure. It seems likely that an upsurge in the foreign demand for CE securities that distinguished 1996 fostered strengthened co-movements between the Czech and Polish markets and fostered a change in the relationship that occurred in September of that year (IMF, 1999).

⁴⁶ Whereas the exact distribution of the test statistics by dummy coefficients is unknown, due to their high values we treat them as significant.

Table 5.1: Results of the Gregory-Hansen Test for Cointegration for the CE Markets (Bivariate Setting)

Indices	ADF*	Lag	Break point/ Observ. num.	Phillips Zt*	Break point	Phillips Za*	Break point
Model C							
WIG-BUX	-5.31**	5	0.39 741	-4.98*	0.39	-51.19**	0.39
WIG-PX50	-4.83*	1	0.29 556	-4.66*	0.29	-43.16*	0.29
PX50-WIG	-4.05	10	0.38 739	-3.78	0.15	-24.12	0.15
PX50-BUX	-4.05	10	0.39 739	-3.78	0.15	-24.13	0.15
BUX-PX50	-3.68	10	0.40 670	-3.42	0.34	-24.11	0.34
BUX-WIG	-5.00*	5	0.38 720	-4.90*	0.39	-50.48**	0.39
Model C/T							
WIG-BUX	-5.49**	5	0.38 720	-5.16*	0.39	-53.90*	0.39
WIG-PX50	-5.14*	1	0.22 421	-4.97	0.22	-49.02	0.22
PX50-WIG	-4.64*	10	0.64 1219	-4.57	0.63	-34.93	0.63
PX50-BUX	-4.64*	10	0.64 1219	-4.57	0.63	-34.93	0.63
BUX-PX50	-3.74	10	0.35 673	-3.52	0.33	-24.57	0.33
BUX-WIG	-5.17*	5	0.38 720	-5.07*	0.38	-52.41*	0.38
Model R/S							
WIG-BUX	-5.33*	5	0.39 741	-5.02*	0.39	-51.79*	0.39
WIG-PX50	-5.39*	1	0.29 556	-5.24*	0.29	-54.42*	0.29
PX50-WIG	-4.23	10	0.54 1031	-3.81	0.15	-28.90	0.15
PX50-BUX	-4.23	10	0.54 1031	-3.81	0.15	-28.89	0.15
BUX-PX50	-4.19	1	0.35 667	-4.14	0.35	-34.52	0.35
BUX-WIG	-4.95*	5	0.38 720	-4.92	0.37	-51.14*	0.37

Note: **, * denotes significance at the 1% and 5% level. Critical values are taken from Gregory and Hansen (1996). Model specifications denote: C – level shift, C/T – level shift with a trend, R/S – regime shift (see Section 5.3).

Test results for the emerging markets group reported in Table 5.2 reject the null hypothesis, thus indicating that the three markets share a long-run relationship that is subject to a change in the coefficients. This finding is in line with the above-mentioned results of the Johansen test. The estimated date of the shift in the mean and both in the mean and slope of the cointegration relationship is on June 12, 1997 and May 9, 1997, respectively. While the Hungarian market posted steady growth in prices due to stable fundamentals since the beginning of the year, the Polish market index experienced losses, which were especially substantial in May 1997 due to the weakness of the zloty (IFC (1998)). Additionally, in May 1997 the Czech currency crisis took place that emerged in a result of a spill-over of financial woes that started in Thailand (IMF (1997)). Gelos and Sahay, 2000, note that the Czech currency crisis had some effect on neighbouring markets. Most probably, these divergent trends in the two markets combined with the currency turmoil in the Czech Republic prompted a change in the relationship parameters detected in May 1997.

Table 5.2: Results of the Gregory-Hansen Test for Cointegration for the CE markets (Multivariate Setting)

Indices	ADF*	Lag	Break point/ Observ. num.	Phillips Zt*	Break point	Phillips Za*	Break point
Model C							
WIG-BUX-PX50	-5.30**	5	0.39 741	-4.98*	0.39	-51.19**	0.39
BUX-WIG-PX50	-5.00*	5	0.38 720	-4.90*	0.39	-50.48**	0.39
PX50-BUX-WIG	-4.05	10	0.39 739	-3.78	0.15	-24.13	0.15
Model C/T							
WIG-BUX-PX50	-5.49**	5	0.38 720	-5.16*	0.39	-53.90*	0.39
BUX-WIG-PX50	-5.17*	5	0.38 720	-5.07*	0.38	-52.41**	0.38

PX50-BUX-WIG	-4.64	10	0.64 1219	-4.60	0.63	-34.93	0.63
Model R/S							
WIG-BUX-PX50	-5.33*	5	0.39 741	-5.02*	0.39	-51.79*	0.39
BUX-WIG-PX50	-4.95	5	0.38 720	-4.91	0.37	-51.14*	0.37
PX50-BUX-WIG	-4.23	10	0.54 1031	-3.81	0.15	-28.89	0.15

Note: **, * denotes significance at the 1% and 5% level. Critical values are taken from Gregory and Hansen (1996). Model specifications denote: C – level shift, C/T – level shift with a trend, R/S – regime shift (see Section 5.3).

The findings of the bivariate cointegration test displayed in Table 5.3 indicate the existence of co-movements between the developed markets and the Polish market. The Gregory-Hansen test results confirm that the Polish stock market is linked with the American and German markets, which echoes the outcomes of conventional testing procedures. However, the test results also provide an indication of a link with the French market, undetected by regular tests, with the structural shift on March 22, 1996. Changes in the relationships with the US and German markets took place on June 17, 1998 and February 23, 1996.

Table 5.3: Results of Gregory-Hansen Cointegration Tests: Poland – Developed

Markets							
Indices	ADF*	Lag	Break point/ Observ. num.	Phillips Zt*	Break point	Phillips Za*	Break point
Model C							
WIG-S&P500	-4.76*	10	0.51 958	-3.94	0.51	-31.60	0.51
WIG-DAX	-4.73*	7	0.49 919	-4.23	0.50	-35.28	0.50
WIG-FTSE	-4.07	10	0.24 438	-3.96	0.45	-31.63	0.45
WIG-CAC40	-4.31	10	0.55 1015	-3.77	0.54	-28.13	0.23
Model C/T							
WIG-S&P500	-4.85*	10	0.51 958	-4.04	0.51	-32.77	0.51
WIG-DAX	-5.27*	10	0.23 419	-4.56	0.24	-40.41	0.23
WIG-FTSE	-4.32	10	0.48 885	-4.10	0.45	-33.42	0.45
WIG-CAC40	-5.51**	10	0.24 438	-4.72	0.23	-42.51	0.23
Model R/S							
WIG-S&P500	-4.76	10	0.51 958	-3.96	0.50	-31.62	0.51
WIG-DAX	-5.06*	10	0.47 881	-4.44	0.50	-38.62	0.50
WIG-FTSE	-4.26	10	0.41 770	-4.07	0.43	-32.78	0.43
WIG-CAC40	-4.95	10	0.50 925	-4.48	0.49	-41.10	0.23

Note: **, * denotes significance at the 1% and 5% level. Critical values are taken from Gregory, Hansen (1996). Model specifications denote: C – level shift, C/T – level shift with a trend, R/S – shift in intercept and in slope (see Section 5.3).

The Gregory-Hansen test shows that the Czech market shares a long-run relationship with the French market, not detected by the Engle-Granger test, with the break estimated to happen on July 21, 1995. The timing of the break seems to be associated with the general downturn that the CE markets experienced in 1995, triggered

by the negative sequences of Mexico's currency crisis at the end of 1994. In particular, the Czech stock market index, PX50, plummeted by around 30 % by July of that year. There is also weak evidence in favor of a link with the US market, with the null hypothesis of no cointegration rejected at the 10 % significance level.

Table 5.4: Results of the Gregory-Hansen test: Czech Republic – Developed Markets

Indices	ADF*	Lag	Break point/ Observ. num.	Phillips Zt*	Break point	Phillips Za*	Break point
Model C							
PX50-S&P500	-3.76	9	0.45 836	-3.65	0.15	-23.54	0.15
PX50-DAX	-4.02	9	0.41 761	-3.67	0.15	-23.62	0.15
PX50-FTSE	-3.79	9	0.41 761	-3.65	0.15	-23.55	0.15
PX50-CAC40	-4.01	9	0.48 895	-3.66	0.15	-23.57	0.15
Model C/T							
PX50- S&P500	-4.34	10	0.64 1189	-4.21	0.64	-29.58	0.65
PX50-DAX	-4.21	9	0.64 1188	-4.28	0.64	-31.27	0.64
PX50-FTSE	-4.29	2	0.72 1337	-4.24	0.64	-30.02	0.64
PX50-CAC40	-4.04	8	0.63 1178	-4.32	0.65	-31.24	0.64
Model R/S							
PX50- S&P500	-4.78	7	0.15 287	-4.74	0.15	-36.92	0.15
PX50-DAX	-4.57	10	0.15 279	-4.41	0.15	-39.60	0.15
PX50-FTSE	-4.02	10	0.62 1147	-3.90	0.21	-27.44	0.21
PX50-CAC40	-5.28*	7	0.15 284	-5.31*	0.15	-44.64	0.15

Note: **, * denotes significance at the 1% and 5% level. Critical values are taken from Gregory, Hansen (1996). Model specifications denote: C – level shift, C/T – level shift with a trend, R/S – shift in intercept and in slope (see Section 5.3).

Notably, results of the Gregory-Hansen test shown in Table 5.5 reveal linkages between the Hungarian market and those of Germany, France, and the USA, none of which is found by the Engle-Granger procedure (break dates: July 23, 1998, June 2, 1998,

and April 7, 1998). This result is in line with the findings of Scheicher (2001) who documents the pivotal influence of global factors on the Hungarian stock market, due to the significant involvement of international investors in this market.⁴⁷ Additionally, Gelos and Sahay, 2000, report a drastic increase in short-term correlations that the Hungarian market display with the U.S. and European stock markets in the period between the Asian crisis in June 1997 and the Russian downturn of August 1998. The dates of the breaks, therefore, most probably reflect global financial turmoil. Noteworthy, estimated structural changes in relationships shared by the CE markets most often take place in 1997 and 1998, i.e., in periods of financial distresses that plagued all emerging markets, suggesting that the higher extent of their integration with the global environment is associated with the increasing exposure to external shocks.

Table 5.5: Results of the Gregory-Hansen Test: Hungary – Developed Markets

Indices	ADF*	Lag	Break point/ Observ. num.	Phillips Zt*	Break point	Phillips Za*	Break point
Model C							
BUX-S&P500	-3.44	9	0.31 581	-3.43	0.32	-28.81	0.33
BUX-DAX	-3.69	1	0.31 585	-3.66	0.32	-32.84	0.32
BUX-FTSE	-3.41	7	0.32 591	-3.38	0.33	-27.51	0.33
BUX-CAC40	-3.37	9	0.32 594	-3.32	0.33	-30.00	0.33
Model C/T							
BUX-S&P500	-4.55	0	0.53 980	-4.92	0.54	-48.19*	0.54
BUX-DAX	-3.99	1	0.52 974	-4.13	0.51	-35.30	0.51
BUX-FTSE	-4.11	7	0.53 980	-4.03	0.51	-35.40	0.54
BUX-CAC40	-3.52	9	0.32 594	-3.46	0.32	-30.97	0.33
Model R/S							
BUX-S&P500	-4.25	0	0.52 976	-4.19	0.52	-36.26	0.52

⁴⁷According to the estimates, foreign investors are in approximately 70 % of trading in Budapest Stock Exchange, 30 % in Polish and a very modest percentage in Czech market (Hanousek and Filer (2000)).

BUX-DAX	-5.63**	1	0.51 949	-5.76**	0.50	-69.88**	0.50
BUX-FTSE	-3.71	7	0.50 920	-3.68	0.49	-31.40	0.49
BUX-CAC40	-5.50**	1	0.49 916	-5.41*	0.49	-65.27**	0.49

Note: **, * denotes significance at the 1% and 5% level. Critical values are taken from Gregory, Hansen (1996). Model specifications denote: C – level shift, C/T – level shift with a trend, R/S – shift in intercept and in slope (see Section 5.3).

5.4.4. Re-estimating Cointegration Vectors and Vector Error Correction Models

Having estimated the break dates, we proceed with the estimation of the cointegration vectors for those markets for which the null hypothesis of cointegration was rejected by the Gregory-Hansen test using the fully modified OLS estimators of Phillips and Hansen (1990). We aim to illustrate the changes in the parameters of the equilibrium relationships over the course of time. The results of FM OLS estimates are shown in Table 5.6. As can be observed, significant changes took place in the magnitude as well as in the sign of the intercepts (as well as in some cases in slopes) of the cointegration equations.

Table 5.6: FM-OLS Estimates of the Cointegration Vectors for the CE Markets before and after the Estimated Break Point

Indices	Estimated Break Date	Estimates before the break		Estimates after the break	
		slope	constant	slope	constant
WIG – BUX	12.06.97	0.49 (0.08)	2.38 (0.26)	0.85 (0.14)	0.92 (0.54)
WIG – PX50	02.09.96	0.99 (0.45)	1.29 (1.22)	0.79 (0.13)	2.07 (0.34)
PX50 – WIG	09.06.99	-0.07 (0.62)	2.97 (2.56)	1.10 (0.11)	-1.97 (0.44)
PX50 – BUX	09.06.99	-0.03 (0.19)	2.81 (0.67)	1.26 (0.24)	-2.21 (0.94)
BUX – WIG	09.05.97	1.84 (0.28)	-4.07 (1.13)	1.13 (0.16)	-0.89 (0.67)

Indices	Estimated Break Date	Estimates before the break		Estimates after the break	
		slope	constant	slope	constant
CE markets as group					
WIG-BUX-PX50	12.06.97	-0.27	6.18	-0.53	7.46
		(0.09)	(0.58)	(0.06)	(0.35)
BUX-WIG-PX50	09.05.97	-0.50	8.10	-0.62	6.51
		(0.09)	(0.75)	(0.06)	(0.34)
		-0.67		-0.48	
		(0.13)		(0.06)	
		-0.65		-0.40	
		(0.13)		(0.06)	
WIG – Developed Markets					
WIG – S&P500	17.06.98	1.02	1.20	1.09	0.82
		(0.36)	(1.00)	(0.28)	(0.85)
WIG – DAX	23.02.96	3.02	-6.12	-0.14	4.72
		(2.49)	(8.31)	(0.12)	(0.45)
WIG – CAC40	22.03.96	4.99	-12.95	-0.13	4.67
		(0.67)	(2.28)	(0.12)	(0.45)
PX50 – Developed Markets					
PX50 – CAC40	21.07.95	5.83	-16.99	-0.21	3.47
		1.59	(5.38)	(0.15)	(0.57)
BUX – Developed Markets					
BUX – S&P500	23.07.98	2.62	-3.94	0.86	1.19
		(0.44)	(1.26)	(0.41)	(1.26)
BUX – DAX	03.06.98	1.86	-2.91	0.29	2.77
		(0.61)	(2.11)	(0.20)	(0.74)
BUX – CAC40	07.04.98	3.61	-9.03	-0.13	4.37
		(0.40)	(1.39)	(0.20)	(0.78)

Note: Model specification taken includes constant. Standard errors of the estimates are denoted in the parentheses. The equations are estimated for those markets for which Gregory-Hansen test rejected the null of no cointegration.

To complement the evidence on cointegration relationships, we model more stable relationships by estimating error-correction model allowing for two regimes, separated by the break point estimated by the Gregory-Hansen test. This allows us to obtain a model that is more appropriate to the data generating process. Starting with a generic ECM with five lags we finished with ECM (1,1) except for one case. The error correction models are estimated in two steps using the previously estimated residuals. The t-statistics of the error correction term may serve as an additional test-statistic for the hypothesis about the presence (absence) of cointegration. We do not report the tables here, but it is available upon request. For the emerging markets in the bivariate setting, with one exception, the

error-correction term is found to be negative and statistically significant. For the pairwise setting with the mature markets only for the relationship between the Hungarian and French, and the Hungarian and German stock markets, the coefficient of the error-correction term is on the border of significance. Only in three out of all cases is the coefficient of the equilibrium error not significant, which could be imputed to the fact that rejection of the null in the Gregory-Hansen procedure might be caused by a stable cointegration relationship. For the purpose of comparison, we also estimate ECM, which does not assume a break in the data. Indeed, for the group of the three developing markets the error correction term is highly significant in conventional ECM; notwithstanding, for more cases the coefficient estimate of the error-correction term is found to be higher significant in the two-regime ECM.

5.5. Conclusion

Several investigations show that ignoring eventual structural may affect the power of conventional cointegration tests and the relevance of conclusions regarding the presence (absence) of cointegration. Subsequently, recent studies incorporated structural change into cointegration methodology. We implement the new procedure for the price series of the three most advanced emerging stock markets in Central Europe. These markets have not undergone as much scrutiny as their counterparts in other regions and the available evidence on their links with the mature markets generated a great deal of controversy. We carry out the Gregory-Hansen residual-based test for cointegration, which explicitly accounts for a structural break in the cointegration relationship, for the CE markets and four mature stock markets and investigate whether the new methodology provides additional evidence on the presence of long-run relationships that the one furnished by the conventional cointegration tests. Our results are based on daily data for stock market indices for the period September 1993 – April 2002.

In fact, the Gregory-Hansen test detects several equilibrium relationships omitted by the conventional cointegration testing procedures. Namely, additional cointegration vectors have been revealed; one of them – within the group of emerging markets, and the other five – between the developing and mature markets. Furthermore, our results show that common long-run relationships do not vanish after a structural change had occurred.

Statistically significant estimates of the error-correction term coefficient in the two-regime error-correction models only strengthen the evidence in favor of cointegration. The presence of equilibrium relationships is likely be attributed to the growing exposure of the CE markets to foreign capital flows.

Our findings suggest stronger evidence in favor of significant long-run relationships shared by the CE markets within the region and globally than was previously reported and support the hypothesis that the markets of Central Europe have become increasingly integrated with the world markets. This evidence implies reduced benefits for international investors who seek to diversify in these emerging markets over the long run.

Chapter 6: Conclusion

The Polish stock market was re-established in 1991 as a result of financial reform and since then has turned into one of the most dynamically developed markets in Central and Eastern Europe. This thesis presents four self-contained essays shedding more light on institutional and regulation factors that influence stock returns in the Polish stock market, which were omitted by previous studies. The factors considered include: trading by institutional investors; regulation of the trading mechanism; interaction with the other CEE emerging and developed European and US markets.

The first essay entitled “Institutional Traders’ Behavior in an Emerging Stock Market: Empirical Evidence on Polish Pension Fund Investors” investigates trading by pension funds and attempts to estimate the extent of herding and positive feedback trading, which may destabilize security prices. Due to strict investment rules, one would expect that Polish pension funds are intensively engaged in this type of trading behavior. Using Lakonishok-Shleifer-Vishny (1992) herding and positive feedback trading measures allows us to directly compare the extent of herding and positive feedback trading in Polish pension fund market with the values of the measure reported by the earlier studies on mature stock markets. Indeed, the values of the obtained point estimates for Polish pension funds are higher than values of herding measures reported in the previous studies. We attribute these findings to specific regulatory provisions, i.e. peer-based relative performance evaluation, penalty structure, and the high concentration in the Polish pension fund industry. Our findings strongly support the presence of substantial herding by Polish pension fund investors, especially for small size stocks and stocks of particular industries. It also emerges from our study that Polish pension fund managers use positive feedback trading strategies, actively selling stocks of smaller firms that performed poorly in the previous period and acquiring well-performing stocks with large capitalization. We do not, however, find that herding and positive feedback trading by the institutions has a significant effect on future stock prices.

The second essay entitled “Stock Market Prices and Institutional Trades: Evidence on Trading by Pension Funds in Poland”, analyzes the effects of pension fund trading on aggregate stock returns. We document a strong positive relation between the flows from Polish pension funds and concurrent stock market returns of the two major

stock market indices, WIG and WIG20. It appears that the trading by the four largest pension funds is responsible for the detected price effect. Our results lend support to the common belief expressed by the Polish stock market observers about the sound impact that pension funds exert on contemporaneous domestic stock prices. We estimate that increase in the value of flows by one standard deviation would cause increase in WIG by 0.07 points and in WIG20 by 0.09 points. However, the detected returns-flows relationship does not appear to persist over time, at least for larger stocks. There is some evidence that institutional trading has more stable effect on the returns of smaller stocks listed in MIDWIG, however, it is only weakly significant. The analysis also indicates that pension funds are sensitive to the market movements as there is a strong positive relationship between the institutional demand and contemporaneous market returns.

The third essay, “Price Limits on a Call Auction Market: Evidence from the Warsaw Stock Exchange”, focuses on the impact of specific regulation of the trading mechanism, price limits, on the daily stock return volatility and autocorrelation in the Polish stock market. This study, focusing on the call auction segment of the WSE with one daily auction, is the first attempt to analyze a call auction market with low trading frequency. Since call auctions provide time-out periods between periodic market clearings, we expect that price limits do not provide additional benefits in terms of reduced volatility and reversed overreaction of stock prices. Our empirical results confirm this conjecture. We find strong evidence in favor of volatility spill-overs to the day after a price limit hit. We also discover strong autocorrelation induced by both upper and lower limit hits. Autocorrelation coefficients on the day subsequent to a limit move are .62 for upper limit hits and .37 for lower limit hits. Our empirical findings unequivocally suggest that price limits in the call auction system of the WSE merely delay price adjustment and cause volatility spill-overs. If the aim of their imposition were to curb overreaction and panic in periods of large price fluctuations, the results indicate that they fail to achieve it. Other potential benefits (such as substitutes for higher margin requirements and the protection against insider trading and price manipulation) are also doubtful in this particular trading structure.

Finally, the last essay entitled “Polish Equity Market Integration with the Emerging European and Developed Markets: A Cointegration Analysis with Shifting

Regimes” investigates the incidence and pattern of the long-run linkages between the Polish and the two CE emerging and four mature markets. We carry out the Gregory-Hansen residual-based test for cointegration, which explicitly accounts for a structural break in the cointegration relationship and is considered superior to the conventional cointegration tests as it allows us to model the time-varying structure of the market interrelations. In fact, the Gregory-Hansen test detects several equilibrium relationships omitted by the conventional cointegration testing procedures. Furthermore, the results of the test demonstrate that long-run relations do not vanish after a structural change had occurred. Modelling long-run relations within the two-regime error-correction models, we obtain significant estimates of the error-correction term coefficient that strengthen the evidence in favor of cointegration. The presence of equilibrium relationships is likely be attributed to the growing exposure of the CE markets to foreign capital flows. Our findings suggest stronger evidence in favor of significant long-run relationships shared by the CE markets regionally and globally than was previously reported and support the hypothesis that the markets of Central Europe and Poland in particular have become increasingly integrated into the world markets. This evidence implies reduced diversification benefits for international investors.

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