Trading System and Market Integration

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Summary

Two markets are perfectly integrated if one cannot construct two portfolios, one from each market, which have identical payoffs but different prices. Real markets are in general not perfectly integrated, due to trading frictions which limit arbitrage activity. Possibly one of the most important trading frictions is the trading system of the market itself. In this paper, we empirically analyze the impact of the trading system on the integration of markets. Our main hypothesis states that screen trading markets are more closely linked that floor trading markets because arbitrage strategies can be carried out more rapidly. We formalize this hypothesis by focusing on several possible measures of market integration. The empirical results provide strong evidence that screen trading leads to higher market integration than floor trading, although this difference in market integration is not found to be arbitrage induced.

Résumé

Deux marchés sont dits parfaitement intégrés lorsqu´il est impossible de construire deux portefeuilles, un par marché, tels que leurs rendements soient différents et leurs prix identiques. Les marchés réels ne sont en général pas parfaitement intégrés à cause de frictions limitant les possibilités d´arbitrage. Le mode même du système d´échange constitue une possible importante source de friction. L´objet de cet article est d´analyser impriquement l´impact du système d´échange sur l´intégration du marché. La principale ambition est de montrer que les marchés informatisés sont plus intégrés que les marchés à la criée, à cause de la plus grande rapidité d´exécution des arbitrages. Les résultats empiriques soulignent une plus grande intégration des marchés informatisés que les marchés à la criée; cependant, cette intégration n´est pas induite par l´arbitrage.

Keywords

Market integration, trading system, time series analysis.

Mots clefs

Intégration du marché, système d´échange, séries temporelles.

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I. Introduction

Financial markets are called integrated if investors consider the instruments traded in these markets as substitutes and therefore prices tend to move together. For instance, rising bond prices often lead to a subsequent increase in stock prices. Other examples include the international linkage of stock markets, which was particularly pronounced during the stock market crash of 1987, and the connection between the prices of a derivative and its underlying.

The degree of integration between two markets is of considerable interest for investors, as closely integrated markets offer new - potentially valuable - trading strategies. Firstly, investors can decide on which market to trade on a given information, in order to minimize personal trading frictions like transaction costs or market entry restrictions. Secondly, investors may exploit information by trading on both markets simultaneously instead of acting in one market only, so that market impact costs are diminished. Thirdly, integrated markets offer hedging opportunities, since a long position in one market can be hedged by building up a short position in the other market. Finally, market integration may reduce investors´operating costs, as only one market needs to be monitored instead of all. The trading strategies just described, however, create additional risk for investors, since the price relation between markets may change over time. The higher the degree of market integration, the more the prices in two markets move together, and the lower the risk.

Market integration results from the trades of all market participants. If, for example, speculators view two markets as substitutes, their trading leads to market integration. An especially high degree of market integration is to be expected if price differences between markets allow for arbitrage trades. When markets are frictionless and arbitrageurs behave competitively, arbitrage trading even assures that the law of one price holds. In this case, the assets traded on different markets are identical in an economic sense, and markets are perfectly integrated. In real markets, however, arbitrage trading is limited by market fricitions leading to imperfect integration.[1] Possible trading frictions include trading costs, order execution lags, and delayed information dissemination. Trading costs reduce the willingness of investors to trade, order execution lags increase the risk of trading, and delayed information dissemination prevents investors from trading since the market does not provide the necessary information.

All of these trading frictions are related to the trading system employed on each market. The trading system strongly influences the costs of running an exchange, which have to be covered by the explicit transaction costs of the investors. Furthermore, the trading system determines how much time it takes to route and execute an order, and how rapidly information from the market is transmitted to the investors. For all of these reasons, the trading system can be expected to have a strong impact on the integration of markets.

Two competing trading systems are the traditional floor and the computerized trading system. In the floor trading system, orders are executed by traders which are physically present at the exchange. In a fully computerized trading system, investors enter their orders into a computer network which matches orders automatically and disseminates the relevant information. During the last years, computerized trading systems have been established in many markets. The success of these systems is attributed to lower transaction costs, faster order execution and accelerated information dissemination.[2] These features of screen trading should increase arbitrage efficiency and, consequently, market integration. The main hypothesis of our study can be stated as follows:

Screen trading leads to a stronger market integration as compared to floor trading.

It is the aim of the paper to test this hypothesis empirically. Empirical evidence builds a basis for the theoretical debate on the advantages of computerized trading systems. To isolate the impact of the trading system on market integration we need two instruments A and B which are identical in all respects except for the trading system. In addition, we need a third instrument C traded on a market which is potentially integrated with those of A and B. When these data sets are available, the integration between A and C can be compared with the integration between B and C. Any discrepancy in market integration reflects the different trading systems for A and B.

Data of the German stock index DAX and the DAX futures is ideally suited in this respect. DAX futures are traded in continuous auctions at the fully computerized German Futures and Options Exchange DTB. The stocks underlying the DAX index (DAX stocks) are floor traded at the Frankfurt Stock Exchange as well as screen traded in the electronic IBIS trading system. The DAX stocks are the most liquid ones traded in Germany and account for about 85 % of total trading volume in stocks. About 35 % of the trading in DAX stocks is executed via the IBIS system and most of the remainder via the Frankfurt Stock Exchange.[3] Therefore, both trading systems show a comparable high liquidity. In addition, market organization (auction versus market maker system) and trading frequency (continuous versus batch trading) are very similar. In both systems, trading takes place in continuous auctions.[4]

We compare the integration between (screen traded) DAX futures contracts and the IBIS-DAX constructed from prices of screen traded stocks with the integration between (screen traded) DAX futures contracts and the FLOOR-DAX based on stock prices from the floor of the Frankfurt Stock Exchange. Possible differences in the degree of market integration can be attributed to the different trading systems in the stock market since market organization, trading frequency and market liquidity are similar in floor and screen traded stock markets.

Our hypothesis was that IBIS-DAX and DAX futures are more closely related for two reasons. Firstly, the efficiency of arbitrage is increased by screen trading as discussed above. Secondly, screen traded stocks and screen traded futures are closer substitutes for speculators than floor traded stocks and screen traded futures as the market trading systems are more similar.

The empirical results provide strong evidence in favor of the main hypothesis that screen trading leads to higher market integration than floor trading. Such a difference in market integration is not found to be arbitrage induced. This finding suggests that different trading strategies of speculators may be the reason for different market integration. However, this topic is not pursued further at this stage, but needs to be examined in the future.

The remainder of the paper is organized as follows. In Section II, the concept of market integration is formalized, and different measures of market integration are discussed. Section III contains the data description. In Section IV, the degree of market integration between spot and futures markets is estimated for IBIS-DAX and FLOOR-DAX data. The main hypothesis of the paper is tested using the measures of market integration detailed in Section II. Section V summarizes the main findings and makes conclusions.

II. Measurement of market integration

Two markets are integrated if the prices in these markets move together. This idea of price comovement can be formalized by means of the correlation between the returns in each market. As Stoll and Whaley (1990) show, perfect market integration implies that the return in one market is perfectly positively correlated with the simultaneous return in the other market. This leads immediately to the first measure of market integration.

Measure 1: The spot-future market integration can be measured by the correlation coefficient between simultaneous returns in the markets. The higher the correlation coefficient, the stronger the market integration is.

If returns in one market are not autocorrelated, another consequence of perfect market integration is the absence of cross-correlations, i.e. returns in one market are uncorrelated with lagged returns in the other market.

The return correlations reflect the trading decisions of all market participants, though these trading decisions are not modeled explicitly. Therefore, Measure 1 has the desirable characteristic that it does not rely on the validity of any underlying trading model. This advantage, however, comes at the cost that Measure 1 cannot distinguish between market integration being induced by speculation or arbitrage.

The measures discussed next allow for such a refined view on market integration, but they rely on trading models. In a recent paper, Chen and Knez (1995) formalize the concept of market integration in a very general setting allowing for several markets and many instruments in each market. The central idea of their approach is that markets are more strongly integrated the smaller the absolute differences in risk adjusted returns per time interval. In fully integrated markets, the risk adjusted returns are equal, and the markets serve as perfect substitutes for investors.

The integration between DAX and DAX futures could be measured by following the approach of Chen and Knez (1995). This is not done here for two reasons. Firstly, statistical inference for the measure of Chen and Knez (1995) has not as yet been developed. Therefore, it is impossible to judge the significance of any difference found between the integration measures for screen and floor trading markets. Secondly, the problem analyzed here is a special case of Chen and Knez (1995), which allows one to put more structure into the trading model. Only the integration between two markets with one instrument in each is examined. Since these instruments are the futures contract and its underlying, they are known to have identical prices at maturity of the futures contract. Therefore, arbitrageurs are supposed to maintain market integration. For arbitrageurs, risk adjusted returns, which underlie the Chen-Knez-approach, are of minor interest. Arbitrageurs can build up opposite positions in the spot and futures markets, carry these positions until maturity of the futures contract and gain riskless arbitrage profits. Therefore, the trading decision of arbitrageurs is based on the mispricing between spot and futures market, but not the risk adjusted returns in each market. This assumption concerning arbitrage trading underlies the first measure of arbitrage induced market integration which is developed below.

Let $S(t)$ be the price of the DAX portfolio at time t and $F(t,T)$ the simultaneous price of a portfolio consisting of DAX futures and bonds with maturity T.[5] This portfolio is constructed in such a way that its payoffs are identical to those of the index portfolio until T. At maturity, index futures are settled at the price $S(T)$, implying that $F(T,T)=S(T)$ holds. Neglecting transaction costs, arbitrage opportunities occur whenever $S(t)\neq F(t,T)$. The arbitrage profit per trade is given by the absolute value of the mispricing $X(t,T)\equiv F(t,T)-S(t)$. This value, $|X(t,T)|$, provides the second measure of market integration.

Measure 2: The spot-future market integration can be measured by the absolute mispricing between spot and futures markets. The smaller the absolute mispricing, the stronger the market integration is.[6]

The measure of arbitrage induced market integration just discussed is based on attainable profits of arbitrageurs following a simple cash-and-carry trading strategy. Attainable arbitrage profits, however, just indicate arbitrage opportunities, but do not reveal whether arbitrageurs actually trade and maintain market integration.

In order to overcome this disadvantage, the individual arbitrage trading model has to be extended to an equilibrium approach which provides insights into the impact of arbitrage trading on observable prices. Garbade and Silber (1983) develop such an equilibrium model of future and spot markets in order to analyze the lead lag relation between corresponding prices. In their approach the interaction of speculators and arbitrageurs leads to the following equilibrium price equations:

$$\Delta S^*(t)=a\,X^*(t-1)+u_S(t) \quad (1)$$

$$\Delta F^*(t,T)=b\,X^*(t-1,T)+u_F(t) \quad (2)$$

where $\Delta S^*(t)\equiv ln[S(t)]-ln[S(t-1)]$ and $\Delta F^*(t,T)\equiv ln[F(t,T)]-ln[F(t-1,T)]$ are the continuously compounded returns, and $X^*(t-1,T)\equiv \ln[F(t-1,T)]-\ln[S(t-1)]$ denotes the mispricing, measured as the difference between logarithmic prices. The error terms $u_S(t)$ and $u_F(t)$ are serially uncorrelated, identically and normally distributed, but may be contemporaneously correlated with each other. The parameters a and b are constant with $a \geq 0$ and $b \leq 0$. They determine how much of the mispricing is reflected in the subsequent spot and futures returns. If $a > |b|$, the spot market leads the futures market, since a stronger price adjustment occurs in the spot market. The overall price adjustment, $\mu \equiv a + |b|$, can be viewed as an arbitrage induced measure of market integration. It equals zero when arbitrageurs do not trade and converges to 1 when there is unlimited arbitrage trading as soon as a mispricing appears.[7] The higher the parameter μ is, the higher the expected reduction of mispricing between time $t-1$ and t by price adjustments in both markets. This can be easily seen by deriving the equilibrium mispricing process from equations (1) and (2). The mispricing change is defined as

(3) $$\Delta X^*(t,T) \equiv \Delta F^*(t,T) - \Delta S^*(t),$$

which directly leads to the equilibrium mispricing process

(4) $$\Delta X^*(t,T) = -\mu X^*(t-1,T) + u(t)$$

where $u(t) \equiv u_S(t) + u_F(t)$. From a statistical point of view, μ is the mean reversion parameter of the mispricing process. If μ is greater than zero, the spot and futures markets are cointegrated in the notion of Engle and Granger (1987), i.e. the mispricing can not grow without bounds but shows a tendency to revert to its mean value of zero. Cointegration between spot and futures markets is a minimal requirement for two markets to be termed integrated in an economic sense. Moreover, the more arbitrageurs trade on a given arbitrage opportunity, forcing μ to increase, the stronger the market integration should be. The value of the mean reversion parameter, μ, serves as the third measure of market integration.

Measure 3: The spot-future market integration can be measured by the mean reversion of the mispricing between spot and futures markets. The higher the mean reversion parameter, μ, the stronger the market integration is.[8]

In Section IV, the three market integration measures just described are estimated for IBIS-DAX and FLOOR-DAX data. Measure 1 records the overall integration between spot and futures markets reflecting the trades of all market participants. Measures 2 and 3 provide additional insights by catching only the market integration resulting from different arbitrage trading strategies. Based on the different measures, it will first be tested as to whether spot-futures′ market integration differs for screen and floor traded stocks, and second whether any discrepancy in market integration results from different arbitrage trading.

III. Data Description

This study is based on data of the German Stock Index DAX and DAX futures. The index consists of 30 major German stocks, selected with respect to high market capitalization, turnover and early availability of opening prices. DAX stocks are floor traded at the Frankfurt Stock Exchange between 10:30 a.m. and 1:30 p.m., where the index value is calculated once a minute based on the most recent transaction prices. Alternatively, stocks can be traded on the fully computerized IBIS trading system from 8:30 a.m. to 5:00 p.m.. Trading of DAX futures contracts takes place on the computer exchange German Futures and Options Exchange (DTB) between 9:30 a.m. and 4:00 p.m..

The spot data set consists of all DAX levels reported from the Frankfurt Stock Exchange, the main floor trading stock exchange in Germany, and from the IBIS system over the sample period 17/12/1993 to 15/9/1994, which is the time interval between the maturity dates of the December-93 and the September-94 futures contracts. IBIS-DAX values are available on a minute by minute basis, but only for those subperiods of a trading day when the Frankfurt Stock Exchange is closed. Since the closing time at the Frankfurt Stock Exchange differs slightly from day to day, we obtain a different number of FLOOR-DAX values each trading day. To avoid this, all FLOOR-DAX levels obtained after 1:30 p.m. are discarded. The futures data set contains all time stamped bid and ask quotes for the futures contract with the shortest time to maturity.[9] The nearby contract is used, as it shows the highest liquidity. The futures midquote is calculated as the arithmetic mean of bid and ask futures quotes, and the effective midquote is assigned to each DAX value. To avoid possible biases at the beginning of a trading session, observations within the first fifteen minutes after the opening of the Frankfurt Stock Exchange or the DTB are excluded from the data set. In summary, for each of 168 trading days, minute by minute observations within the following time windows are used in the study:

9:45 a.m. – 10:30 a.m.: IBIS-DAX and Future
10:45 a.m. – 1:30 p.m.: Floor-DAX and Future
1:45 p.m. – 4:00 p.m. : IBIS-DAX and Future

In order to construct spot equivalent portfolio values, $F(t,T)$, as described in Section II, all futures midquotes $f(t,T)$ are corrected for the net holding costs of the corresponding index portfolio using the following formula:

$$(5) \qquad F(t,T) \equiv f(t,T) \cdot e^{-r(t,T)\cdot(T-t)}$$

In equation (5), $r(t,T)$ denotes the annual riskless rate of return for an investment from time t to T and $T-t$ is the time to maturity of the futures contract measured in years. For the calculation of the spot equivalent futures price in (5), daily money market rates with maturities of one day, 1 month and 3 months are used.[10] Matching maturities are achieved by linear interpolation of the nearest available rates. Finally, continuously compounded 1 minute returns are calculated as:

$$(6) \qquad \Delta S^*(t) \equiv ln[S(t)] - ln[S(t-1)]$$

$$(7) \qquad \Delta F^*(t,T) \equiv ln[F(t,T)] - ln[F(t-1,T)]$$

Overnight returns as well as IBIS returns for the period 10:30 a.m. to 01:45 p.m. are discarded, i.e. each observation in the return series refers to a 1 minute return. Given the data, the highest possible observation frequency is one minute. This frequency is used in the study since longer time intervals may not be suited to capture the impact of arbitrage trading on market integration.

One problem encountered in the analysis of high frequency index data is the infrequent trading effect. Since the DAX is calculated from the most recent transaction prices of the constituent stocks, the reported index value becomes stale if the stocks are not traded simultaneously. As a result, the observed index does not reflect the true value of the underlying stock portfolio. Consequently, infrequent trading introduces a spurious positive autocorrelation into observed index returns, caused by delayed trading of some of the component stocks. Table 1 provides the autocorrelations ($\hat{\rho}$) of FLOOR-DAX and IBIS-DAX returns with lags of up to ten minutes.[11]

Table 1: Autocorrelations of the DAX returns.

	FLOOR-DAX				IBIS-DAX			
Lag	**Obs**	$\hat{\rho}$	**Stdv**	**t-value**	**Obs**	$\hat{\rho}$	**Stdv**	**t-value**
1	27552	0.436**	0.020	22.38	29736	0.448**	0.014	31.32
2	27384	0.332**	0.009	38.10	29400	0.286**	0.010	29.52
3	27216	0.222**	0.008	28.79	29064	0.207**	0.009	23.29
4	27048	0.124**	0.014	8.65	28728	0.152**	0.008	18.91
5	26880	0.110**	0.019	5.95	28392	0.111**	0.009	12.88
6	26712	0.040**	0.014	2.79	28056	0.081**	0.008	10.15
7	26544	0.020**	0.008	2.64	27720	0.062**	0.008	7.54
8	26376	0.004	0.008	0.48	27384	0.038**	0.008	4.97
9	26208	-0.005	0.008	-0.62	27048	0.022**	0.008	2.97
10	26040	-0.015	0.008	-1.83	26712	0.020**	0.008	2.43
Significant on a 1% level: **, 5% level: *								

The calculation of standard errors exploits a method proposed by Diebold (1988), designed to take ARCH-effects into account, which are present in the DAX series. The first few autocorrellations are high, reaching values of up to 0.45, and significantly different from zero. This result is a strong indication of stale prices in the index, since the autocorrelation in futures returns, which are not spurious due to infrequent trading, is close to zero for all lags.[12]

Stoll and Whaley (1990) propose a model which corrects the *index returns* for the effects of infrequent trading in order to obtain the unobservable true index returns. In essence, the return series is filtered with an ARMA filter to remove serial correlation. The method of Stoll and Whaley (1990) was recently extended in two respects by Jokivuolle (1995). Firstly, the approach of Jokivuolle (1995) allows for cointegration between true and observed index values and, secondly, enables one to determine true *index levels* instead of *index returns* only. This second point is crucial for studies analyzing the impact of arbitrage trading on prices, since arbitrageurs react to a mispricing between the *levels* of spot and futures markets.

To estimate true index values using the approach of Jokivuolle (1995), an AR(4) model is adopted to the FLOOR-DAX return series and an AR(6) model to the IBIS-DAX return series. The number of lags is chosen with the Information Criterion of Schwarz (1978). After correcting, significant serial correlation remains neither in the FLOOR-DAX nor in the IBIS-DAX returns. In the remainder of the paper we refer to true index values and not to observed index values whenever index levels or index returns are mentioned.

IV. Results

The first measure of market integration suggested in Section II is the correlation coefficient between the contemporaneous returns in both markets denoted by $\Delta S^*(t)$ and $\Delta F^*(t,T)$, respectively. According to (7), the futures return is based on spot equivalent futures prices $F(t,T)$ and $F(t-1,T)$, not on the futures prices $f(t,T)$ and $f(t-1,T)$ directly. One could suspect that calculating futures returns from spot equivalent futures prices introduces some kind of model dependence into the market integration Measure 1. This is not the case, however, since futures and spot equivalent futures prices just differ by a discount factor which does not change during a trading day. Consequently, the discount factors cancel out when intraday returns are calculated, and futures returns based on futures prices or spot equivalent futures prices are identical.

Table 2 reports the simultaneous and lagged correlations between futures and spot returns for both FLOOR-DAX ($\hat{\rho}_F$) and IBIS-DAX ($\hat{\rho}_I$). The numbers in the first column refer to the time period (in minutes) by which futures returns lead spot returns. Positive numbers indicate a lead of the futures market and negative numbers a lead of the spot market. Standard errors are again adapted to take into account ARCH-effects following the lines of Diebold (1988). The significance of the correlation coefficients can be judged from a comparison of the t-values with the quantiles of their asymptotic distribution, which is standard normal. A reliance on asymptotic tests is justified here due to the large number of observations available.[13]

Table 2: Results for Measure 1: Correlations between DAX and Futures returns.

	FLOOR				IBIS						
Lag	**Obs**	$\hat{\rho}_F$	**Stdv**	**t-value**	**Obs**	$\hat{\rho}_I$	**Stdv**	**t-value**	$\hat{\rho}_F - \hat{\rho}_I$	**Stdv**	**t-value**
-5	25872	0.010	0.007	1.39	27048	0.002	0.008	0.31	0.008	0.011	0.72
-4	26040	0.026**	0.008	3.21	27384	0.007	0.008	0.96	0.018	0.011	1.63
-3	26208	0.019**	0.007	2.75	27720	0.015	0.008	1.91	0.004	0.011	0.37
-2	26376	0.049**	0.007	6.62	28056	0.003	0.008	0.37	0.046**	0.011	4.24
-1	26544	0.102**	0.008	13.53	28392	0.054**	0.009	5.98	0.048**	0.012	4.10
0	26712	**0.140****	0.008	17.85	28728	**0.338****	0.017	19.91	**-0.198****	0.019	-10.60
1	26544	0.270**	0.010	27.53	28392	0.344**	0.011	31.84	-0.074**	0.015	-5.04
2	26376	0.197**	0.008	24.89	27720	0.107**	0.009	12.15	0.090**	0.012	7.62
3	26208	0.103**	0.007	14.01	27720	0.050**	0.009	5.71	0.053**	0.011	4.69
4	26040	0.052**	0.007	6.96	27384	0.005	0.008	0.62	0.047**	0.011	4.27
5	25872	0.014	0.008	1.79	27048	0.017*	0.008	2.19	-0.003	0.011	-0.27

Significant on a 1% level: **, on a 5% level: *

Integration Measure 1 is given for IBIS and FLOOR data in the row corresponding to lag 0, which reflects the correlation between contemporaneous returns. For both markets, the measures are significantly above zero but smaller than one. As was to be expected, there is market integration, although not a perfect one. The IBIS correlation of 0.338 lies markedly above the FLOOR correlation of 0.14. The difference between the correlation coefficients shown in column 10 of table 2 is highly significant as can be seen from the corresponding t-value of -10.60. This finding supports the main hypothesis of the paper: Screen trading leads to higher market integration than floor trading.

The results for the lagged correlations point into the same direction. For both IBIS and FLOOR, the futures market shows a stronger lead than the cash market. Similar results are well documented in the literature for different indices and sample periods, as for example in Stoll and Whaley (1990), Chan (1992), and Kempf and Kaehler (1993). The important new insight here is that the lead-lag structure between spot and futures markets is weaker for IBIS returns than for FLOOR returns.

Integration measures 2 and 3 are applied to further determine whether the differences between IBIS and FLOOR market integration indicated by Measure 1 can be attributed to the trading of arbitrageurs. As a second measure, the absolute mispricing is used, which describes the size of arbitrage opportunities in each pair of spot and futures markets. From all mispricing observations, the mean absolute mispricing for FLOOR and IBIS data is estimated.

An important task is to obtain a correct estimate of the standard deviation of the sample mean, since the mispricing series shows high positive serial correlation. The estimator of Newey and West (1987) is applied here, which is consistent even in the presence of autocorrelation. Some complications occur, however, due to the intraday data structure. Since the Newey-West estimator is a weighted sum of all autocorrelations up to a prespecified maximal lag length, each autocorrelation estimate should use only those observations which belong to the same trading day, as was done here. To account for the slow decrease in serial correlation, a maximal lag length as high as 120 is chosen, which refers to a time period of two hours.

Table 3 summarizes the results. A comparison between FLOOR and IBIS indicates that the mean absolute mispricing is higher for the FLOOR, but the difference between be estimates for either pair of markets is not statistically different from zero. Thus, we cannot conclude that screen trading markets offer less potential arbitrage profits than floor trading markets.

Table 3: Results for Measure 2: Absolute Mispricing.

	Mean absolute Mispricing (in Index Points)	**Stdv** (Newey/West, 120 Lags)	**Obs**	**Difference Floor-IBIS**	**Stdv**	**t-value**
FLOOR	3.81	0.213	29063	0.24	0.32	0.75
IBIS	3.57	0.239	26879			

The last measure of market integration focuses on the dynamics of the mispricing series. In this case, it is not the absolute size of mispricing which is measured but how quickly the mispricing reverts to zero. Referring to the model of Garbade and Silber (1983), the integration measure μ is estimated from equation (4) derived in Section II:

$$(4) \qquad \Delta X^{*}(t,T) = -\mu\, X^{*}(t-1,T) + u(t)$$

Model (4) was used by Dickey and Fuller (1979) to devise a test for the presence of a unit root in the underlying time series, i.e. a test whether the parameter μ equals zero. The unit root hypothesis is important for both economical and statistical reasons. Firstly, if the parameter μ equals zero, the difference between spot and spot equivalent futures price does not form a cointegration relationship[14], and the prices could move arbitrarily far apart from each other without being forced to come closer together again. This is hardly compatible with any economic notion of market integration. Secondly, one needs to reject the unit root hypothesis of the mispricing series in order to apply standard inference techniques for the comparison between the $\hat{\mu}$-values of IBIS and FLOOR. Therefore, unit root tests for both mispricing series were carried out. Instead of the Dickey and Fuller (1979) procedure, a test which is due to Phillips and Perron (1988) was carried out.[15] The latter test needs weaker assumptions concerning the error terms $u(t)$, allowing for heteroscedasticity and autocorrelation. Results are reported in Table 4. The mispricing series of both IBIS and FLOOR show highly significant test statistics, which suggests that both series are mean reverting, and that spot and futures markets are integrated to some degree.

Table 4: Results for Measure 3: Mean Reversion of the Mispricing Process.

	Phillips-Perron Test (20 Lags)	$\hat{\mu}$	**Stdv** (Newey/West, 20 Lags)	**Obs**	$\hat{\mu}_{FLOOR} - \hat{\mu}_{IBIS}$	**Stdv**	**t-value**
FLOOR	-9.48**	0.026	0.00222	26712	0.002	0.00265	0.76
IBIS	-12.53**	0.024	0.00144	28726			

Significant on a 1% level: **, on a 5% level: *

A comparison between the integration measures $\hat{\mu}_{FLOOR}$ and $\hat{\mu}_{IBIS}$ reveals no significant difference. The parameter estimated for the FLOOR mispricing series even takes a slightly higher value. As a consequence, the difference in market integration between floor trading and screen trading markets indicated by Measure 1 cannot be attributed to an increased arbitrage trading.

V. Conclusion

This paper deals with the question of whether market integration depends on the trading system in the markets. Based on arguments outlined in the literature the main hypothesis states that screen trading leads to higher market integration as compared with floor trading. This hypothesis was tested using intraday data of screen traded futures and stocks which are both screen and floor traded.

Two main results were obtained in the paper. Firstly, futures and spot prices move together more closely when both instruments are screen traded. This finding supports the main hypothesis of the paper. Secondly, the observed discrepancy in market integration cannot be attributed to different arbitrage trading. This surprising result has two possible explanations, which need to be investigated further. The arbitrage based integration measures may rest on inappropriate arbitrage trading models and thus fail to detect arbitrage induced market integration. Another explanation is, however, that speculators and not arbitrageurs assure the stronger market integration. Speculators who are active in the futures market can easily trade stocks in the IBIS system as both instruments are screen traded. This allows them to switch back and forth between the (screen traded) futures and spot markets whenever the relative prices in the markets change. [16] This substitution strategy is much more difficult to follow using floor traded stocks, since speculators watching the futures screen cannot trade on the floor directly. Therefore, speculators substituting between futures and stocks can be expected to assure a stronger market integration in screen traded markets. This hypothesis is left for further research.

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1 If, for example, stocks of a company are traded at several exchanges, the stock prices usually differ slightly. Rasch (1996), p. 174, reports for German stocks average price differences between different exchanges of up to 2%.

2 For example, Gerke (1993) and Grünbichler, Longstaff and Schwartz (1994) discuss the possible advantages of screen trading.

3 In addition to the Frankfurt Stock Exchange, there are seven regional exchanges in Germany, but all of them account only for a small part of the trading in DAX stocks.

4 For example, see Schmidt (1993) for a brief description of the FLOOR and IBIS trading system.

5 Futures are treated as forwards throughout the paper, i.e. marking to market is neglected. This simplification is expected to have no major influence on the results, since price differences between futures and forwards are generally found to be very small. See e.g. Rendleman and Carabini (1979).

6 In perfectly integrated markets, $|X(t,T)| = 0$ holds for all $t, 0 \leq t \leq T$.

7 For $\mu = 1$, the approach of Garbade and Silber (1983) simplifies to the cost-of-carry-model.

8 In perfectly integrated markets, the measure is not defined, since in those markets $|X(t,T)| = 0$ holds for all $t, 0 \leq t \leq T$.

9 The spot and futures data stems from the German Finance Database, Karlsruhe.

10 The interest data were supplied by the German Finance Database, Mannheim.

11 Note that nowhere in this study lagged observations are used which belong to a different trading day or a different trading period (morning and afternoon for the IBIS-DAX) within a day. This explains the different numbers of observations used for different lags, as shown in Table 1.

12 There is no infrequent trading effect in index futures, as the future trades as a single instrument. None of the first twenty autocorrelation coefficients differs from zero at a 1% significance level. The largest of these coefficients takes a value of 0.02.

13 See columns 2 and 6 of Table 2.

14 This assumes that the spot and spot equivalent futures series are themselves integrated. DAX and DAX futures were tested for a unit root, which could not be rejected on a 5% significance level. The test statistics are omitted here.

15 Critical values for both tests can be found in standard Dickey-Fuller tables, as for instance in Banerjee et al. (1993).

16 See Sutcliffe (1993), pp. 111-113, for trading strategies in index futures and stocks which lead to a comovement of futures and stock prices.