AN EMPIRICAL ANALYSIS OF THE U.S. MARKET FOR INTERNATIONAL EQUITY

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First: August 1998
Current: October 1999

Abstract

This paper investigates the role of U.S. financial markets in global equity trading and research by means of the pricing relationship between American Depositary Receipts (ADR) traded in the U.S. capital markets and corresponding ordinary shares traded in the issuing company's home stock market. Characteristics evaluated include price transmission and dominance/ satellite relationships in price-setting. In addition, the paper provides a unique overview of the ADR market and sheds light on equilibrium relationships between ADRs and underlying ordinary shares. The analyses conducted are based on a representative sample of 614 stocks listed and traded in unsynchronized financial markets during the period January 1, 1996 through January 19, 1998. Observed cointegration across markets leads to a vector error correction model incorporating a short-term adjustment mechanism being the appropriate representation of the data. In addition, the data synchronization problem gives rise to adjustments to the standard model. The standard model is, hence, extended to incorporate synchronous trading, non-synchronous sequential trading, and two types of non-synchronous parallel trading.

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* This paper is an excerpt from my master's thesis at the University of Karlsruhe, Germany. I am Ph.D. student at GSIA, Carnegie Mellon University. I gratefully acknowledge Kenneth C. Abbott and Thomas Daula from Bankers Trust Company, New York. and the support from Citibank, The Bank of New York, and McKinsey & Company. Tobias Kirchner and Torsten Lüdecke from the University of Karlsruhe provided helpful comments. Financial support was received from GSIA (Richard K. Mellon Fellow).

1 Introduction

American Depositary Receipts (ADR) are American securities that represent ownership in non-American companies. The general opinion on Wall Street is that ADRs trade exactly like ordinary shares of the corresponding non-U.S. company.[1] In a bank's risk management system, systematic risk of ADRs is captured usually by representing ADRs as an equivalent number of the underlying shares.[2] Further, in the literature on international finance, ADRs and home market shares are characterized as being either identical or not meaningfully different securities. However, simple statistical measures such as correlation coefficients indicate the opposite. Several questions arise naturally: Do these seemingly identical securities follow a single underlying process or to what extent do the processes differ? How can the interdependence of these processes be described and what are major factors in distinguishing it? What can be inferred about integration and relative importance of the world's capital markets as well as information transmission across markets? In order to answer these questions, we consider and evaluate various aspects of depositary receipts – including institutional features, foreign exchange characteristics as well as country-specific regulation and investment constraints. The remainder of this work is organized as follows. Section 2 gives an overview over literature on American Depositary Receipts and dually-listed securities in general, related to the analysis conducted in this work. Section 3 gives an overview over depositary receipts and elaborates on differences between depositary receipts and underlying securities. The data and methodology utilized are discussed in Section 4. Section 5 presents the results of the comprehensive empirical analysis. Finally, a summary and concluding remarks are provided in Section 6.

2 Literature

The paper unifies earlier research on market-dominance/satellite-relationships and international price transmission, extends them and adds new aspects. Moreover, the extensive sample size allows a representative characterization of the whole ADR market - as of early 1998. Finally, important conclusions about the relative role of the United States in global equity trading and research are

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[1] Interviews with employees of Bankers Trust Company, New York.

[2] As an example, a US$5 million holding of Glaxo-Wellcome ADRs, which are traded on the NYSE, is usually assumed to be equivalent to holding the same amount of Glaxo-Wellcome PLC UK ordinary shares. Ordinary shares, in turn, are represented as holding the local stock market index. Hence, holding Glaxo-Wellcome ADRs or

drawn. The seminal work on dominant-satellite market relationships is Garbade and Silber (1978). Their paper suggests a taxonomy for categorizing relationships between market centers that trade identical securities using intra-day transactions data. If second market and immediately preceding first market transactions have a smaller variance than successive first market transactions, the second market is a satellite of the first market. If they are equal, then the markets are symmetrical. Rosenthal (1983) performs the first efficiency test of the ADR market, a test of intra-market efficiency. He computes serial correlations for a sample of 54 stocks using weekly returns from 1974 to 1978 to test for weak-form efficiency[3] and concludes that the market is weak-form efficient. Kato, Linn and Schallheim (1992) perform a more direct test of the arbitrage between home and ADR prices. For a sample of 67 stocks from three countries with daily returns during 986 to 1988, they estimate the correlation between the dollar-price equivalent of the domestic market share price changes adjusted for bundling of depositary shares into receipts and the ADR price changes. Their tests can not reject that the correlations are equal to unity, and they conclude that no arbitrage strategy can effectively exploit any deviations.

Eun and Shim (1989) investigate the international transmission of stock market movements by estimating a nine-market vector autoregression (VAR) system using daily rates of returns on the stock market indices from the period 1980 to 1985.[4] Eun and Shim find an asymmetry in the interdependence structure of national stock markets, in that innovations in the U.S. are rapidly transmitted to other markets in a clearly recognizable fashion, whereas no single foreign market can significantly explain U.S. market movements. Unfortunately, their analysis is disturbed by omitting an error correction term in the VAR.[5] Karolyi (1993) studies the dynamic return volatility patterns of Canadian and U.S. stocks. He finds that stock price movements originating in the U.S. due to macroeconomic news announcements affect Canadian stocks on a delayed basis of one to two days, especially in the 1981 to 1985 period.[6] Lau and Diltz (1994) examine the transmission of pricing information between the New York and Tokyo Stock Exchanges using opening and closing stock

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ordinary shares both are assumed to be holding the FTSE-100 price index, and only this position is modeled in a bank's risk management system.

[3] Rosenthal found that weak correlations were observed at the weekly level, but for returns cumulated to the monthly level, all correlation patterns dissipated.

[4] They also use impulse-response functions to trace out the dynamic responses of one market to innovations in another.

[5] Note that, formally, their model is mis-specified.

[6] However, this delayed reaction is significantly diminished for cross-listed Canadian stocks and for all stocks in later subperiods from 1985 through 1989.

prices for seven Japanese firms from 1988 through 1989. They employ a four-step instrumental variables procedure and conclude that markets are semi-strong efficient. Harris et al. (1995) use synchronous transactions data for one stock from the NYSE and two regional exchanges to estimate an error correction model. Johansen's test yields two cointegrating vectors, which verifies the expected long-run equilibrium of equal prices across exchanges. The two error correction terms finally indicate that all three exchanges contribute to price discovery. Webb, Officer and Boyd (1995) examine the leading and lagging returns relationship between portfolios of ADRs and of their domestic market shares for the period from 1985 to 1989 using a three-day leading and lagging market index return model. They find evidence that ADRs behave differently than domestic securities by estimating the time structure of the relationship between domestic and U.S. returns. In general, the U.S. market acts as the leading market in equity pricing, since significant negative one-day lag coefficients are found which may capture a correction attributed to mispriced systematic risk characteristics. The linkage is found to be strongest for UK companies cross-listed in New York and weakest for Japan and South African companies.[7] Ben-Zion et al. (1996) examine the interrelations between stocks listed and traded in two international markets. They apply an error correction model (ECM) which incorporates a one-period short run adjustment mechanism to five U.S./ Israel dually-listed stocks using daily data between 1988 and 1993. The problem of unsynchronized trading hours is dealt with by adjusting the error correction term in the ECM. In order to test for unit roots and cointegration, they conduct augmented Dickey-Fuller and Phillips-Perron tests. They find that arbitrage opportunities are generally not available and that the domestic market acts as the dominant market and the foreign market acts as a satellite market.

Karolyi and Stulz (1996) examine covariance dynamics of a portfolio of Japanese ADRs traded on the NYSE and their similarity to the domestic-market Nikkei 225 index.[8] They find that intraday and overnight correlations between the U.S. index and the Japanese ADR portfolio mimick well those between the U.S. index and the domestic-market Nikkei 225 index. Moreover, correlations and covariances are high when markets move a lot, since large index shocks are more likely to be global. Eun and Jang (1997) examine similar patterns in global transmissions of stock returns and

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[7] As the authors mention, the structure of cross-autocorrelations in returns is fundamentally perturbed by the influence of the October 1987 Market Crash, however.

[8] Their sample includes intraday returns and trading volume on the ADRs, the Nikkei 225 and Standard and Poor's 500 stock indexes from 1988 to 1992. To the extent that correlations between returns on securities around the world

volatility between Europe, Japan and the U.S. In contrast to Eun and Shim (1989), they apply a VAR *with* error correction to 56 firms directly listed on all three major stock exchanges, i.e. Tokyo, London, New York, using daily stock returns during the period 1988 through 1990. After constructing equally weighted national portfolios, they conduct Granger causality tests of inter-market stock returns and check for informational efficiency by using impulse-response functions. The main findings are that the firm's home market causes the overseas markets in the Granger sense, that the succeeding overseas market actively contributes to the price discovery but gets little feedback. Interestingly, the returns and volatility shocks are importantly influenced by foreign exchange surprises for cross-listed stocks, in that the home market does not react to an exchange rate shock but the overseas markets respond in such a manner that the pricing parity can be maintained.

The methodology of this paper is closely related to the work of Eun and Shim (1989), Ben-Zion et al. (1996), Eun and Jang (1997), but extends them in a variety of aspects. The technique employed in the first part of the econometric analysis is essentially the same as in Ben-Zion et al. (1996) except that the asynchronous trading model in Ben-Zion et al. (1996) is generalized to a taxonomy of four different models.[9] Granger causality tests conducted in the second part of the econometric analysis are lent from Eun and Jang (1997) but adapted to fit the specific asynchronous trading model applied in this work. Reaming, a statistical measure of the degree of causality is used to characterize asymmetries in dominance/ satellite relationships. The large number of countries and geographical regions allows for cross-comparisons. Further, the analysis is conducted on individual firm level instead of national portfolio level. The sample size – with 614 compared to 56 firms – is representative of the total market. Finally, this work is the first in focusing on institutional as well as conceptual differences between ADRs and underlying ordinary shares. In summary, the paper tries to provide a unique overview of the ADR market, investigate observable equilibrium relationships between ADRs and ordinary shares as well as causality relationships between the U.S. ADR market and foreign stock markets. This leads to conclusions about the role of the United States in global equity trading and research. Factors influencing short-term as well as

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determine the potential for international diversification, their focus is on intraday and overnight return correlation patterns and the fundamental economic factors drive those patterns.

[9] This is due to the fact that 38 countries from five geographical regions instead of one are represented in the analysis.

long-term price differences in the context of ADRs are also investigated. Before presenting empirical results, features that may cause these phenomena shall be discussed.

3 Depositary Receipts

American Depositary Receipts are negotiable certificates issued by a United States bank or trust company.[10] American Depositary Receipts evidence American Depositary Shares (ADS)[11] which, in turn, represent a certain number of deposited ordinary shares of the foreign company. ADR certificates, therefore, represent an ownership interest in a foreign private issuer's securities deposited, usually outside the U.S., with a financial institution as depository.[12] The underlying securities represented by ADRs may be either debt or, more commonly, equity instruments.[13] A typical depositary share represents a single deposited share. However, the ADS, and so the ADR, may be issued in units that represent either a fraction or multiples of the deposited security. Further, ADR certificates are issued in registered form[14] facilitating (i) the payment of dividends to security holders, (ii) the transfer of ownership of deposited securities, and (iii) communication between the foreign issuer and security holders. Owners of the DRs have the right to redeem their DRs and obtain the true underlying shares.[15] ADRs trade in U.S. dollars and the depository makes all dividend payments on the underlying home shares to investors, also in U.S. dollars.[16] ADRs

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[10] Depositary receipts were first introduced in 1927 in response to a law passed in Britain, which prohibited British companies from registering shares overseas without a British-based transfer agent. UK shares were not allowed to leave the UK physically, and so, to accommodate U.S. investor demand, a U.S. instrument had to be created; this was called an American Depository Receipt. ADRs are now used to create domestic access to almost all markets around the world. As of March 1, 1998, a record high worldwide total of 1898 Depository Receipt programs were established representing companies in 70 countries.

[11] The U.S. Securities and Exchange Commission defines a „Depositary Share" as „a security, evidenced by an American Depositary Receipt, that represents a foreign security or a multiple of or fraction thereof deposited with a depositary."

[12] Saunders (1993), p. 49

[13] Ibid.

[14] I.e., registered in the record holder's name on the books of the depositary.

[15] Levich (1998), p. 531. In case of foreign ownership restrictions of foreign shares they have to be sold in the foreign market and the owner receives the cash proceeds. Note that arbitrage of this sort ensures that the prices of the DR and the underlying shares are close.

[16] Depository banks include The Bank of New York, Citibank, JP Morgan, Bankers Trust Company, and Deutsche Morgan Grenfell. They provide custody of collateral, issuance and cancellation of DRs, and stock transfer agency. The U.S. banks, known as the *depository bank*, also performs various shareholder functions; such as receiving and disseminating to the ADR investors information relating to the company's shareholder meetings, financial information, rights and exchange offers and collecting and converting to U.S. dollars the dividend payments and other payments to which the ADR holders are entitled.

may be listed on the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX) or National Association of Securities Dealers Automated Price Quotation System (NASDAQ). Currently, ADRs represent over 10% of NYSE volume and over 9% on AMEX. Depositary receipts have become the predominant vehicle for foreign companies to gain access to a U.S. shareholder base, to raise capital in the U.S., and for international investments of U.S. citizens and institutions.[17] Based on a survey of over 1200 U.S. institutions in 1995 that invest in foreign equities, 70% own DRs and 50% own only DRs.[18] According to Deutsche Morgan Grenfell, 90% of U.S. institutions today hold ADRs.[19]

3.1 Types of DR Facilities

There are several types of DRs, each of which involves a different level of disclosure of information and compliance with the regulations of the Securities and Exchange Commission (SEC). Depositary receipt facilities can be classified along five dimensions: (1) programs placed with (a) only U.S. investors, (b) U.S. investors and other countries' investors not including the firm's home market, and (c) only other countries' investors not including the firm's home market; (2) programs unsponsored versus sponsored by the issuing foreign company, (3) public versus private programs based on where the DRs are traded and (4) non-capital raising versus capital raising based on the objective of the foreign company when establishing the program. In addition, DRs can (5) be either listed on a major exchange or traded over-the-counter. Perhaps the most important distinction for issuers of ADRs is that some structures allow the company to raise capital

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[17] Deutsche Morgan Grenfell (1996), p. 3.1. According to professionals, the primary advantage for investors of DRs relative to a direct investment in the home market shares is cost efficiency. DRs reduce transaction and monitoring costs, provide liquidity, and mitigate investment barriers in foreign countries. They are seen as the most efficient, transparent, cost effective and liquid method for an American investor, both institutionally and individually, to make specific foreign investments. ADRs enable U.S. investors to acquire and trade non-U.S. securities in U.S. dollars without concern for the differing settlement timetables and the problems typically associated with overseas markets, especially securities custody, undependable settlements, confusing tax conventions and currency exchange. Also, they allow investors to buy foreign securities at current market prices, whereas country funds may sell at a premium. Furthermore, they provide non-U.S. companies with access to the U.S. capital markets, the largest investor base in the world. However, ADRs possess all the other problems associated with buying foreign stock rather than domestic stock. ADRs trade in U.S. dollar but bear the foreign currency risk of the firm's cash flows. Limited financial information on the foreign company and exposure to changes in foreign tax policies are important considerations when buying an ADR. In addition, foreign ownership restrictions especially in Asia may prohibit effective international arbitrage and give rise to substantial discounts or premiums on some ADR programs. Liquidity is also often much lower for ADRs than for local shares in their home market. For these and other reasons, DRs and underlying local shares are not identical securities and pricing of these securities can differ depending on the efficacy of international arbitrage.

[18] Karolyi (1998), pp. 5-6

[19] Deutsche Morgan Grenfell (1996), p. 3.1

in the U.S., while others simply provide a mechanism which makes it easy for U.S. investors to buy and trade existing shares. The type of ADR program employed depends on the requirements of the issuer. The five principal types of ADR programs are (1) unsponsored ADRs, (2) sponsored Level-I ADRs, (3) sponsored Level-II ADRs, (4) sponsored Level-III ADRs, (5) Rule 144A ADRs. Global Depositary Receipts (GDRs) are normally treated in the same way as ADRs.[20]

3.2 Mechanics of ADR Transfer

The mechanics of ADR transfer are similar to those utilized in transfers of other U.S. security instruments.[21] The holder of an ADR certificate can (i) transfer the certificate in the United States through endorsement and delivery to the depositary.[22] The depositary, in turn, transfers the ownership of the underlying deposited securities by making an entry on the depository's books.[23] As an alternative to the transfer of a holder's ADR certificates through a depositary in the U.S., upon surrender of ADR certificates to the depositary, the ADR holder may elect either to (ii) receive the deposited shares (underlying) represented by the ADR certificate[24], or (iii) sell the deposited shares in the foreign market (in the case of SEC-registered and most privately placed ADR issues), in which case the foreign shares would be released to the designee of the ADR holder for delivery against payment to close the foreign sale. These three different alternatives of trading ADRs shall ensure that prices of the same company's shares keep aligned across markets by allowing securities traders to conduct effective inter-market arbitrage. Nevertheless, intra-market

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[20] Since the idea was conceived and used primarily in the U.S., these instruments are called *American* DRs. Today, however, DRs can be offered in more than one market outside the issuer's home country. American Depositary Receipts are issued in the U.S., whereas *European* Depositary Receipts are issued in European capital markets like UK and Luxembourg, and *Global* Depositary Receipts are issued in several places. Beside this difference, GDRs and ADRs are identical from a legal, operational, technical and administrative standpoint. Both are U.S. dollar denominated instruments representing ownership in non-U.S. securities, trade and settle according to the same standards, pay dividends in U.S. dollars, and are eligible for book entry settlement. The services provided by the depository bank and the provisions, representations and warranties of the Deposit Agreements are identical.

[21] It is important to note that the record or legal owner of the deposited securities is the depositary (or its nominee). See Saunders (1993), p. 53.

[22] Saunders (1993), p. 53

[23] „Property represented by certificates of stock may be deemed to be held by the company within state whose creature it is," and certificate of stock is not stock itself, but merely evidence of stockholder's interest in the company. Jellenik v. Huron Copper Mining Co., 177 U.S. 1, 13 (1899). See Saunders (1993), note 22, p. 53.

[24] The general instructions to Form F-6 provide: [t]he holder of the ADRs is entitled to withdraw the deposited securities at any time subject only to (i) temporary delays caused by closing transfer books of the depositary or the issuer of the deposited securities or the deposit of shares in connection with voting at a shareholders' meeting, or the payment of dividends, (ii) the payment of fees, taxes and similar charges, and (iii) compliance with any laws or

trading[25] accounts for approximately 95% of all depositary receipt trading, whereas only 5% of trades occur between the U.S. and local markets.[26]

3.3 Depositary Receipts vs. Ordinary Shares

Despite general opinion, depositary receipts and underlying ordinary shares are institutionally and conceptually different in a variety of aspects. By definition, American Depositary Receipts (ADRs) are certificates evidencing American Depositary Shares (ADS), which represent a certain amount of underlying ordinary shares of a foreign company. Thus, both securities, depositary receipts and underlying ordinary shares, represent ownership interest in a foreign issuer.[27] From legal standpoint, „stock itself but also certificates and receipts, such as ADRs and ADS, are securities.“[28] Further, holders of either security are eligible for voting their ownership rights and receiving cash distributions in any form. Thus, both securities are identical from a basic theoretical viewpoint. As we show, depositary receipts and underlying securities are not identical securities in real world. DRs and home market shares differ in a variety of aspects including (i) institutional features, (ii) operational characteristics, (iii) legal and fiscal treatment, and (iv) conceptual understanding. The major differences can be summarized as follows:

(1) From legal standpoint, depositary shares evidenced by ADRs as well as ADRs themselves are „securities, separate and apart from the deposited shares they represent.“[29] (2) The underlying deposited shares are securities representing direct ownership of a company and representing the right to receive the company's future cash flows in the form of dividends and other cash distributions. Depositary receipts, however, are (only) certificates on the ownership of deposited securities. Hence, DRs represent *indirect ownership* and, hence, share some features with country

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governmental regulations relating to ADRs or to the withdrawal of deposited securities. See Saunders (1993), note 24, pp. 53-54.

[25] Intra-market trading is buying and selling existing DRs. Inter-market trading, in contrast, means buying in one market and/ or selling in another market. These two markets usually are the U.S. and the company's local market. Inter-market trading induces the creation and/ or cancellation of DRs, and occurs in times when demand in one market is higher than in the other.

[26] Bank of New York (1997), p. 5

[27] „Property represented by certificates of stock may be deemed to be held by the company within state whose creature it is,“ and certificate of stock is not stock itself, but merely evidence of stockholder's interest in the company. Jellenik v. Huron Copper Mining Co., 177 U.S. 1, 13 (1899). See Saunders (1993), note 22, p. 53.

[28] Section 2(1) of the Securities Act defines a security as „any ... stock[,] ... certificate of deposit for a security, ... [or any] receipt for ... any of the foregoing.“ See Saunders (1993), note 53, p. 58.

[29] See note 28.

funds and derivative securities.[30] (3) As specified in the Deposit Agreement and required by U.S. regulation, DRs may be exchanged for the underlying ordinary shares at all times only subject to temporary delays.[31] Therefore, DRs include an *option to exchange* one asset for another. On the other hand, ordinary shares can be deposited against issuance of DRs.[32] (4) Depositary receipts also differ from home market shares, because they include a *service contract* with the depository. Most of the costs of the embedded service contract is paid for by the foreign private issuer to the depositary in the form of fees – as specified in the Deposit Agreement. Thus, investors profit from the services provided by the depositary without direct paying. Therefore, one could expect that investors are willing to pay a *convenience premium* for DRs compared to ordinary shares. (5) The deposit agreement establishes a contractual relationship between the foreign private issuer and the depositary. Hence, it is very flexible in adapting the rights and responsibilities of the parties. As a consequence, the *contractual features* of ADRs often differ from those of ordinary shares and, second, the ADR holder faces an additional *contract risk*. Examples include that ADR holders under certain circumstances are not eligible to vote their shares and that subscription rights usually are not distributed directly to ADR holders. (6) Furthermore, the name of the custodian holding the ordinary shares represented by depositary receipts and not the holder of the ADR is listed in the ordinary share register of the company on behalf of the depository bank.[33] (7) Depositary receipts trade in the United States according to U.S. regulation, settlement system, and market customs. They are quoted in *U.S. dollars*, trade and settle in U.S. dollars, and pay dividends in U.S. dollars. ADRs are treated as *American securities* by many institutions in contrast to home market securities. Home market shares, on the other hand, trade in local currency according to local market customs and often bear *additional risks*. Settlement risk, for instance, is substantially lower in the U.S. than

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[30] It is hypothesized that treatment of foreign DR owners may be different from domestic shareholders, e.g., in case of bankruptcy filing. No such cases are known to us, however.

[31] The general instructions to Form F-6 provide: [t]he holder of the ADRs is entitled to withdraw the deposited securities at any time subject only to (i) temporary delays caused by closing transfer books of the depositary or the issuer of the deposited securities or the deposit of shares in connection with voting at a shareholders' meeting, or the payment of dividends, (ii) the payment of fees, taxes and similar charges, and (iii) compliance with any laws or governmental regulations relating to ADRs or to the withdrawal of deposited securities. See Saunders (1993), note 24, pp. 53-54.

[32] It is questionable, however, whether this exchange option has a strictly positive value. Apparently, the value of this embedded option depends on two assets. Questions that follow immediately are: „Which are these assets?“ „What are their risk characteristics?“ „Are they different?“ „How can their price processes be described?“ „How can the value of the option be determined?“

[33] The consequences of this treatment are hard to predict but default risk of the depository and other risk factors may influence the valuation of DRs.

in most other equity markets.[34] (8) ADRs trade in *registered form* whereas local stocks often trade in bearer form. But securities in bearer form may be advantageous for some types of investors. (9) ADRs and ordinary shares trade in different stock markets, in different parts of the world and at different times during the day and in some cases even during the week and year. As a consequence, supply and demand for these securities and the types of investors may differ at a certain point in time and throughout time.[35] Liquidity, transaction costs, and other market characteristics may also differ between those markets.[36] Foreign ownership restrictions in several countries, particularly in Asia, prohibit effective inter-market arbitrage and widen price bounds. In addition, cancellation fees, which increase transaction costs, are imposed by the depository bank on ADR holders who want to exchange ADRs for the underlying stock. The effects of these *timing and locational differences* can even be aggravated in times of a global crisis and large stock market shocks. The foreign exchange market also plays an important role. In times of restricted currency convertibility, local markets may be non-accessible for foreigners whereas trading in ADRs may still be possible.[37] (10) Depositary receipts may represent a multiple or a fraction of home market shares and local regulation may impose restrictions on the required number of depositary receipts for cancellation.[38] (11) Finally, *taxation* of both securities differs. In particular, foreign shares often are subject to withholding taxes in their home country.

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[34] „Trade failure“ rates are estimated to be 0.5 percent of trades in the U.S. See Karolyi (1998), note, p. 5.

[35] According to Wendell Starke, chairman for Invesco in North America: „The U.S. investor may prove to be longer-term oriented than some who have been more active in emerging markets in the past, thereby proving to be a stabilizing factor.“ See „The rise and rise of a perfect product“ in Global Investor (December 1994/ January 1995).

[36] See „The rise and rise of a perfect product“ in Global Investor (December 1994/ January 1995) for a discussion of this topic: „Opinions differ as to the liquidity of the instrument. ... ADRs are backed by ordinary shares held in the home market. In fact, the existence of ADRs makes it easier to off-load, because an ADR investor could more easily find a buyer abroad in addition to having the option to sell back into the home market,“ says Bank of New York's Sturdy. Chenenix-Trench of Barings takes a different view. „One of the problems with ADRs is that they are only traded by foreigners and foreign institutions, they don't have the liquidity support of the underlying market, so you can get very exaggerated price movements. ...“

[37] A citation from the ADR REPORT shall emphasize the actuality of this risk: „Because of a sharp drop in recent months by the local currency, the rupiah, pricing Indonesian ADRs was becoming more difficult, one trader said. „You can't buy or sell the local currency, so all the trading in Indonesia has gone offshore,“ he said. „You're just throwing darts. What's Telekom worth if you don't know what the underlying shares are worth?“ See ADR REPORT: „Emerging markets highlights“, January 26, 1998.

[38] E.g., „[d]ue to the requirements of the Japanese Commercial Code the Depositary Shares represented by this [r]eceipt may only be presented for cancellation and release of the underlying [s]hares of The Bank of Tokyo-Mitsubishi, Ltd. In multiples of 1,000 Depositary Shares.“ Deposit Agreement between The Bank of New York and Japanese The Bank of Tokyo-Mitsubishi, Ltd concerning establishment of Level-II ADRs. In Bank of New York (1997).

Table 1: Features of Depositary Receipts and Ordinary Shares with Long-term Price Impact

Feature	Explanation
Convenience	▪ ADRs are very convenient instruments for U.S. investors and include a service contract with the depository. ▪ Most of the costs of the embedded service contract is paid for by the foreign private issuer as specified in a typical Deposit Agreement. ▪ Investors profit from the services provided by the depositary without paying for them and should be willing to pay a price premium for ADRs. ▪ Ceteris paribus, the value of the depositary receipt should be higher than the value of the underlying ordinary shares.
Contracting	▪ Depositary receipts and ordinary shares exhibit different contractual features. ▪ Contractual differences include restricted voting rights on depositary receipts, restricted merit distributions, and different book ownership. ▪ Contractual differences impose contract risk on holding depositary receipts and, therefore, should make depositary receipts less valuable for investors than owning ordinary shares.
Risk Exposure	▪ ADRs and ordinary shares are subject to different risk factors. ▪ Risks include the opportunity to trade in ADRs but not in local shares in times of economic or political turbulence or restricted currency convertibility in the issuer's home country. ▪ Most of the exposure favors DRs versus ordinary shares and should increase the value of depositary receipts relative to common stock, ceteris paribus.

These various features may have different implications on the pricing of both types of securities. Over short periods of time, differences in supply and demand for a distinct firm's stock across markets may lead to price differences. Direct transaction costs, market segmentation and low liquidity in either market, which impose indirect transaction costs, may prevent instantaneous arbitrage.[39] Differences in transaction costs and fiscal treatment across markets as well as other one-sided market frictions may have asymmetric long-term effects on either price process – discriminating a particular type of asset. In the case of fundamental differences between depositary receipts and underlying ordinary shares, long-term price deviations between DR and common share prices may persist. From our viewpoint, certain features should be given particular notice. We summarize these in Table 1. Nevertheless, even in the case that fundamental differences are substantial, holders of depositary receipts could avoid most detrimental effects simply by exchanging the DR for the underlying security. As mentioned, this is possible at all times subject only to certain restrictions as provided in the general instructions to Form F-6.[40] Therefore, we can think of the monetary impact of the fundamental differences between depositary receipts and underlying as being subsumed in the value of the *embedded option* to exchange depositary receipts for actual shares.

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[39] This effect, however, should be short-term in nature and should not have a long-term effect on the pricing of ADRs.

[40] See Note 15 and Note 24.

4 Analysis

4.1 Data

The data sample employed in the analysis includes 614 non-U.S. companies from 38 countries.[41] The period of time covered ranges from January 1, 1996 to January 19, 1998. The number of price observations for most companies is 536. Daily closing price data as well as daily trading volume on depositary receipts and ordinary shares was provided by Datastream.[42] In order to directly relate prices of securities traded in different markets and currencies, daily stock prices were converted into U.S. dollars. Daily foreign exchange rates on the 40 countries in the analysis were provided by Datastream in the form of market middle prices.[43] In addition, daily stock index levels – mostly at local market closing – were obtained from Bankers Trust Company's Risk Management Database for all major world stock market indices as well as the U.S. Standard & Poor's 500 (S&P500) Index. Other relevant information including type of program, home country, home currency, sponsorship, exchange where traded, deposit ratio, firm's industry, CUSIP and other codes, and depositary bank information was provided by The Bank of New York's Depositary Receipt Database and Bankers Trust Company's Depositary Receipt Database.

Price series were corrected for capital adjustments (splits, rights offerings, etc.) as well as adjusted to ratio changes of ordinary shares per depositary share. Where such information was not available or structural changes in price trajectories not explainable, series were eliminated. Securities that had been de-listed during the examined time period have also been deleted. Multiple DR programs from a single foreign issuer (non-pairs) also were removed from the sample. Price data on several companies, particularly from Asia and Australia, showed a large number of zero daily rate of returns due to identical prices on consecutive days. Data series pairs with zero daily close-to-close returns more than 50 percent of the time were eliminated.[44]

The remaining sample is very heterogeneous and representative of the current DR market. The analysis covers forty percent of all existing DR programs and nearly two-thirds of all countries having DR facilities established during the sample period 1996 and 1997. Maybe more important,

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[41] The initial sample included more than 800 DRs from 40 countries.

[42] On most over-the-counter traded depositary receipts, daily turnover data was not available.

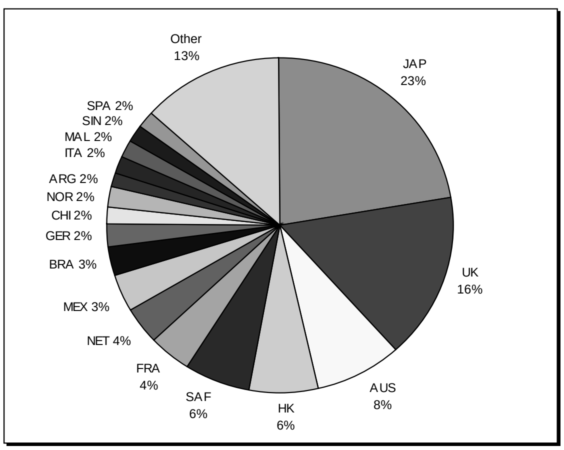
[43] The data are equivalent to market bid-ask-midpoints.

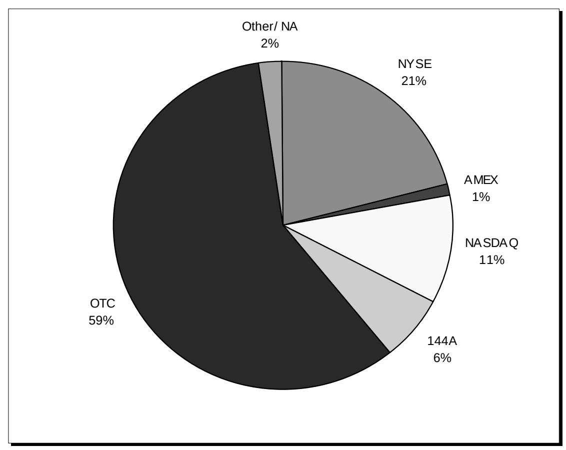
47.9% of all U.S. exchange traded depositary receipts are part of the analysis. The home countries primarily represented include Japan (142 depositary receipts included in the analysis), United Kingdom (118), Australia (79), Hong Kong (55), and South Africa (47). With 58 DRs in the sample, the banking sector is the dominant industry.[45]

Table 2: Sample vs. DR Market Composition

	DR Market (03/98)	Sample	% of DR Market
Countries	70	38	54.3%
Number of DRs	1898	614	32.3%
NYSE	298	126	42.3%
AMEX	8	7	87.5%
NASDAQ	166	66	39.8%
144A	339	39	11.5%
OTC	892	359	40.2%
Sponsored	1606	427	26.6%
Unsponsored	292	178	61.0%

Figure 1: Country and Exchange Distribution of Final DR Sample in Analysis





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[44] Following the procedure in Webb et al. (1995). The securities identified in this procedure were most likely illiquid and empirically exhibited low trading volume in either market.

[45] Summarizing, as of March 1, 1998, a record high worldwide total of 1898 Depository Receipt programs were established representing 70 countries. The countries with the highest number of all established DR programs are UK (239), Australia (160), Japan (155), and South Africa (116). During 1996 and 1997 the number of countries having DR programs established was much lower than on March 1, 1998, the date of the market statistics provided. The final sample includes five firms that trade in form of NY registered shares, namely Philips Electronics N.V., Royal Dutch Petroleum Company, Unilever N.V., KLM Royal Dutch Airlines, and Aegon N.V, which are all from the Netherlands.

4.2 Methodology

When analyzing the interrelationship between depositary receipts and underlying shares, one would suggest that there exists a long-run equilibrium relationship between depositary receipt and ordinary share prices, since both securities can be substituted for each other. However, depositary receipts and ordinary shares are neither traded in the same capital market system nor in the same country nor at the same time during the day. Therefore, in the presence of intra-market imperfections or inter-market segmentation, prices of seemingly equivalent assets like depositary receipts and ordinary shares need not be identical at all times. Transaction costs, regulatory restraints in some countries, and other factors may prohibit effective inter-market arbitrage. An arbitrage band allowing for significant short-term price deviations arises. In the long-run, however, economic forces arising from arbitrage opportunities should hinder prices from wandering in such a way that they drift too far apart and disequilibrium forces will tend to align prices.

4.2.1 Basic Model

The discussion on the equivalence of ordinary shares and depositary receipts in Section 3.3 lets one suppose that both securities' prices are not identical in equilibrium but rather linked systematically. Suppose the long-run equilibrium is given by the following linear relation:[46]

$$y_t = \beta_1 x_t + e_t \qquad (4.1)$$

where x_t is the ordinary share price at t, y_t the depositary receipt price at t, and e_t a gaussian *equilibrium error* term.

Ordinary share and depositary receipt prices are in equilibrium, when e_t=0. Whenever y_t turns out to differ from $\beta_1 x_t$, some sort of adjustment must occur to restore the equilibrium in the subsequent period. If the system is to return to the long-run equilibrium, the movements of at least one of the variables must respond to the magnitude of the disequilibrium. The dynamic model implied is one of *error correction*, since short-run dynamics of the variables in the system of simultaneous equations are influenced by last period's deviation (y_{t-1}-$\beta_1 x_{t-1}$) from the long-run

[46] All prices denoted by small letters are logarithmic prices. In the following discussion, the ratio between depositary shares and deposited shares is assumed to be unity. Note that we are assuming a proportional price difference instead of constant absolute US$ differences.

relationship.[47] A simple error correction model applied to the ordinary share and depositary receipt relationship is as follows.

$$\Delta y_t = \alpha_y (\beta_1 x_{t-1} - y_{t-1}) + \varepsilon_{yt} \tag{4.2}$$

$$\Delta x_t = \alpha_x (y_{t-1} - \beta_1 x_{t-1}) + \varepsilon_{xt} \,. \tag{4.3}$$

where β_1 is the parameter given in (4.1), ε_{xt} and ε_{yt} are white-noise disturbances and α_x and α_y, are *speed of adjustment* parameters. The larger α_x, the greater is the response of Δx_t to the previous period's deviation from long-run equilibrium. At the opposite extreme, very small values of α_x imply that daily local stock returns are unresponsive to last day's equilibrium error. The same is true for α_y with respect to the response of today's depositary receipt return Δy_t to last day's equilibrium error $e_{t-1}=(y_{t-1}-\beta_1 x_{t-1})$.

The equivalence between error correction and cointegration[48] is unaltered if we formulate a more general model than (4.2) and (4.3) by introducing lagged changes of each security's prices into both equations. Hence, in contrast to Ben-Zion et al. (1996), our generalization is motivated by the theory of *vector autoregression* (VAR) models. Thus, the error correction model in (4.2) and (4.3) becomes the following *vector error correction model* (VECM).

$$\Delta y_t = \alpha_1 + \alpha_y (\beta_1 x_{t-1} - y_{t-1}) + \sum_{i=1}^{p} \alpha_{11}(i) \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_{12}(i) \Delta x_{t-i} + \varepsilon_{yt} \tag{4.4}$$

$$\Delta x_t = \alpha_2 + \alpha_x (y_{t-1} - \beta_1 x_{t-1}) + \sum_{i=1}^{p} \alpha_{21}(i) \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_{22}(i) \Delta x_{t-i} + \varepsilon_{xt} \,. \tag{4.5}$$

[47] Early versions of error correction mechanisms are Sargan, J.D. (1964) „Wages and Prices in the United Kingdom: A Study in Econometric Methodology“ in *Econometric Analysis for National Economic Planning* and Phillips, A.W. (1957) „Stabilization Policy and the Time Forms of Lagged responses“ in the *Economic Journal* 67, pp. 221-248.

[48] The concept of cointegration as introduced by Engle and Granger (1987) suggests that the equilibrium error e_t in (4.1) must be stationary, if the equilibrium is meaningful. In terms of the two variable equation (4.1), if ordinary share and depositary receipt price levels are both $I(1)$ and the linear combination $y_t-\beta_1 x_t=e_t$ is stationary, then the variables are cointegrated of order $CI(1,1)$. The cointegrating vector β is $(1, -\beta_1)$ and deviations e_t are temporary in nature. Thus, the cointegrating combination can be interpreted as an equilibrium relationship. Further, if we assume that ordinary share and depositary receipt price levels are both $I(1)$, an error correction representation that could be applied to the relationship between depositary receipts and ordinary shares *necessitates* the two variables to be cointegrated of order $CI(1,1)$. On the other side, Granger (1981) shows that the restrictions necessary to ensure that the variables are $CI(1,1)$ guarantee that an error correction model exists. These two findings illustrate the *Granger representation theorem* stating that for any set of $I(1)$ variables, error correction and cointegration are equivalent representations.

where the cointegrating vector $(1,-\beta_1)$ is given by equation (4.1), ε_{xt} and ε_{yt} are white-noise disturbances, which may be correlated with each other, and α_1, α_2, α_x, α_y, $\alpha_{11}(i)$, $\alpha_{12}(i)$, $\alpha_{21}(i)$, and $\alpha_{22}(i)$ are parameters.[49]

4.2.2 Extended Model

The vector error correction model described above assumes synchronous data. As described in Section 4.1, the data that form the basis for our analysis, however, are official stock exchange closing prices. Since time zones and trading hours differ between the United States and most other world's stock exchanges, depositary receipt and local stock closing prices are reported at different times. Thus, reported depositary receipt prices are nonsynchronous with corresponding ordinary share prices.[50] Therefore, the above vector error correction model is not valid for estimating most depositary receipt and local share time series. The model is applicable only to the synchronous part of the ADR sample. In order to adjust for this *data synchronization problem*, a taxonomy is established to categorize the companies in the analysis, and the vector error correction model (4.4) and (4.5) is modified.

The criteria for classifying trading of dually-listed securities are based on official trading hours in the corresponding stock markets. Four types can be distinguished. The first type, group A, includes the pairs where trading takes place synchronously at all times. If trading in ADRs and ordinary shares takes place sequentially, one market already closes before the other market opens on the same calendar day. Stock exchanges of this type constitute group B. Third, trading in one market may start and finish earlier than in the other market. Thus, trading hours overlap nonsynchronously and trading takes place simultaneous over some time during the day. In this case, the U.S. ADR market usually opens and closes later than the corresponding foreign stock market, and corresponding depositary receipts are assigned to group C. In some cases, the firm's domestic

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[49] The system can be estimated using ordinary least squares regression. Due to the Granger representation theorem, the omission of the equilibrium error term entails a misspecification error. Engle and Granger suggest estimating (4.4) and (4.5) by ordinary least squares (OLS) in a two-step procedure. First, OLS is used to obtain the estimator of β_1 in equation (4.1). If the variables are cointegrated, an OLS regression yields a super-consistent estimator of the cointegrating parameter despite the nonstationarity of the variables. Then, the estimator is used to substitute β_1 in equations (4.4) and (4.5) to estimate the parameters α_1, α_2, α_x, α_y, $\alpha_{11}(i)$, $\alpha_{12}(i)$, $\alpha_{21}(i)$, and $\alpha_{22}(i)$. The second step is identical to substituting the error correction terms in (4.4) and (4.5) with the estimated residuals from the former regression. This two-step estimation procedure, however, rests on the assumption that y_t and x_t are cointegrated of order $CI(1,1)$. It is, therefore, important to test for cointegration and for unit roots in the variables.

[50] In addition, ordinary share prices of firms from different countries are also nonsynchronous.

stock market closes after the closing in New York. These depositary receipts make up the fourth category, group D.[51] In summary, the categorization is as shown below. Table 4 summarizes closing times of the stock exchanges included in the DR sample. In order to adjust for this data synchronization problem, the VECM in (4.4) and (4.5) is generalized to four separate systems of dynamic simultaneous equations, and the sample of depositary receipts is clustered into four separately analyzed groups.

In case of **synchronous** trading hours on the U.S. and domestic stock market (group A), the model under consideration is given by (4.4) and (4.5) and the error correction equation is the one in (4.1).[52]

Table 3: Synchronicity of International Stock Trading

Group	Data Synchronization
A	Synchronous trading hours with the U.S market
B	Non-synchronous, non-overlapping trading hours with the U.S. market
C	Non-synchronous, overlapping trading hours with the U.S. market (U.S. market closes later)
D	Non-synchronous, overlapping trading hours with the U.S. market (U.S. market closes earlier)

[51] All Asian, the African and some European stock exchanges close before U.S. stock markets open on the same calendar day. From the countries represented in the sample, New Zealand, Australia, Japan, Hong Kong, Singapore, Taiwan, the Philippines, Korea, Malaysia, Indonesia, Thailand, India, South Africa, Turkey, Hungary, Austria, and Germany belong to this category. Hence, they comprise group B. (This classification is only true for the sample period 1996 through 1997. Recently, trading hours on several exchanges have changed towards extended trading.)

Most European markets, on the other hand, have overlapping opening hours with the United States. Denmark, Norway, Switzerland, Portugal, Belgium, the Netherlands, Finland, Sweden, Italy, France, Spain, the United Kingdom, and Ireland open before the New York markets open and close before the U.S. ADR market closes, thus allowing for simultaneous trading over a significant period of time. Depositary receipt programs established by firm from these countries comprise Group C.

Finally, most South American stock exchanges close at the same time when the New York ADR market closes. Brazil, Argentina, and Mexico belong to this group A. Two South American exchanges, Venezuela and Chile, close earlier than New York, however. Because the Venezuelan stock exchange in Caracas closes three hours before New York, Venezuela was assigned to group C, and Chile – with only half an hour time lag – was assigned to group A.

Colombia closes at 5:45 PM Eastern Standard Time (EST), almost two hours after New York closes. It is likely that new information on Colombian companies arrives after the closing in New York. Hence, the hypotheses that reported Bogotá prices incorporate information not included in New York closing prices can not be rejected. Colombia, therefore, forms a fourth group of world exchanges, that exhibit non-synchronous overlapping trading hours with the United States but close after New York (Group D). But because no reliable data was available on Colombian ADRs, the fourth model is not elaborated in the following.

[52] In all models under consideration, a lag length of five (p=5) was chosen.

Table 4: World Stock Exchange Closing Times

Region/ Country	Closing Time (EST)	Group
NORTH AMERICA		
USA	**4:00 PM**	
Canada	3:00 PM	A
ASIA		
New Zealand	10:30 PM	B
Taiwan	11:00 PM	B
Philippines	11:00 PM	B
Australia	1:00 AM	B
Japan	1:00 AM	B
Korea	1:00 AM	B
Hong Kong	2:55 AM	B
India	3:30 AM	B
Indonesia	4:00 AM	B
Malaysia	4:30 AM	B
Singapore	4:30 AM	B
Thailand	4:30 AM	B
SOUTH AMERICA		
Venezuela	1:00 PM	C
Chile	3:30 PM	A
Brazil	4:00 PM	A
Argentina	4:00 PM	A
Mexico	4:00 PM	A
Colombia	5:45 PM	D

Region/ Country	Closing Time (EST)	Group
EUROPE		
Hungary	7:00 AM	B
Germany	7:30 AM	B
Austria	9:00 AM	B
Luxembourg	9:00 AM	B
Turkey	9:00 AM	B
Denmark	10:00 AM	C
Norway	10:00 AM	C
Switzerland	10:30 AM	C
Portugal	10:30 AM	C
Belgium	10:30 AM	C
Netherlands	10:30 AM	C
Finland	11:00 AM	C
Sweden	11:00 AM	C
Italy	11:00 AM	C
France	11:00 AM	C
Spain	11:00 AM	C
United Kingdom	11:30 AM	C
Ireland	12:30 PM	C
AFRICA		
South Africa	9:00 AM	B

Note: Group A – Synchronous trading hours with the U.S.
Group B – Non-synchronous, non-overlapping trading hours with the U.S.
Group C – Non-synchronous, overlapping trading hours with the U.S. (U.S. closes later)
Group D – Non-synchronous, overlapping trading hours with the U.S. (U.S. closes earlier)

Source: FIBV: „Market Information on FIBV Member Exchanges - 1998“, www.fibv.com

When trading hours in the U.S. and the domestic stock market are non-overlapping (group B), ordinary share and depositary receipt trading takes place sequentially. Hence, the degree of short-run error correction on the domestic stock market depends on the deviation from long-run equilibrium of last day's closing prices y_{t-1} and x_{t-1}. New York trading, ceteris paribus, responds solely to the difference between the latest two closing prices, which are last day's U.S. closing price y_{t-1} and today's foreign stock exchange closing price x_t. Hence, in the case of **non-synchronous non-overlapping** trading hours, the model under consideration is

$$\Delta y_t = \alpha_1 + \alpha_y \left(\beta_1 x_t - y_{t-1}\right) + \sum_{i=1}^{p} \alpha_{11}(i) \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_{12}(i) \Delta x_{t-i+1} + \varepsilon_{yt} \qquad (4.6)$$

$$\Delta x_t = \alpha_2 + \alpha_x \left(y_{t-1} - \beta_1 x_{t-1}\right) + \sum_{i=1}^{p} \alpha_{21}(i) \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_{22}(i) \Delta x_{t-i} + \varepsilon_{xt}\,. \qquad (4.7)$$

where all parameters are as defined above.

Note that the two error correction terms now differ. Furthermore, the U.S. return Δy_t on day t also depends on the domestic return Δx_t on day t. In this case, two error correction equations have to be estimated. The additional regression equation is given by:[53]

$$y_{t-1} = \beta_1 x_t + e_t \tag{4.8}$$

When analyzing the pricing dynamics of depositary receipts of European firms traded in New York, one has to consider that the respective European exchange can respond to news from U.S. exchanges on the same day, et vice versa, since trading takes place simultaneously on both exchanges for some time during the day.[54] During parallel trading hours, both exchanges adjust to last day's equilibrium error $e_{t-1} = y_{t-1}-\beta_1 x_{t-1}$ according to their own, firm-specific partial adjustment parameters α_x and α_y, respectively. In addition, they are linked by feedback. However, after the European stock exchange has closed, U.S. ADR trading has time to solely adjust to the latest deviation from long-run equilibrium. Therefore, the speed of adjustment of U.S. depositary receipt trading can be measured by the term $\beta_1 x_t-y_{t-1}$. Further, the European stock exchange's response to deviations from the long-run depositary receipt/ ordinary share relationship can be measured by the ordinary stock's price reaction to the term $y_{t-1}-\beta_1 x_{t-1}$, when neglecting the feedback effect of simultaneous trading. Hence, in the case of **non-synchronous overlapping** trading hours, the model under consideration is the same as described by equations (4.6) and (4.7).[55]

4.2.3 Test of Unit Roots

By definition, cointegration necessitates that the variables be integrated of the same order. Thus, in order to validate the assumed VEC model, the first step in the analysis conducted was to pretest each variable on unit roots to determine its order of integration. For this purpose, augmented

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[53] The fact that in (4.8) x_t is regressed on y_{t-1} is due to the economic consideration that the ADR price typically is the dependent variable. Because of interdependence in restrictions imposed by the two equations (4.6) and (4.7), the dynamic system has to be estimated by seemingly unrelated regression (SUR) rather than OLS.

[54] As a consequence, it is not possible to measure the degree of interdependence between the two exchanges during parallel trading, since only closing prices are available.

[55] Again, this system is estimated by seemingly unrelated regression rather than ordinary least squares regression. Note that incorporating all three terms $(\beta_1 x_{t-1}-y_{t-1})$, $(\beta_1 x_t-y_{t-1})$, and Δx_t in the equation for Δy_t leaves us with an unidentified system due to $(\beta_1 x_t-y_{t-1}) = (\beta_1 x_{t-1}-y_{t-1}) + \beta_1 \Delta x_t$.

Dickey-Fuller (ADF) tests were used to infer the number of unit roots in x_t and y_t.[56] With a constant, a time trend and five lagged difference terms, the regression equation is

$$\Delta p_t = \gamma_1 p_{t-1} + \sum_{i=1}^{5} \gamma_{i+1} \Delta p_{t-i} + \gamma_7 + \gamma_8 t + \varepsilon_t \tag{4.9}$$

where: p_t = security price at t.

4.2.4 Test of Cointegration

The test of cointegration for x_t and y_t verifies whether the residuals of the equilibrium regression are stationary. The augmented Dickey-Fuller tests used here are exactly those of the unit roots above, but applied to the residuals e_t in (4.1).[57] Engle and Granger (1981) provide applicable test statistics that can be used to test the hypothesis a_1=0 in

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + \sum_{i=1}^{n} a_{i+1} \hat{e}_{t-i} + \varepsilon_t \ . \tag{4.10}$$

The critical values for the augmented DF test, when both the null and alternative hypotheses have no or fourth order autoregressions, are summarized in Table 7.

4.2.5 Test of Precedence

Finally, causality tests were conducted to check whether current local stock returns can be explained by lagged depositary receipt returns, et vice versa. The tests applied are based on *Granger causality* tests but adapted to the nonsynchronicity of reported price data. In a two-variable error correction model, $\{y_t\}$ does not Granger cause $\{x_t\}$ if and only if all the coefficients $\alpha_{21}(i)$ and the speed of adjustment parameter α_x in equation (4.5) are equal to zero. The direct way to determine Granger causality is to use a standard F-test to test the restriction

$$H_0: \alpha_x = \alpha_{21}(1) = \alpha_{21}(2) = ... = \alpha_{21}(p) = 0$$

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[56] See Dickey and Fuller (1981).

[57] The augmented version of the DF test was applied, since diagnostic checks indicated that the $\{\varepsilon_t\}$ sequence in the regression $\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + \varepsilon_t$ exhibit serial correlation. In this case, the unaugmented version is misspecified while the augmented one is correctly specified. Note that in the cointegration test it is not appropriate to use either of the confidence intervals reported in Dickey and Fuller (1981). The Dickey-Fuller statistics are inappropriate because the residuals $\hat{e}_t$ used in (4.4) and (4.5) are not the actual error terms. Rather, these residuals are estimated error terms that are obtained from the estimate of the equilibrium regression.

For the purpose of testing precedence in non-synchronous data, the standard Granger causality test was adapted to fit the dynamic simultaneous equation models (4.4) through (4.7). Null and alternative hypotheses were extended for the additional terms in the equations and corrected for omitted ones. [58] The null hypothesis tested, thus, is the same as in a standard VAR:

$$H_0\!: \alpha_{21}(1) = \alpha_{21}(2) = ... = \alpha_{21}(p) = 0$$

5 Empirical Results

5.1 Basic Facts

In general, empirical results indicate that ADRs and underlying ordinary shares are closely related equity securities. Daily return correlation coefficients between prices of depositary receipts and underlying common shares are significantly positive but vary across companies. Averaged over all 614 pairs of securities, the daily return correlation is 0.8105. On a weekly and monthly basis, this number increases to 0.9496 and 0.9749, respectively.[59] Further, nonsynchronous trading hours may suggest significant leading/lagging return relationships. Significantly high lagged correlation coefficients, particularly with lag length one, are found for several firms.[60] Averaged over all 614

[58] For operational reasons, the error correction terms were omitted from the equations tested. The consequence was found not to be very significant, since preceding returns of the corresponding security in the other market are already incorporated in all B- and C-type systems. In contrast to true VEC specifications, this restriction is feasible when estimating systems of dynamic simultaneous equations.

[59] The increase in magnitude of the coefficient indicates that both types of securities are linked through a long-run equilibrium. Daily contemporaneous return correlations range from 0.0740 to 0.9933 and were found to be relatively low for many South American firms, for companies from New Zealand, Australia, Korea, Thailand, and other Asian DR programs, but also for Irish firms. Over-the-counter (OTC) traded ADRs, in general, exhibit very high contemporaneous return correlation coefficients between daily depositary receipt and local stock returns, whereas listed ADRs exhibit relatively low contemporaneous return correlation coefficients as well as daily return comovement indicators.

[60] Companies from Chile, Denmark, Ireland, New Zealand, and the Philippines exhibit the highest lagging coefficients, where home market returns lag U.S. market movements one day. The highest one-day lagged return correlation coefficients exhibited Irish Elan company with 0.7332, when comparing depositary receipt returns on day t with local stock returns on day t+1, and Brazilian Copene PNA with 0.5441, when comparing today's home market returns with tomorrow's ADR return. Interestingly, the top 20 list of high leading correlations comprise only South American DR programs, which are mainly over-the-counter traded. Leading and lagging correlations for OTC traded ADRs particularly from Japan, Australia and New Zealand, on the other hand, are close to zero. In the case of U.S. exchange traded DRs, the significance of cross-correlations with positive or negative lag lengths heavily depends on the country of origin and other factors rather than the place where traded. Both coefficients, lagging and leading correlations with any lag length, are systematically lower than unlagged return correlations, however.

pairs of securities, ADR prices are only few more volatile than the respective common shares; with 0.02305 average daily standard deviation of ADR prices compared to 0.02271 for ordinary shares.[61]

The volatility of contemporaneous differences between depositary receipt and underlying common share prices plays an important role in explaining price differences. The sample period includes the *market crash* of October 1997 and the volatile period around this event. In lieu with this period of high volatility in securities prices, a significant increase in volatility of daily price differentials between DRs and ordinary shares was found empirically for many companies during 1997.[62] Further, many pairs of securities exhibit higher price differentials in U.S. dollar terms during the second half of the sample period as compared to the first half.[63]

Since fluctuations in foreign exchange rates are recognized as important risk factors in owning ADRs, the influence of exchange rates on U.S. ADR returns was analyzed.[64] The correlation between ADR returns and first differences of foreign exchange rates was used as primary measure for this analysis. Interestingly, the list of the twenty highest ADR return/ exchange rate return correlations includes predominantly companies from Korea, Malaysia, and Mexico. This is indicative of the fact that exchange rate fluctuations can be an important risk factor, and second, the exposure of dually-listed securities to exchange rates differs widely within a single country and between currencies.[65]

Furthermore, the behavior of depositary receipts and underlying ordinary shares was investigated with respect to their comovement with stock market indices. The sample average daily ADR/stock index return correlations are 0.20557 for the U.S. S&P 500 index and 0.50552 for the domestic index, respectively. Thus, they are significantly higher with the corresponding home

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[61] The ADR market is more volatile compared to the local market for Indian, Russian, Chinese and Hungarian firms, and less volatile for Thailand and Venezuela. With an average standard deviation 0.03933 of daily ADR prices over the sample period and all Russian firms in the sample, depositary receipt programs established by Russian companies are the least volatile U.S. traded security relative to domestically traded shares, where the respective figure is 0.04322. Average standard deviation of ADR prices from companies traded in Bangkok, however, is 0.05210 per day compared to 0.03897 for common shares and, thus, higher in the U.S. market. The respective numbers for Venezuelan companies are 0.030899 for depositary receipt prices and 0.02581 for underlying common shares.

[62] Overall, average standard deviation of daily price differences increased from 0.206 in 1996 to 0.297 in 1997. This effect was particularly significant for NYSE listed depositary receipt programs, where the respective number increased from 0.342 in the first half of the sample period to 0.504 in the second half.

[63] Most significantly, the median price difference over the sample period between NYSE traded depositary receipts and common shares increased from 6.5 to 10.4 cents.

[64] See Bank of New York (1997).

market index, which was not only found on average but also in most individual cases. Nevertheless, return correlations of ADRs are slightly lower with the domestic stock index and slightly higher with the S&P 500 than the respective figures of common shares – 0.50552 compared to 0.52812 with the domestic index and 0.20557 compared to 0.19287 with the S&P 500.[66] Hence, stocks dually-listed in the United States still trade domestically and are more exposed to systematic risk in the home market than in the U.S.[67]

An important feature of the overall ADR market is that trading is concentrated in few issues. During the sample period 1996 through early 1998, Royal Dutch Petroleum was the firm with highest U.S. market interest (2.62619 million shares per day, on average). Royal Dutch is followed by Brazilian telecom company Telebras (2.33286 million), Finnish Nokia (1.05724 million), and Unilever (996.69 thousand).[68] Interestingly, mainly European companies particularly from the United Kingdom, and Latin American firms are in the top 20. Another interesting result is related to the percentage of no price changes on two consecutive days. On average, 12.8 per cent of all day-to-day depositary receipt returns are zero, ranging from as low as 5.32 per cent for German companies to 23.43 per cent for Malaysian firms.[69]

The heterogeneity of the sample lead to a classification of the sample into two distinct groups. One group of depositary receipt securities (Cluster I) trade exactly like the corresponding home market securities, which means that price differences between ADR and dollar-translated and ratio-adjusted ordinary share prices are negligible. Price differentials in this group are very close to zero with some short-term exemptions over time and ADR prices track local stock price almost perfectly. Cross-correlations of rate of returns in this group are typically close to unity, serial correlations of price differences close to zero and serial correlations of changes in price differences (one-day lag) significantly negative.[70] The second group of security pairs (Cluster II) behaves different. *Mostly*

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[65] See Table 11.

[66] The results are biased by the fact that many of the companies in the sample are weighted in their respective home country's stock market index. Thus, correlation coefficients with the home market index are necessarily higher than with the U.S. index, in which the firm may not be included.

[67] See Table 12.

[68] Royal Dutch Petroleum and Unilever N.V. are traded as NY registered shares.

[69] The corresponding ordinary shares exhibit on 16.93 per cent of all trading days during the sample period 1996 through 1997 unchanged closing prices.

[70] This case suggests that the U.S. ADR market is a satellite market of the company's home stock market. Most over-the-counter traded depositary receipt programs fall in this group. Reasons for this may include missing investor

ADRs that exhibit significant trading volume in the United States or, even more important, trade on a U.S. exchange show distinct price process characteristics. The price process is characterized by different daily price movements compared to foreign market prices, thus lower cross-correlation coefficients of rate of returns and comovement ratios compared to OTC traded ADRs. 292 out of 614 firms in the analysis exhibit daily contemporaneous cross-correlations below 0.9. In this group, contemporaneous price differences between ADR and local share, which may have negative or positive values, can be substantial and are changing over time, but exhibit serial correlation. Contemporaneous cross-correlations are still close to unity, but leading or lagging cross-correlations of price changes can be significant as well, depending on other factors being discussed later. In this case, the U.S. ADR market is no satellite market and may even be dominating the company's home stock market in terms of setting securities prices.[71] The classification into Cluster I and II of the 614 companies in the sample was further refined by separating OTC and privately traded programs in pairs of securities with low and high volatility of price differences. Exchange listed DRs were categorized depending on the average daily U.S. turnover relative to the average daily domestic turnover in [0, 0.01), [0.01, 0.1), [0.1, 0.5), [0.5, 1), [1, ∞).

Major factors leading to different bahavior of the securities were identified as being the firm's country of origin and geographical region as well as the exchange on which the depositary receipt is traded.[72] ADRs listed on the NYSE trade broadly similar to NASDAQ-listed ADRs, whereas AMEX traded ADRs form a different group. Over-the-counter traded as well as privately placed ADRs, on the other hand, also exhibit similar price process characteristics.[73]

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interest but also the fact that trading efficiency and transparency is relatively low in OTC markets and that, as a consequence, turnover rates actually are low.

[71] The ratio of standard deviation of daily price differences and average ADR price over the sample period was used as a proxy for the categorization of ADR and local stock price processes.

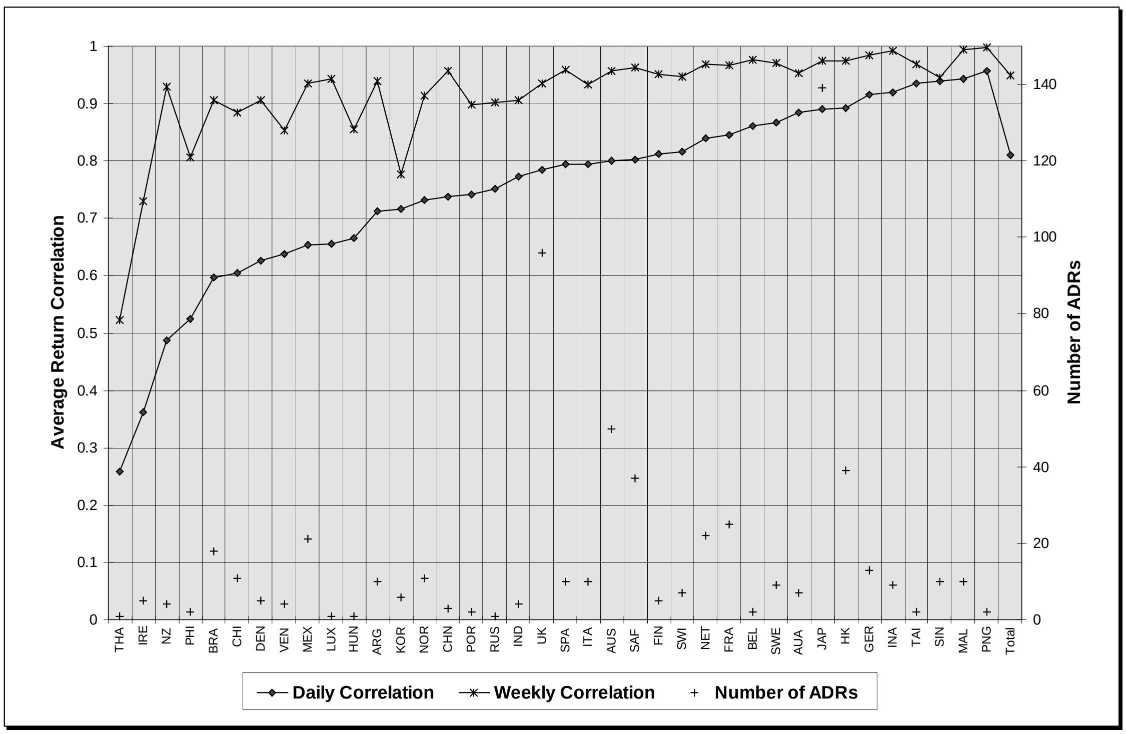
[72] Depositary receipts of South American companies as a group behave very similarly. They are the only group that is traded almost synchronously with the depositary receipts in the U.S. Thus, both markets are directly competing for market share. For instance, with commonly high one-day leading correlation coefficients, the U.S. over-the-counter market for South American firms is simply a satellite of the domestic market. For most U.S. exchange listed South American ADRs, the U.S. market is the leading market, however. Other homogeneous groups include East Asian companies and separately, firms from Australia and New Zealand. On the other side, European firms are a more heterogeneous group. Despite this fact, Scandinavian firms, for instance, form another homogeneous sub-group. Finally, some countries exhibit unique pricing dynamics and others are not represented enough in the sample to categorize them. South Africa, for instance, is the only African country represented in the analysis.

[73] However, it is important to note that one should be careful in interpreting institutional features of different exchanges as cause for the differences in ADR pricing. More likely, other features – such as operational efficiency, associated costs for sponsoring firms, buyers and sellers, public interest, and general market importance and image – result in preferring one market over another for listing purposes, and in different characteristics of arising price process

Table 5: Characteristics of ADR Sample Clusters

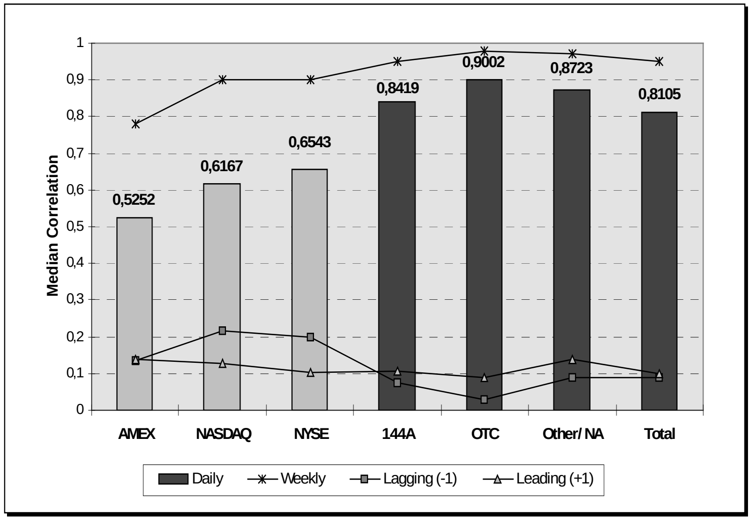
Cluster I	Cluster II
• Return correlations are close to unity.	• Return correlation coefficients and comovement ratios are relatively low.
• Price differences are negligible.	• Contemporaneous price differences may be substantial.
• Serial correlation of price differences is close to zero.	• Contemporaneous price differences exhibit serial correlation.
• Serial correlation of changes in price differences is significantly negative.	• Leading or lagging return correlations can be significant.
• U.S. ADR market is a satellite market.	• U.S. ADR market is contributing to the price discovery process

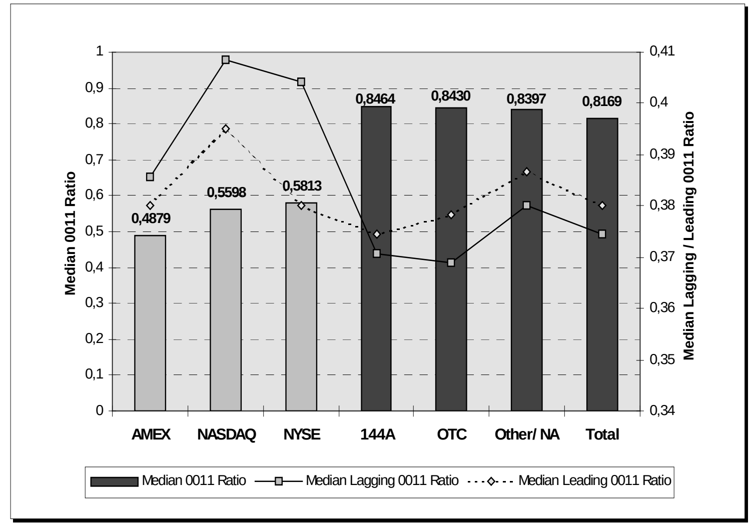
Figure 2: Average Daily and Weekly ADR / Local Stock Return Correlation per Country

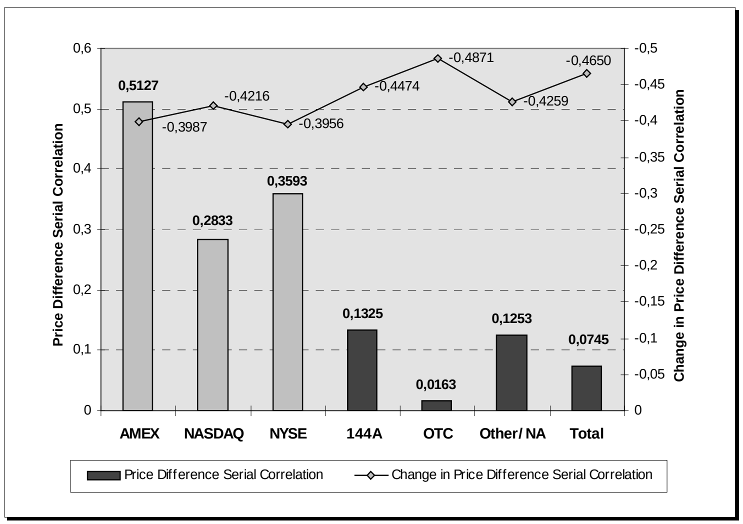


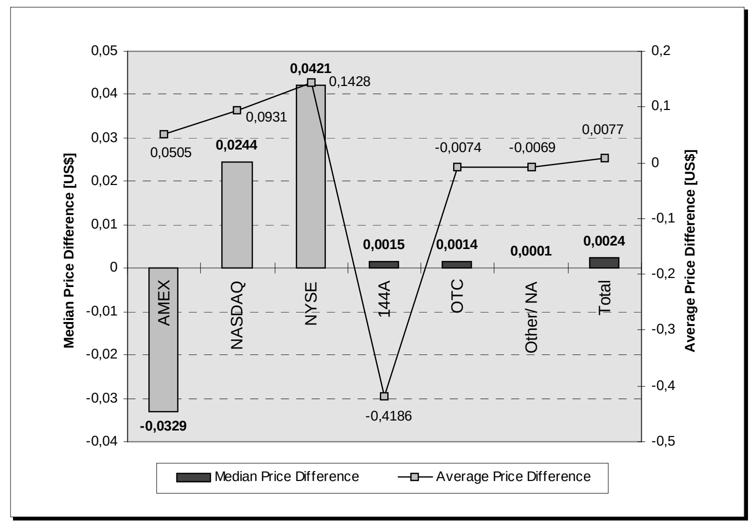
dynamics. Typically, ADR turnover rates are a closely related factor, that can be used as a measure of the significance of these features.

Figure 3: Median Return Correlation, Comovement Ratio, Price Differences, and Serial Correlation of Price Differences and of Changes in Price Differences per Exchange









5.2 Cointegration and Long-Run Price Relationship

Augmented Dickey-Fuller (ADF) tests reveal that *all price processes of depositary receipts and ordinary shares are stationary in first differences*.[74] After categorizing the 614 DR programs into groups A to D as done in Table 4 above, the corresponding interdependent system of equations (4.4) and (4.5) or (4.6) and (4.7) was estimated in a two-step procedure according to the Engle-Granger methodology.[75] In the first step of the Engle-Granger methodology, the linear long-run relationship between logarithmic price levels was estimated. *Except for certain Asian depositary receipts*[76]*, all estimates $\hat{\beta}_1$ of the regression equation's slope are close to unity*. The exception of Asian Rule 144A ADRs is due to five Korean programs, which trade at substantial discounts compared to ordinary shares. Overall, with a t-value of 16.77, *U.S. exchange-listed ADRs are in the long run statistically significant more expensive than ordinary shares*, i.e. taking an average stock price of US$40, ADRs would cost 21 cents more in the cointegration equilibrium.

Further, ADF tests for unit roots in the time series of the regression residuals $\hat{e}_t$ in (4.1) and (4.8) indicate that *almost all corresponding price processes of depositary receipts and ordinary shares are cointegrated*, since the regression residuals are stationary in levels.[77] However, Korean firms do not show significant DF-values and, thus, the hypothesis that the residuals are non-stationary can not be rejected.[78] As can be inferred from Table 20, price processes of neither Korea Electric Power, Yukong, LG Electronics, Hyundai nor Hankuk are cointegrated. The only cointegrated Korean firm is Hansol. Thus, the models estimated are misspecified in the former cases and a VEC-type model is not applicable. However, these are the only exceptions found.

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[74] See Table 16.

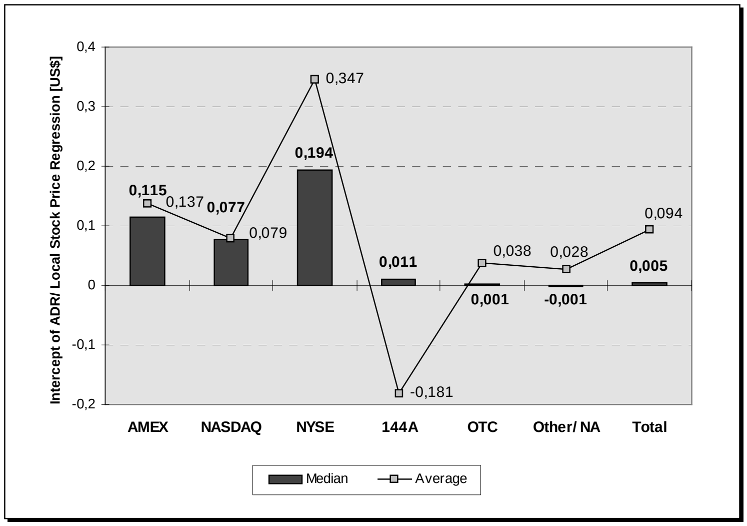
[75] In order to reduce the complexity of the analysis and to derive results on appropriately aggregated levels, depositary receipt indices and corresponding common share indices were constructed, and systems A to C estimated using the index times series.

[76] More exactly, these are Korean DRs that are placed privately according to Rule 144A.

[77] Hence, each of the former pairs of corresponding securities are cointegrated of the same order, i.e. of order one or *CI*(1,1). For reasons of relative importance, test results are presented, again on aggregated levels, in Table 16.

[78] In Table 20, estimation results are summarized on individual firm level for the Korean firms in the sample, and also for the Chilean (Chilean companies consistently showed unique price relationships between ADRs and local shares and, thus, were investigated in particular. However, they did not behave unusual in terms of cointegration.) and German companies as well as the top 10 ADRs with respect to U.S. turnover.

Figure 4: Intercepts β_0 of ADR/ Stock Price Regression



Persistent long-run price differences between ADR and ordinary stock prices – forementioned in Section 5.1 – are also found when (1) estimating a simple OLS regression of returns and when (2) determining median price differences over the sample period. Hence, positive long-run price differences exist between ADRs and ordinary shares. These price differences are found to be higher for more actively traded depositary receipts and, therefore, higher for exchange listed rather than OTC-traded DRs. See Figure 4 and Table 14 for details.

5.3 Dominance-Satellite Relationships and the Role of Marketplace

As discussed above, tests for unit roots and cointegration reveal that almost all corresponding series are cointegrated across markets. Thus, the appropriate representation for each of these pairs of securities is a vector error correction model (VECM) incorporating a short-term adjustment mechanism.[79] As can be inferred from the parameter estimates and R^2s in Table 18, the explanatory

[79] After determining the linear long-run equilibrium price relationship between depositary receipts and corresponding ordinary shares, the simultaneous equations of first differences Δx_t and Δy_t were estimated using ordinary-least-squares (OLS) in case of model A and seemingly-unrelated regression (SUR) in the other cases. Numerical results are presented in Table 18. If firm-specific findings did not vary much within a group of companies from the same country, an index comprising only these firms was constructed and estimated. Therefore, firms from one country and traded on one market place (NYSE, NASDAQ, or OTC) often were analyzed jointly. The indices then comprise either all ordinary shares or all depositary receipts from the companies out of a certain group. Further, the most relevant parameters of each system are summarized in Table 18, separately for each geographical region and each refined cluster. It gives an overview of the speed of adjustment parameters α_x and α_y as well as the coefficients $\alpha_{21}(1)$ and $\alpha_{12}(1)$ of the preceding returns in the corresponding market.

power of the regression equations differs widely across geographical regions, market place, and behavioral cluster.

a) In the case of almost all over-the-counter traded country-specific clusters of companies, the explanatory power of regression equation (4.5) (Model A) or (4.7) (Models B and C) is close to nil. The speed of adjustment parameter α_x as well as the coefficient $\alpha_{21}(1)$ of the first lagged term of the corresponding security are insignificantly different from zero except for Asia (dominantly Japan). Thus, *ordinary share prices do react neither to ADR/stock price differences nor to preceding ADR returns, if the firm's depositary receipts are traded over-the-counter in the U.S.* On the other side, the explanatory power of regression equation (4.6) to explain contemporaneous ADR returns is close to certainty and, as can be seen from the values of α_y and $\alpha_{12}(1)$, the U.S. ADR market makes up two-thirds of the deviation from long-run equilibrium already on the same trading day ($\alpha_y = 0.635$) and mimics domestic share returns on the same day to one-third ($\alpha_{12}(1) = 0.3202$).[80] Hence, *OTC ADRs react instantly to domestic share price movements and adjust according to deviations from the cointegrating equilibrium.*

b) In contrast, all of these most relevant parameters α_x, α_y, $\alpha_{21}(1)$, and $\alpha_{12}(1)$ are significantly different from zero in case of all exchange-listed depositary receipt programs. Therefore, the explanatory power of regression equation (4.4) and (4.5) (Model A) or (4.6) and (4.7) (Models B and C) is satisfying. In effect, this means that *a two-way interdependence exists between exchange-listed depositary receipt and local share price movements*. Lagged U.S. returns and price deviations enter in the return process $\{\Delta x_t\}$ of ordinary securities in the firm's home market et vice versa.

However, the **magnitude of reaction** of either market varies by geographical region. *European and African companies react more heavily to preceding price deviations $\beta_1 y_{t-1}-x_{t-1}$ than Asian and Australian firms* (34.87% and 45.63% partial adjustment on home market compared to 24.42% and 26.97%, respectively). This, however, may simply be due to different time lags between U.S. and domestic trading. The *same is true for U.S. market reactions* Δy_t to preceding price deviations $x_t-\beta_1 y_{t-1}$ of companies from these geographical regions (44.26% and 49% partial adjustment in the U.S. ADR market compared to 29.27% and 31.07%, respectively). Interestingly, *European markets react more heavily* to preceding U.S. movements Δy_{t-1} than any other geographical region ($\alpha_{21}(1) = 0.6707$).

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[80] Most likely, the U.S. market is illiquid and simply a satellite of the domestic market.

Further, the relative magnitude of the speed of adjustment parameters compared to the corresponding security indicates that in case of U.S. exchange listing of the DR program neither market is a satellite of the other. In case of low U.S. turnover, the domestic speed of adjustment parameter is lower than the corresponding ADR parameter but typically still significant at the 99% confidence level. The fact that *reactions are significant* at the 95% or even 99% level is independent of the U.S. market share, however. Globally, the partial adjustment parameters are 27.75% on the consecutive trading day for the domestic market compared to 41.38% on the same trading day for the U.S. market. Thus, *for U.S. exchange-listed ADRs it is true that both markets react to deviations from equilibrium – independent of the U.S. market share of overall turnover – but the magnitude of domestic reactions Δx_t to deviations from long-run equilibrium is increasing with the relative importance of the competing U.S. market*. The degree to which either market is a satellite of the other or dominates the other is further investigated in the next section.

In addition, the explanatory power of the autoregressive equation (4.7) to explain contemporaneous stock returns Δx_t *increases* with increasing U.S. ADR turnover relative to trading volume in domestic ordinary shares. This is due to more significant reactions (higher absolute values and higher t-values) of contemporaneous stock returns Δx_t to deviations $\beta_1 y_{t-1}-x_{t-1}$ from equilibrium. On the other side, R^2 of the regression (4.6) to explain contemporaneous DR returns Δy_t *decreases* with increasing U.S. ADR turnover relative to domestic trading volume. Thus, *the higher U.S. trading volume in ADRs the more independent from the firm's home market do ADR prices move*.

The big exception from these findings, however, is South America. Due to synchronous trading in ADRs and ordinary shares, the cointegration model applied differs and none of the variables in the equations are able to explain the others. Independent of the market place, the explanatory power of either regression is low. Most significant in these equations is the OTC-traded depositary receipt's reaction Δy_t to preceding common share returns Δx_{t-1} (t-value = 5.1326). For South American firms listed on the NYSE, AMEX, or NASDAQ, the only parameter, that is overall significant at the 90% level, is New York's reaction to last day's home market return (t-value = 1.8413). Interestingly, within the same group of companies, the home market reactions are stronger error correcting than the U.S. market. Overall, the speed of adjustment parameter α_x is twice as high as α_y.

5.4 Price Transmission in Global Equity Markets

The causality tests conducted provide evidence for the findings in the first part of the analysis and reveal a variety of new results.[81] Generally, empirical F-test values are high enough to reject the hypothesis that lagged stock returns do not cause contemporaneous depositary receipt returns in almost all cases. Hence, this is evidence of the fact that *lagged stock returns cause ADR returns*. Only in the case of some South American firms dually-listed on a U.S. exchange, the hypothesis can not be rejected at the 99% confidence level. Overall, as can be inferred from Table 19, precedence relations are not as significant for South American companies as for companies from the rest of the world. This is due to synchronous, parallel trading hours in North and South America as compared to non-synchronous trading with the U.S. in the rest of the world and, hence, to a different test equation.[82] Hence, in all of the sample cases *the domestic stock market of firms dually-listed in the U.S. capital markets is no pure satellite of the U.S.*

The picture is different when explaining domestic returns through lagged U.S. ADR price movements. *For most over-the-counter DR programs, the null hypothesis that U.S. ADR returns do not cause domestic common stock returns can not be rejected*. The influence of America on ordinary share returns for Australia, New Zealand, and South America is supported neither at the 99%, 95%, nor 90% confidence level. The same is true for European and Asian firms at the 99% level. Only for South African companies, the U.S. over-the-counter market actively sets prices in the home market with 99% confidence. In the case of South America – including Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela – U.S. returns can explain neither domestic returns of OTC-traded programs nor of U.S. exchange-listed ones. *Exchange-listed depositary receipts of companies from the rest of the world, however, actively influence succeeding ordinary share price movements* – as in the case of the reverse direction.

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[81] Adapted Granger causality tests were conducted to infer (1) which stock market is preceding the other in terms of setting prices, (2) which market for dually-listed securities is only a satellite market, (3) what factors are important for explaining the dominance of one market, and (4) whether there is an asymmetry in the dominance/ satellite relationship across markets. A summary of the tests conducted is given in Table 19 on aggregated regional levels and separately for each refined cluster. Further, test results are presented for each individual Korean company in Table 20 in order to determine whether domestic and U.S. prices of dually-listed Korean firms move independently – since they were found not to be cointegrated.

[82] See Section 4.2.3.

As a refinement of the investigation of causality relations, the magnitude of the F-statistic was used to measure the **degree of causality** between marketplaces.[83] When looking at these values in either test, a jump in the F-values of over-the-counter traded programs compared to exchange-listed ones can be found. This indicates that *information transmission from one market to the other varies by ADR marketplace* and that there is a *fundamental difference in the relevance of one market for the other when comparing over-the-counter and exchange-traded depositary receipts*. Under the null hypothesis that the company's home market does not cause the U.S. ADR market, F-values are as high as around 1,000 for OTC programs compared to approximately 100 for exchange-listed.

Secondly, there is an *asymmetry in the importance of the market organization, under which depositary receipts are traded, for setting prices in either market*. When comparing OTC-traded DRs with low price difference volatility and OTC-traded DRs exhibiting high price difference volatility, there is a shift in F-values, but it is of lower magnitude compared to exchange-listed DRs. As can be inferred from Table 19, F-statistic values of high turnover over-the-counter depositary receipt programs lie between those of OTC programs exhibiting a low variance of price differences and those of exchange-listed programs but much closer to the OTC programs. With F-values of 3.68 compared to 25.67, the fact that ADR returns cause local stock returns is much less significant. On the other hand, local stock returns causing ADR movements is much more significant in the case of OTC programs than for low turnover exchange-listed programs (462.22 compared to 168.50).

Hence, a firm's domestic stock market is relatively more important in explaining U.S. returns for U.S. over-the-counter traded ADRs with substantial U.S. turnover than for U.S. exchange-listed depositary receipts with minimal U.S. turnover. In the reverse direction, however, lagged DR returns of U.S. over-the-counter programs are less important in explaining contemporaneous home market returns than the respective returns of U.S. exchange-listed programs – independent of the U.S. turnover.

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[83] In general, an F-statistic is used to test whether all of the right-hand-side parameters (except for the intercept) are equal to zero under the null hypothesis. Hence, in the systems of dynamic simultaneous equations estimated the F-statistic tests the joint hypothesis that one variable can explain another through its lagged or unlagged values.

The value of the statistic is influenced by the magnitude of each individual parameter as well as the standard error of each parameter. Therefore, the „degree of causality" can be determined by taking the magnitude of the F-statistic as a measure of the degree to which the lagged values of one parameter enter in the equation of the other, i.e. to which degree one parameter is preceding the other. The higher the F-statistic the higher is the level of significance of one parameter preceding the other.

The third finding in this context is that there is an opposite trend of the F-statistic in the five clusters of exchange-listed DR programs. Under the null that the U.S. ADR market does not cause the domestic market, F-values are significantly increasing with the relative U.S. turnover. Thus, the *U.S. becomes more important for the domestic market with increasing trading volume relative to the home market*. On the other side, F-test values are significantly decreasing relative to increasing U.S. turnover under the null that the domestic market does not cause the U.S. ADR market. Therefore, *the relative importance of lagged local stock returns in explaining U.S. ADR returns is, ceteris paribus, decreasing with increasing U.S. turnover*. Information transfer from the ADR market to the home stock market is much stronger for exchange-traded than for over-the-counter traded depositary receipts. In the reverse direction, the link is much weaker for exchange-traded DRs than for OTC-traded DRs. Therefore, one can conclude that the market organization itself and not ADR turnover is the key factor in explaining this asymmetry.

The adapted Granger precedence tests performed for each individual Korean firm revealed that, despite the fact that five out of six firms are not cointegrated, prices of ordinary shares traded in Seoul and depositary receipts traded in New York do not evolve independently. High F-values under the null hypothesis that stock returns do not cause ADR returns lead to rejecting this hypothesis. Thus, the Korean market influences ADR price movements inspite of large price differences. The analysis of the Korean firms in particular revealed that prices of corresponding pairs of securities do not move independently from each other. However, not all corresponding prices series are cointegrated. Overall, the analysis of the global pricing of dually-listed securities reveal that in all sample cases *prices of American Depositary Receipts traded in the United States are linked with the prices of underlying ordinary shares in the home market* despite the fact that contemporaneous return correlation coefficients may be low.

5.5 Price Differences and Market Place

Besides the unproportional importance of U.S. trading in price-setting of foreign securities, the observed price behavior of ADRs versus ordinary shares is puzzling in terms of existence and persistence of significant short-term price deviations and the existence of fundamental long-term one-sided price differences.[84] This phenomenon may be related to the well-known country fund and twin

[84] The results for German companies and the top 10 firms with respect to U.S. turnover are provided supplementary in Table 20.

securities puzzles, for which several explanations have been given in the past. The asymmetry between U.S. exchange traded and OTC traded ADRs, however, sheds new light on this fact and allows us to eliminate some of the possible explanations. Table 6 summarizes possible explanations.[85] Further research has to be conducted, however, to clarify this issue.

Table 6: Possible Explanations for Price Differences between ADRs and Ordinary Shares

Possible Considering the Observed Asymmetry Exchange/OTC?	w/o	w/
Data Problems (Nonsync. Trading, Closing Prices, No Trades)	Yes	Yes
Transaction Costs/ Deposit Fees	Yes	Yes
Shortsale Restrictions	In Few Cases	In Few Cases
Frictions in Instantaneous Arbitrage	Yes	Yes
Deposit/ Cancellation Restrictions	Yes	Yes
Investment Barriers, Restrictions on Foreign Ownership	In Specific Cases	In Specific Cases
Foreign Exchange	In Certain Periods	In Certain Periods
Informational Asymmetries (Non-sync. Trading Hours, Equity Research, Informed Trading)	Yes	Yes
Convenience Premium (Dividends in US$, Company Reports, …)	Yes	Yes
Home Market Bias (in Trading)	Yes	No
Exposure to Country-specific Sentiment Shocks	Yes	No
Risk Characteristics (Exposure to FX Risk, Market Volatility)	Yes	No
Contractual Features (Voting Rights Issues, Institutional Diff's)	Yes	No
Tax-induced Investor Heterogeneity	Yes	No

6 Conclusion

This paper investigates the role of U.S. financial markets in global equity trading and research by means of the pricing relationship between depositary receipts and underlying ordinary shares. In addition, the paper provides a unique overview of the ADR market and sheds light on equilibrium relationships between ADRs and underlying ordinary shares. The main findings of the in-depth empirical analysis are summarized in Table 21. It can be concluded that, for U.S. investors, ADRs provide an adequate U.S. dollar-denominated foreign investment instrument, that replicates a foreign company's ordinary share price pattern to a high degree. Much of the risk of direct foreign investments is effectively eliminated. Investment barriers and other market frictions, however, can cause ADR and underlying share prices to differ widely. Despite this fact, securities prices do not move independently even if they are not cointegrated. More interestingly, U.S. exchange-listed ADRs are slightly more expensive than ordinary shares. This has been attributed partially to market segmentation and fundamental differences between ordinary and depositary shares. The results indicate that U.S. ADR investors pay a convenience premium for liquid ADRs.

[85] See Section 3.3 for a discussion.

The *company's country of origin* and the *U.S. marketplace on which the depositary receipt is traded* are major factors in distinguishing the inter-market pricing relation between ADRs and underlying shares. Price transmission across markets and equilibrium price adjustments of ADRs and underlying shares are strongest for European stocks, which seems to reflect higher market integration. Hence, investors can take as a rule that the higher the trading overlap as well as integration of U.S. and local stock market, the more closely ADR prices resemble local stock prices and the lower idiosyncratic risk of ADRs.

In the case of most *OTC traded* ADRs, the U.S. market is simply a price-taking satellite market, whereas most depositary receipts *traded on U.S. exchanges* exhibit own price processes and the U.S. market contributes actively to the price discovery process. International issuers targeting the U.S. capital markets should be aware of this effect attributable to the marketplace. An important alternative market for an issuer's shares is seemingly created only by U.S. exchange-listing depositary receipts.

Furthermore, the relative importance of the market places in terms of price-setting is *biased towards the United States*. The United States stock markets play a relatively more significant role in explaining foreign market returns than local markets in explaining U.S. market returns. This phenomenon is relevant to all market participants trying to understand the interrelation of international capital markets. With growing market integration, the U.S. stock market becomes unproportionately more important for local stock markets in terms of revealing price information. This is evidence of the dominance of the U.S. stock markets in global equity trading and research. In total, this leads to the general conclusion that market organization itself is a major factor in explaining the dynamics of the interrelation of both types of securities.

Besides the well-known pros and cons of ADRs, an issuer seeking access to a U.S. investor base or to U.S. capital should therefore consider in particular that U.S. ADR investors are paying a premium for liquid foreign securities and that exchange-listing has major impacts on the pricing dynamics and liquidity of ADRs. Notably, the pricing of direct listings does not fundamentally differ from the pricing of U.S. exchange-listed ADRs. Since the causes for existing price differences between ADRs and underlying ordinary shares have not been clarified satisfactorily, this should be subject to further research.

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8 Appendix

Table 7: Critical Values in ADF Test for Cointegration

	Critical Values		
	90%	95%	99%
No Lags	2.84	3.17	3.77
Lags	2.91	3.17	3.73

Table 8: Listing and Sponsorship of Final DR Sample in Analysis per Country

		Exchange						**Sponsorship**		
Country	Total	NYSE	AMEX	NASD	144A	OTC	Other/ NA	Sponsored	Unsponsored	NA
ARG	10	6	0	0	2	1	1	10	0	0
AUA	7	0	0	0	1	5	1	6	0	1
AUS	50	9	0	9	2	30	0	41	9	0
BEL	2	0	0	0	0	2	0	2	0	0
BRA	18	5	0	0	1	12	0	18	0	0
CHI	11	9	0	1	0	1	0	11	0	0
CHN	3	2	0	0	1	0	0	3	0	0
DEN	5	3	0	0	1	1	0	4	1	0
FIN	5	1	0	0	3	1	0	5	0	0
FRA	25	7	0	5	2	10	1	22	3	0
GER	13	1	0	0	2	10	0	9	4	0
HK	39	3	0	1	0	35	0	35	4	0
HUN	1	0	0	0	0	1	0	1	0	0
INA	9	0	0	0	5	0	4	9	0	0
IND	4	2	0	0	0	1	1	4	0	0
IRE	5	2	0	2	0	1	0	5	0	0
ITA	10	5	0	0	3	2	0	8	2	0
JAP	139	11	0	15	1	112	0	32	107	0
KOR	6	1	0	0	5	0	0	6	0	0
LUX	1	0	0	0	1	0	0	1	0	0
MAL	10	0	0	0	0	10	0	3	7	0
MEX	21	10	2	0	0	9	0	20	1	0
NET	22	8	0	2	1	9	2	18	2	2
NOR	11	3	0	1	1	6	0	11	0	0
NZ	4	2	0	1	0	1	0	3	1	0
PHI	2	1	0	0	1	0	0	2	0	0
PNG	2	0	0	0	0	2	0	2	0	0
POR	2	1	0	0	1	0	0	2	0	0
RUS	1	0	0	0	0	0	1	1	0	0
SAF	37	0	0	11	1	25	0	16	20	1
SIN	10	0	0	0	0	9	1	5	4	1
SPA	10	6	0	0	0	4	0	10	0	0
SWE	9	2	0	4	1	2	0	9	0	0
SWI	7	1	0	1	0	5	0	7	0	0
TAI	2	0	0	0	1	0	1	2	0	0
THA	1	0	0	0	0	1	0	1	0	0
UK	96	28	5	13	2	47	1	82	13	1
VEN	4	0	0	0	0	4	0	4	0	0
Total	614	129	7	66	39	359	14	430	178	6

Table 9: Zero Returns in Time Series and ADR/ Stock Return Correlations per Country

	No. of DRs	Zero Returns (Avg.)		ADR/ Stock Return Correlation				
		DR	Stock	Daily (Min.)	Daily (Max.)	Daily (Avg.)	Weekly (Avg.)	Monthly (Avg.)
ARG	10	15.41%	16.77%	0.5086	0.8842	0.7128	0.9389	0.9705
AUA	7	8.31%	11.80%	0.5110	0.9700	0.8845	0.9536	0.9895
AUS	50	15.94%	16.87%	0.1799	0.9925	0.8008	0.9562	0.9843
BEL	2	5.33%	11.21%	0.8211	0.9026	0.8619	0.9775	0.9708
BRA	18	15.64%	19.25%	0.3603	0.8848	0.5960	0.9058	0.9714
CHI	11	19.36%	26.10%	0.3966	0.7721	0.6048	0.8839	0.9566
CHN	3	16.98%	22.17%	0.5699	0.9749	0.7385	0.9578	0.9186
DEN	5	14.25%	15.55%	0.4962	0.7507	0.6268	0.9058	0.9624
FIN	5	6.20%	16.97%	0.4742	0.9757	0.8125	0.9502	0.9870
FRA	25	9.07%	7.79%	0.4096	0.9799	0.8452	0.9675	0.9880
GER	13	5.32%	7.69%	0.4669	0.9717	0.9156	0.9848	0.9878
HK	39	19.52%	19.24%	0.2071	0.9904	0.8933	0.9746	0.9813
HUN	1	17.20%	21.50%	0.6648	0.6648	0.6648	0.8551	0.9571
INA	9	21.35%	25.88%	0.8919	0.9593	0.9204	0.9925	0.9781
IND	4	16.08%	27.20%	0.6226	0.9507	0.7724	0.9053	0.9130
IRE	5	18.62%	20.60%	0.0740	0.6786	0.3628	0.7295	0.9154
ITA	10	15.02%	7.84%	0.5037	0.9700	0.7946	0.9341	0.9743
JAP	139	6.64%	17.29%	0.3440	0.9853	0.8912	0.9740	0.9871
KOR	6	14.83%	17.66%	0.4915	0.9832	0.7154	0.7761	0.7489
LUX	1	5.98%	12.90%	0.6561	0.6561	0.6561	0.9424	0.9811
MAL	10	23.43%	23.98%	0.8907	0.9793	0.9441	0.9946	0.9896
MEX	21	19.26%	19.60%	0.2623	0.8697	0.6527	0.9356	0.9668
NET	22	7.50%	9.51%	0.2864	0.9773	0.8387	0.9689	0.9884
NOR	11	10.96%	20.07%	0.4608	0.9679	0.7325	0.9143	0.9651
NZ	4	16.80%	24.10%	0.2449	0.9373	0.4881	0.9305	0.9822
PHI	2	14.11%	29.81%	0.3892	0.6586	0.5239	0.8057	0.9718
PNG	2	12.24%	18.32%	0.9454	0.9692	0.9573	0.9981	0.9972
POR	2	18.53%	11.59%	0.5436	0.9389	0.7412	0.8979	0.9536
RUS	1	6.69%	40.19%	0.7515	0.7515	0.7515	0.9027	0.9850
SAF	37	15.05%	21.52%	0.4372	0.9790	0.8023	0.9636	0.9810
SIN	10	22.62%	27.85%	0.7004	0.9842	0.9400	0.9448	0.9675
SPA	10	14.24%	10.45%	0.6326	0.9698	0.7940	0.9580	0.9857
SWE	9	12.72%	14.31%	0.7888	0.9866	0.8660	0.9704	0.9870
SWI	7	8.22%	9.98%	0.6232	0.9463	0.8167	0.9469	0.9863
TAI	2	14.95%	16.82%	0.8859	0.9842	0.9351	0.9690	0.9981
THA	1	23.55%	17.57%	0.2580	0.2580	0.2580	0.5232	0.4291
UK	96	13.32%	15.31%	0.1631	0.9933	0.7839	0.9349	0.9666
VEN	4	19.74%	17.06%	0.4653	0.7776	0.6371	0.8531	0.9761
Total	614	12.80%	16.93%	0.0740	0.9933	0.8105	0.9496	0.9749

Table 10: Lagged ADR/ Stock Return Correlations and Comovement Ratios CR per Country

	ADR/ Stock Return Correlation				Comovement Ratio *CR*				
	Lagging (-1)		Leading (+1)		Contemporaneous			Lagging (-1)	Leading (+1)
	Maximum	Average	Maximum	Average	Minimum	Maximum	Average	Average	Average
ARG	0.4051	0.1085	0.5343	0.2325	0.4748	0.7383	0.6079	0.4009	0.4616
AUA	0.1533	0.0614	0.1772	0.0764	0.5869	0.8654	0.8058	0.3659	0.3682
AUS	0.5828	0.1225	0.2042	0.0699	0.4486	0.9103	0.7416	0.3888	0.3783
BEL	0.1451	0.1277	0.2584	0.2258	0.7477	0.7701	0.7589	0.4120	0.4232
BRA	0.2869	0.0720	0.5441	0.3773	0.4935	0.7364	0.5716	0.3898	0.5502
CHI	0.4055	0.2590	0.4875	0.1654	0.4467	0.6972	0.5527	0.4095	0.3932
CHN	0.0727	0.0464	0.1629	0.1039	0.5740	0.9738	0.7178	0.3789	0.3937
DEN	0.4323	0.3361	0.2473	0.0909	0.4513	0.6748	0.5609	0.4433	0.3761
FIN	0.5106	0.1077	0.0832	-0.0112	0.5364	0.8820	0.7371	0.3851	0.3510
FRAU	0.4233	0.1214	0.2734	0.0857	0.4941	0.8953	0.7473	0.3813	0.3812
GER	0.4543	-0.0043	0.0665	-0.0125	0.5701	0.8673	0.8159	0.3602	0.3571
HK	0.3408	0.0332	0.2688	0.0296	0.3498	0.9776	0.8786	0.3835	0.3832
HUN	-0.0002	-0.0002	0.1964	0.1964	0.6075	0.6075	0.6075	0.3951	0.4157
INA	0.2611	0.0950	0.2623	0.0805	0.8112	0.8935	0.8627	0.3949	0.3877
IND	0.3276	0.0944	0.2210	0.0887	0.5701	0.9172	0.7369	0.4536	0.4132
IRE	0.7332	0.1795	0.1871	0.0987	0.3533	0.5845	0.4582	0.4274	0.4003
ITA	0.1180	0.0239	0.2134	0.0802	0.5140	0.8579	0.6929	0.3575	0.3739
JAP	0.2788	0.0044	0.4377	0.0423	0.4505	0.8879	0.7882	0.3522	0.3670
KOR	0.2169	0.1424	0.2289	0.1462	0.5103	0.9215	0.6364	0.3789	0.3876
LUX	0.1318	0.1318	0.3387	0.3387	0.5907	0.5907	0.5907	0.4082	0.4457
MAL	0.1635	0.0725	0.1593	0.0909	0.7850	0.9514	0.8680	0.3627	0.3676
MEX	0.2650	0.0868	0.5437	0.2804	0.4795	0.6841	0.5896	0.3984	0.4558
NET	0.5254	0.1270	0.2098	0.0550	0.4523	0.8673	0.7363	0.3952	0.3790
NOR	0.5984	0.1160	0.2956	0.1260	0.4879	0.8953	0.6848	0.3851	0.3908
NZ	0.5415	0.3010	0.2040	0.1124	0.4639	0.8935	0.6272	0.4159	0.3759
PHI	0.5135	0.4355	0.0779	0.0665	0.4860	0.5551	0.5206	0.5627	0.3493
PNG	0.0648	0.0178	0.0845	0.0496	0.8486	0.9178	0.8832	0.3839	0.3989
POR	0.1347	0.0629	0.1266	0.0719	0.4860	0.8030	0.6445	0.3574	0.3692
RUS	0.1151	0.1151	0.1284	0.1284	0.6766	0.6766	0.6766	0.3731	0.4015
SAF	0.5593	0.1707	0.2196	0.1098	0.4636	0.9178	0.7561	0.4148	0.3977
SIN	0.3200	0.0703	0.3295	0.0755	0.8217	0.9533	0.8804	0.3392	0.3445
SPA	0.3153	0.1712	0.1947	0.1120	0.5234	0.8505	0.6959	0.3993	0.3809
SWE	0.2844	0.1172	0.3131	0.1570	0.6106	0.8972	0.7171	0.3743	0.3913
SWI	0.2909	0.1242	0.1564	0.0713	0.5217	0.7875	0.6751	0.4018	0.3915
TAI	0.0426	0.0046	0.0637	0.0333	0.9421	0.9551	0.9486	0.3558	0.3708
THA	0.0178	0.0178	0.1727	0.1727	0.6748	0.6748	0.6748	0.3596	0.3708
UK	0.5355	0.1284	0.3409	0.1315	0.3981	0.8729	0.7044	0.3932	0.3957
VEN	0.2018	0.1288	0.3474	0.1886	0.5934	0.7823	0.6917	0.3854	0.4438
Total	0.7332	0.0898	0.5441	0.0989	0.3498	0.9776	0.7383	0.3823	0.3898

Table 11: Dually-Listed Securities/ Foreign Exchange Return Correlations

Return Correlation	Minimum	Maximum	Median	Average	Std. Dev.	Skewness	Kurtosis
FX/ ADR [US$]	-0.19235	0.63739	0.13973	0.15778	0.01886	0.73725	0.73770
FX/ Local Stock [US$]	-0.12064	0.76233	0.22735	0.24173	0.01963	0.80499	1.17053
FX/ Local Stock [LC]	-0.30771	0.59902	-0.00771	-0.01143	0.01862	0.91178	2.28831

Table 12: Dually-Listed Securities/ Stock Index Return Correlations

	Daily Return Correlation between								
	ADR [US$] -			Local Stock [US$] -			Local Stock [LC] -		
	S&P500 [US$]	Loc. Index [US$]	Loc. Index [LC]	S&P500 [US$]	Loc. Index [US$]	Loc. Index [LC]	S&P500 [US$]	Loc. Index [US$]	Loc. Index [LC]
Min.	-0.15848	-0.19658	-0.16636	-0.12229	-0.22130	-0.22024	-0.10023	-0.22118	-0.21966
Avg.	0.20557	0.50552	0.44643	0.19287	0.52812	0.45529	0.23194	0.43789	0.49482
Max.	0.64776	0.95397	0.96231	0.61352	0.96947	0.96482	0.61084	0.95880	0.96893

Table 13: Median and Standard Deviation of Price Differences per Exchange for 1996 and 1997

	1996 (Average of ...)		1997 (Average of ...)	
	Median of Price Differences	Std. Deviation of Price Differences	Median of Price Differences	Std. Deviation of Price Differences
AMEX	-0.00591	0.21824	0.09486	0.32124
NAS	0.07651	0.33775	0.07649	0.44141
NYSE	0.06479	0.34221	0.10359	0.50358
144A	0.02268	0.16078	0.03880	0.19591
OTC	0.00002	0.14934	-0.02365	0.21652
Other/ NA	-0.01344	0.12119	-0.00365	0.35730
Total	0.02120	0.20644	0.01590	0.29740

Table 14: Descriptive Statistics of Median ADR/ Local Stock Price Differences per Exchange

Exchange	No. of DRs	Median Price Difference over Sample Period			
		Minimum	Maximum	Median	Average
AMEX	7	-0.09457	0.25792	-0.03292	0.05051
NASDAQ	66	-0.1908	0.96205	0.02438	0.09311
NYSE	126	-0.25297	4.0859	0.04206	0.14281
144A	39	-7.38743	0.8408	0.00148	-0.41861
OTC	359	-6.96854	0.49129	0.00138	-0.00744
Other/ NA	17	-0.12657	0.06898	0.00013	-0.00689
Total	614	-7.38743	4.0859	0.00239	0.00765

Table 15: Descriptive Statistics of ADR and Stock Price Time Series per Exchange

Average of ...	**AMEX**	**NASDAQ**	**NYSE**	**144A**	**OTC**	**Other/ NA**	**Total**
Number of DRs	7	66	126	39	359	17	614
Zero Returns							
ADR	24.5%	16.6%	16.3%	12.1%	10.8%	14.9%	12.8%
Stock	19.6%	16.1%	13.5%	17.6%	17.3%	21.5%	16.9%
ADR Price [US$]							
Average	12.49137	34.74352	34.03785	23.11058	36.84338	22.14465	34.37211
Std. Deviation	2.10151	5.37187	5.69729	3.80076	7.1864	4.89772	6.34162
Autocorrelation	0.98586	0.98976	0.98916	0.99026	0.99056	0.98896	0.99013
Stock Price [US$]							
Average	11.9887	34.60099	33.86004	23.55522	36.78689	19.45073	34.23465
Std. Deviation	2.36882	5.40174	5.72841	3.89409	7.21487	5.9631	6.40705
Autocorrelation	0.99006	0.99087	0.98992	0.98997	0.99093	0.99062	0.99071
ADR Return							
Average	-0.00025	-0.00013	0.00018	-0.00088	-0.00067	-0.00037	-0.00049
Std. Deviation	0.02556	0.02211	0.01962	0.02603	0.02363	0.02569	0.02305
Autocorrelation	-0.0498	0.00176	0.01272	0.0304	0.01681	0.06663	0.0144
Stock Return							
Average	0.00012	-0.00008	0.00022	-0.00047	-0.00062	-0.00021	-0.00042
Std. Deviation	0.02239	0.02104	0.01958	0.02486	0.02342	0.02631	0.0227
Autocorrelation	0.0769	0.04017	0.03484	0.04427	0.0212	0.06549	0.02757
Price Difference ADR-Stock							
Minimum	-1.05034	-1.84185	-2.03552	-1.74137	-1.78234	-1.96347	-1.81649
Maximum	1.34739	2.01134	2.37127	1.08639	1.44784	1.97578	1.66301
Span	2.39773	3.85319	4.40679	2.82776	3.23018	3.93925	3.4795
Median	0.05051	0.09311	0.14281	-0.41861	-0.00744	-0.00689	0.00765
Mean	0.06378	0.08111	0.13817	-0.41921	-0.0165	0.01209	0.00029
Std. Deviation	0.30718	0.40304	0.45157	0.30461	0.21576	0.34563	0.28798
Skewness	0.04873	0.02792	0.04807	0.72719	-0.30947	-0.94448	-0.16483
Kurtosis	4.10621	6.12877	6.6477	42.82286	53.54933	38.9551	39.10475
Autocorrelation	0.56551	0.2675	0.36006	0.23932	0.072	0.19897	0.16457
Autocorrelation of Change in Price Difference	-0.33841	-0.41851	-0.38594	-0.39572	-0.46894	-0.41046	-0.44055
Return Correlation							
Lag Correlation	0.13387	0.21557	0.20016	0.07353	0.03749	0.08973	0.0898
Lead Correlation	0.13756	0.1282	0.10408	0.10507	0.08995	0.13999	0.09894
Daily Corr	0.52519	0.61667	0.65428	0.84193	0.89471	0.87231	0.8105
Weekly Corr	0.7795	0.89939	0.8996	0.95074	0.97787	0.97011	0.9496
Monthly Corr	0.81994	0.96766	0.95859	0.96111	0.9865	0.97424	0.97491
Comovement Ratio CR							
Lagging (-1)	0.38869	0.40646	0.40922	0.3793	0.37096	0.38602	0.38235
Contemp.	0.49932	0.57082	0.58459	0.76751	0.81268	0.78459	0.73833
Leading (+1)	0.38814	0.3955	0.38835	0.39141	0.38982	0.39814	0.38978

Table 16: Results of Unit Roots Tests, Error Correction Equation Estimation, and Cointegration Tests I

			Unit Root Test		Equation (4.8)				Equation (4.1)				Cointegration Test	
			ADR	Stock									e_t in (4.8)	e_t in (4.1)
		DRs	F-Statistic	F-Statistic	β_1	Std. Error	t-Statistic	R^2	β_1	Std. Error	t-Statistic	R^2	F-Statistic	F-Statistic
Asia	All	196	-1.23721	-1.23152	0.99393	7.58E-04	-8.00543	0.99459	0.99593	3.53E-05	-115.2852	0.99999	-9.55208	-1.9034
	Exchg.	33	-0.58798	-0.65247	1.00483	1.55E-04	31.25265	0.98587	1.00466	1.13E-04	41.36263	0.99251	-6.8147	-5.48873
	OTC	155	-0.67418	-1.22232	0.99676	9.69E-04	-3.33838	0.99402	0.99932	3.18E-04	-2.14756	0.99936	-9.68748	-6.51987
	144A	8	0.66187	0.13877	0.87389	2.48E-03	-50.7999	0.84729	0.87333	2.47E-03	-51.2369	0.84835	1.27917	0.6215
Australia/ NZ	All	50	-0.20197	-0.26182	0.99987	2.76E-04	-0.45296	0.99273	0.99989	1.57E-04	-0.71294	0.99764	-7.04584	-6.7788
	Exchg.	19	-0.80226	-0.90566	0.99947	3.71E-04	-1.44007	0.9936	0.99975	3.69E-04	-0.68144	0.99369	-5.86991	-6.77606
	OTC	29	-0.07109	-0.23102	1.0001	3.65E-04	0.26797	0.98796	0.99989	1.09E-04	-1.00489	0.99893	-9.27023	-8.94132
	144A	2	-2.64405	-2.74957	0.99978	1.67E-04	-1.30452	0.9911	1.00002	3.88E-05	0.5485	0.99952	-10.47114	-8.07321
India	All	5	-1.94737	-1.98039	1.00128	5.84E-04	2.19851	0.99011	1.00076	1.87E-04	4.07722	0.99898	-8.58141	-8.05222
	Exch.	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	OTC	1	-0.87765	-0.80722	0.99729	1.24E-03	-2.19443	0.95464	0.99679	8.36E-04	-3.84011	0.9792	-8.97224	-8.11524
	144A	4	-2.33207	-2.43191	1.00128	6.20E-04	2.06194	0.99032	1.00081	2.08E-04	3.87233	0.99891	-8.51098	-8.13907
Europe	All	183	-1.76863	-1.78095	0.99987	1.07E-04	-1.19395	0.99443	1.00004	2.09E-06	18.96469	1.00E+00	-9.95614	-7.63739
	Exchg.	80	-1.97401	-2.2068	1.00068	8.40E-05	8.04762	0.99741	1.00087	5.54E-05	15.79732	0.99888	-8.10305	-6.81825
	OTC	91	-1.39314	-1.54751	0.99985	1.28E-04	-1.13748	0.99062	1.0	4.04E-05	-0.00029	0.99906	-9.86052	-7.97362
	144A	12	-2.73366	-2.83545	1.00049	1.13E-04	4.31522	0.98765	1.00061	3.24E-05	18.90121	0.99898	-9.17275	-7.60596
South Africa	All	33	-1.38262	-1.31836	1.00064	2.88E-04	2.22086	0.99576	1.00009	4.74E-05	1.88546	0.99988	-9.47884	-8.49718
	Exchg.	11	-2.69893	-2.68626	1.00006	2.36E-04	0.24315	0.99697	0.9996	1.96E-04	-2.02717	0.99791	-8.19306	-7.22693
	OTC	22	-1.00133	-0.89667	1.00074	3.10E-04	2.39193	0.9953	1.00014	7.23E-05	1.87058	0.99974	-9.3773	-8.49557
	144A	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South America	All	47	-1.57484	-1.59391	NA	NA	NA	NA	0.99997	1.07E-05	-3.08835	0.99994	NA	-6.88627
	Exchg.	26	-1.7002	-1.91013	NA	NA	NA	NA	1.00119	8.28E-05	14.36771	0.9982	NA	-5.9281
	OTC	18	-1.37876	-1.46415	NA	NA	NA	NA	0.99983	2.06E-04	-0.8226	0.99424	NA	-7.12446
	144A	3	-1.79647	-1.89336	NA	NA	NA	NA	0.99947	1.73E-04	-3.03929	0.99045	NA	-6.8751
World w/o	All	467	-1.53024	-1.53376	0.99918	3.54E-04	-2.31046	0.99443	0.99999	1.57E-06	-3.24723	1.00E+00	-10.1459	-7.97948
South America	Exchg.	143	-0.58664	-0.63792	1.00134	1.01E-04	13.30924	0.99402	1.00143	8.51E-05	16.77064	0.99573	-6.48768	-6.65763
	OTC	298	-1.4064	-1.41032	0.99871	5.29E-04	-2.43629	0.99443	0.99999	2.37E-06	-3.09047	1.00E+00	-9.89387	-7.9553
	144A	26	0.01659	-0.53429	0.96406	6.12E-04	-58.68764	0.9267	0.96385	6.03E-04	-59.96217	0.92894	0.10059	0.42258

Note: *The critical values in the unit root tests of the price series are -3.13 (90%), -3.42 (95%), -3.98 (99%).*
The critical values of the t-statistic under the null hypothesis $\beta_1 \neq 1$ are 1.648 (90%), 1.965 (95%), 2.586 (99%).
The critical values in the test for cointegration are -2.91 (90%), -3.17 (95%), and -3.73 (99%). See Table 7.

Table 17: Results of Unit Roots Tests, Error Correction Equation Estimation, and Cointegration Tests II

		Unit Root Test		**Equation (4.8)**				**Equation (4.1)**				**Cointegration Test**	
		ADR	**Stock**									**e_t in (4.8)**	**e_t in (4.1)**
		F-Statistic	**F-Statistic**	β_1	**Std. Error**	**t-Statistic**	**R^2**	β_1	**Std. Error**	**t-Statistic**	**R^2**	**F-Statistic**	**F-Statistic**
Korea	Hansol	-0.11722	-0.40074	1.00483	0.00071	6.79152	0.99333	1.00393	0.00017	22.79763	0.99961	-8.20607	-3.31335
Korea	Korea El. Pwr	-1.51377	-0.78764	1.09356	0.0025	37.4289	0.74029	1.09282	0.00249	37.26818	0.74181	-1.92897	-1.64411
Korea	Yukong	-1.29349	-1.20625	0.69818	0.00524	-57.6424	0.62496	0.69785	0.00519	-58.18368	0.63061	0.00575	-0.26126
Korea	LG Electron.	-1.51503	-1.4509	0.69915	0.00606	-49.6838	0.66323	0.69873	0.006	-50.25214	0.66925	0.14878	-0.02421
Korea	Hyundai	-1.83716	-2.11825	0.94381	0.00515	-10.9007	0.78712	0.94326	0.00509	-11.14756	0.79217	0.10309	-0.86586
Korea	Hankuk	-1.53184	-1.48896	0.56523	0.00624	-69.7026	0.45359	0.56505	0.00621	-70.0545	0.45799	-0.07137	-0.27067
Chile	Telexchile	-2.86639	-2.75275	NA	NA	NA	NA	1.01482	0.00069	21.53001	0.99044	NA	-5.19571
Chile	Provida	-3.36718	-3.13338	NA	NA	NA	NA	1.00877	0.00031	28.17855	0.96749	NA	-6.39764
Chile	Madeco	0.84393	0.70196	NA	NA	NA	NA	1.00745	0.00034	21.91293	0.9772	NA	-5.82163
Chile	Chilectra	-1.24746	-1.49544	NA	NA	NA	NA	0.9999	0.00009	-1.05518	0.99765	NA	-9.34674
Chile	Cervezas	-2.05569	-2.04368	NA	NA	NA	NA	1.00904	0.00024	37.16624	0.9849	NA	-5.26037
Germany	Daimler-Benz	-0.92349	-1.02358	1.00048	0.00013	3.80328	0.99428	1.00062	0.00012	5.36905	0.99534	-10.04344	-9.78522
Germany	OTC	-1.28547	-1.41333	0.99994	0.00013	-0.47404	0.99414	1.00013	0.00004	3.4945	0.99953	-10.48954	-6.23416
UK	British Petrol.	-2.35029	-2.22379	1.00093	0.00013	6.9382	0.99519	1.00113	0.0001	10.87769	0.9971	-6.09191	-4.00764
UK	Danka	-2.28892	-2.13322	1.00183	0.00051	3.6276	0.97072	1.00159	0.00028	5.64474	0.99087	-8.71587	-7.41903
UK	Glaxo Wellc.	-2.93553	-2.80139	0.99923	0.00017	-4.502	0.99565	0.99958	0.00011	-3.86724	0.99829	-10.82605	-8.78238
Australia	News Corp	-1.7079	-1.46034	0.99898	0.00022	-4.6038	0.97979	0.99904	0.00021	-4.55427	0.98193	-7.51817	-6.67573
Finland	Nokia	-1.58378	-1.55385	0.99962	0.0002	-1.8795	0.99678	0.99991	0.00021	-0.41781	0.99662	-7.70474	-8.32297
Netherlands	Royal Dutch	-2.84532	-2.82135	0.99992	0.00013	-0.6407	0.99484	1.0001	0.00012	0.82455	0.99542	-10.27443	-9.2626
UK	SmithKline B.	-3.11149	-2.95836	1.00013	0.00018	0.7301	0.99609	1.00058	0.00016	3.68889	0.99717	-6.36128	-6.09032
Brazil	Telebras	-1.27193	-1.39284	NA	NA	NA	NA	0.99986	0.00011	-1.24012	0.99882	NA	-6.73359
Netherlands	Unilever N.V.	-3.82133	-3.71247	1.00011	0.00014	0.7824	0.99591	1.00038	0.00016	2.36728	0.99486	-6.55878	-7.15649
Argentina	YPF	-3.23076	-3.36956	NA	NA	NA	NA	0.9998	0.00009	-2.21966	0.99852	NA	-7.5927

Note: *The critical values in the unit root tests of the price series are -3.13 (90%), -3.42 (95%), -3.98 (99%).*
The critical values of the t-statistic under the null hypothesis $\beta_1 \neq 1$ are 1.648 (90%), 1.965 (95%), 2.586 (99%).
The critical values in the test for cointegration are -2.91 (90%), -3.17 (95%), and -3.73 (99%). See Table 7.

Table 18: Results of Cointegration Model Estimation per Geographical Region and Cluster

	OTC Traded		**OTC Traded**				**Exchange Traded**		**Exchange Traded**									
			Volatility of Price Differences						**Average Daily ADR Turnover / Average Daily Stock Turnover**									
	All		**Low**		**High**		**All**		**[0, 0.01)**		**[0.01, 0.1)**		**[0.1, 0.5)**		**[0.5, 1)**		**[1, ∞)**	
Asia																		
Model	B		B		B		B		B		B		B		B		B	
# of DRs	155		144		11		33		20		8		3		0		2	
α_x	-0.662	-2.658*	-0.6596	-2.6445	-0.0285	-0.439	0.2442	2.9478	0.3349	3.3821	0.6461	6.1379	0.0101	0.7229	NA	NA	0.2632	4.3007
$\alpha_{21}(1)$	0.5444	2.2799	0.5346	2.2343	0.3706	3.2811	0.5267	5.6191	0.3126	2.8691	0.1379	1.3144	0.3653	7.1253	NA	NA	0.3571	5.5037
R^2 (Δx_t)	0.056		0.0572		0.1582		0.199		0.1521		0.2513		0.2644		NA		0.3052	
α_y	0.6457	7.5778	0.6416	7.5329	0.1307	4.8232	0.2927	5.8199	0.3251	5.9951	0.4991	7.0436	0.0235	1.9798	NA	NA	0.3731	6.3039
$\alpha_{12}(1)$	0.3098	3.5043	0.3146	3.5613	0.7619	22.833	0.4053	7.4764	0.36	6.3969	0.2543	3.6117	0.4697	12.4036	NA	NA	0.2172	3.3144
R^2 (Δy_t)	0.893		0.8936		0.8402		0.5767		0.6247		0.5509		0.3136		NA		0.3068	
Australia/ NZ																		
Model	B		B		B		B		B		B		B		B		B	
# of DRs	29		29		0		19		8		4		5		1		1	
α_x	-0.0241	-0.0878	-0.0241	-0.0878	NA	NA	0.2697	4.1153	0.502	4.0086	0.1672	2.3376	0.2898	5.5604	0.2575	4.269	0.5234	7.6531
$\alpha_{21}(1)$	0.1113	0.4391	0.1113	0.4391	NA	NA	0.4349	6.2079	0.2924	2.3315	0.394	5.2658	0.4769	7.7395	0.3117	4.7644	0.0542	0.7664
R^2 (Δx_t)	0.0577		0.0577		NA		0.3628		0.1891		0.2022		0.4376		0.2908		0.3921	
α_y	0.7874	10.1666	0.7874	10.1666	NA	NA	0.3107	4.6469	0.4593	6.4988	0.4063	7.0713	0.1346	2.283	0.2959	4.6982	0.3825	4.3235
$\alpha_{12}(1)$	0.1768	2.2458	0.1768	2.2458	NA	NA	0.4443	6.1157	0.3192	4.4879	0.2489	3.8684	0.3035	4.5324	0.4422	6.3124	0.329	3.7737
R^2 (Δy_t)	0.9157		0.9157		NA		0.3747		0.6472		0.4676		0.1725		0.3647		0.2683	
Europe																		
Model	B		B		B		B		B		B		B		B		B	
# of DRs	91		76		15		80		24		30		16		4		6	
α_x	0.4147	1.5464	0.7124	1.9354	-0.0034	-0.0389	0.3487	3.1631	0.0933	1.1506	0.1883	1.8744	0.4136	3.6787	0.6311	6.7548	0.4579	4.6025
$\alpha_{21}(1)$	-0.0479	-0.1865	-0.2855	-0.8495	0.1862	1.7198	0.6707	5.9597	0.3732	3.7853	0.6667	5.9566	0.5389	4.8744	0.2545	2.7572	0.482	4.9398
R^2 (Δx_t)	0.0352		0.0339		0.0237		0.3242		0.0742		0.2235		0.3505		0.5202		0.4751	
α_y	0.6475	8.6139	0.9711	10.2915	0.2494	6.0125	0.4426	6.3985	0.2804	6.8218	0.2858	5.0317	0.5719	6.9392	0.6148	5.7517	0.6044	6.1466
$\alpha_{12}(1)$	0.2373	3.1276	-0.0744	-0.7864	0.5422	11.5816	0.4031	5.6869	0.4262	9.2979	0.5986	9.9617	0.2938	3.5276	0.0446	0.4305	0.2952	2.9916
R^2 (Δy_t)	0.9034		0.9156		0.7452		0.6413		0.6663		0.7112		0.5797		0.2877		0.473	

	OTC		OTC Traded				Exchange		Exchange Traded									
	Traded		Volatility of Price Differences				Traded		Average Daily ADR Turnover / Average Daily Stock Turnover									
	All		Low		High		All		[0, 0.01)		[0.01, 0.1)		[0.1, 0.5)		[0.5, 1)		[1, ∞)	
South Africa																		
Model	B		B		B		B		B		B		B		B		B	
# of DRs	22		21		1		11		0		2		3		4		2	
α_x	0.1561	0.4166*	-0.1872	-0.5062	0.3605	3.7104	0.4563	4.3661	NA	NA	0.2109	2.6085	0.4328	3.1999	0.4654	4.9147	0.4834	4.8318
$\alpha_{21}(1)$	0.4575	1.3019	0.6691	1.931	0.0626	0.6398	0.4302	4.1556	NA	NA	0.1378	1.6833	0.3931	2.986	0.3442	3.5733	0.3125	3.1992
R^2 (Δx_t)	0.0673		0.066		0.1274		0.4122		NA		0.1103		0.2774		0.3719		0.4205	
α_y	0.7448	9.0653	0.7505	9.0429	0.4578	6.3286	0.49	5.5973	NA	NA	0.455	7.0235	0.5869	6.8428	0.3765	4.5004	0.5817	6.1585
$\alpha_{12}(1)$	0.2238	2.7207	0.2226	2.6671	0.3094	4.1655	0.4684	5.3304	NA	NA	0.3098	4.4448	0.3159	3.6894	0.535	6.362	0.4172	4.3979
R^2 (Δy_t)	0.9469		0.9454		0.5615		0.5651		NA		0.5284		0.6776		0.5213		0.5393	
South America																		
Model	A		A		A		A		A		A		A		A		A	
# of DRs	18		0		18		26		3		6		6		2		9	
α_x	0.2586	1.5369	NA	NA	0.2586	1.5369	0.2085	1.2983	0.2586	2.0367	0.1308	1.1017	0.2606	2.1742	0.144	2.7615	0.1968	1.365
$\alpha_{21}(1)$	-0.1329	-0.7856	NA	NA	-0.1329	-0.7856	0.0612	0.349	-0.1746	-1.3194	0.3075	2.2018	0.0737	0.5761	0.2256	3.4386	0.1269	0.8557
R^2 (Δx_t)	0.03		NA		0.03		0.0499		0.0237		0.053		0.0713		0.1073		0.0516	
α_y	0.2966	2.382	NA	NA	0.2966	2.382	0.1058	0.628	0.1886	1.6092	0.1097	0.9146	0.1363	1.1957	0.0692	1.1194	0.181	1.0694
$\alpha_{12}(1)$	0.6208	5.1326	NA	NA	0.6208	5.1326	0.3463	1.8413	0.5258	4.3809	0.2137	1.5136	0.2425	2.0228	0.1096	1.32	0.2709	1.4687
R^2 (Δy_t)	0.3904		NA		0.3904		0.0752		0.1696		0.0432		0.1104		0.0495		0.0445	
World w/o South America and India																		
Model	B		B		B		B		B		B		B		B		B	
# of DRs	297		270		27		143		53		43		27		9		11	
α_x	-0.7193	-2.9006	-0.7222	-2.9089	-0.0555	-0.5551	0.2775	3.1674	0.2676	2.7057	0.2806	2.5006	0.0997	2.0438	0.2509	4.0988	0.4804	5.9093
$\alpha_{21}(1)$	0.5957	2.4973	0.5858	2.4518	0.3728	2.9223	0.6961	7.7522	0.5885	5.4478	0.695	6.1559	0.879	14.1763	0.3515	5.3117	0.3034	3.7358
R^2 (Δx_t)	0.0521		0.0544		0.0831		0.4257		0.2152		0.3608		0.4932		0.3062		0.4626	
α_y	0.635	7.5406	0.6349	7.5142	0.2488	6.1064	0.4138	5.6761	0.3319	6.027	0.4749	6.0385	0.1448	3.1332	0.3083	4.8716	0.5052	5.3766
$\alpha_{12}(1)$	0.3202	3.6535	0.3204	3.6439	0.6075	13.3904	0.45	5.9209	0.4339	7.4692	0.4284	5.2595	0.6485	11.0556	0.4297	6.1126	0.3201	3.4263
R^2 (Δy_t)	0.8946		0.8948		0.826		0.5242		0.6544		0.6298		0.4322		0.3652		0.3811	

Notes: α_x *Speed of adjustment parameter in (4.5) (Model A) or (4.7) (Model B)*
$\alpha_{21}(1)$ *Coefficient of regressor Δy_{t-1} in (4.5) (Model A) or (4.7) (Model B)*
α_y *Speed of adjustment parameter in (4.4) (Model A) or (4.6) (Model B)*
$\alpha_{12}(1)$ *Coefficient of regressor Δx_{t-1} in (4.4) (Model A) or Δx_t in (4.6) (Model B)*
* *Values in respective second columns are t-statistics. The critical values are 1.648 (90%), 1.965 (95%), 2.586 (99%)*
R^2 (Δx_t) *R-squared of regression equation (4.5) (Model A) or (4.7) (Model B)*
R^2 (Δy_t) *R-squared of regression equation (4.4) (Model A) or (4.6) (Model B).*

Table 19: Results of Granger Causality Tests per Geographical Region

			OTC Traded	OTC Traded		Exchange Traded	Exchange Traded				
				Volatility of Price Differences			Average Daily ADR Turnover / Average Daily Stock Turnover				
			All	Low	High	All	[0, 0.01)	[0.01, 0.1)	[0.1, 0.5)	[0.5, 1)	[1, ∞)
Asia	No. of Stocks		155	144	11	33	20	8	3	0	2
	No. of Observations		529	529	529	529	529	529	529	NA	529
	Null Hypothesis:										
	ADR does not cause Stock	F-Statistic	2.44412	2.48253	3.55053	23.03824	13.47914	25.06609	15.19258	NA	35.41752
	Stock does not cause ADR	F-Statistic	822.14940	830.73810	503.64700	120.67188	148.80509	102.97180	38.03912	NA	31.65393
Australia/ NZ	No. of Stocks		29	29	0	19	8	4	5	1	1
	No. of Observations		529	529	NA	529	529	529	529	529	529
	Null Hypothesis:										
	ADR does not cause Stock	F-Statistic	1.70255	1.70255	NA	51.44844	20.00018	22.70159	69.57916	33.90023	46.89092
	Stock does not cause ADR	F-Statistic	944.16958	944.16958	NA	53.01359	168.61898	69.94714	19.63161	49.74223	31.20150
Europe	No. of Stocks		91	76	15	80	24	30	16	4	6
	No. of Observations		529	529	529	529	529	529	529	529	529
	Null Hypothesis:										
	ADR does not cause Stock	F-Statistic	2.50361	2.16130	1.89667	45.52969	6.83214	27.86617	50.28885	89.06562	84.40212
	Stock does not cause ADR	F-Statistic	825.44516	914.96147	276.77072	159.48219	179.40912	232.98523	120.28296	29.53712	76.75791
South Africa	No. of Stocks		22	21	1	11	0	2	3	4	2
	No. of Observations		529	529	529	529	NA	529	529	529	529
	Null Hypothesis:										
	ADR does not cause Stock	F-Statistic	3.76221	3.76679	9.40186	59.69698	NA	9.86314	30.44479	51.69573	58.33410
	Stock does not cause ADR	F-Statistic	1529.84227	1495.55104	114.62285	116.86704	NA	96.12460	181.88936	102.03318	102.34569
South America	No. of Stocks		18	0	18	26	3	6	6	2	9
	No. of Observations		530	NA	530	530	530	530	530	530	530
	Null Hypothesis:										
	ADR does not cause Stock	F-Statistic	0.51595	NA	0.51595	1.46810	0.53265	3.63362	2.82568	9.81333	2.19489
	Stock does not cause ADR	F-Statistic	56.33955	NA	56.33955	4.13157	15.48901	2.31048	6.36638	3.79499	2.73604
World w/o South America and India	No. of Stocks		297	270	27	154	53	43	27	9	11
	No. of Observations		529	529	529	529	529	529	529	529	529
	Null Hypothesis:										
	ADR does not cause Stock	F-Statistic	2.34458	2.43000	3.68142	78.12082	25.66976	55.12550	93.82389	38.16397	73.24303
	Stock does not cause ADR	F-Statistic	836.12942	841.68579	462.22319	96.28994	168.50181	153.74138	72.01919	49.38526	51.39273

Note: The critical values of F-statistic are 3.054 (99%), 2.232 (95%), and 1.859 (90%).

Table 20: Results of Granger Causality Tests for Individual Firms

		F-Statistic	
	Null Hypothesis	**ADR does not cause Stock**	**Stock does not cause ADR**
Korea	Hansol	1.5908	4973.29
Korea	Korea Electric Power	7.15932	31.8188
Korea	Yukong	0.92898	57.1685
Korea	LG Electronics	1.63467	295.392
Korea	Hyundai	1.41074	96.7964
Korea	Hankuk	2.9919	98.1931
Germany	Daimler-Benz	60.48804	60.28366
Germany	OTC	5.78346	1250.94
UK	British Petroleum	28.81436	166.8762
UK	Danka	26.69365	407.0815
UK	Glaxo Wellcome	18.40789	205.7003
Australia	News Corp	60.03507	63.66707
Finland	Nokia	81.02212	59.98598
Netherlands	Royal Dutch	50.26492	84.41072
UK	SmithKline Beecham	44.63209	102.9762
Brazil	Telebras	6.70263	0.82755
Netherlands	Unilever N.V.	95.73555	22.09723
Argentina	YPF	7.60541	1.991

Note: The critical values of F-statistic are 3.054 (99%), 2.232 (95%), and 1.859 (90%).

Table 21: Summary of Empirical Results

Feature	Empirical Finding
Comovement	▪ Depositary receipt and common stock prices are significantly correlated for most pairs of securities. ▪ Rates of return and comovement ratios, however, differ widely across corresponding securities. ▪ Some firms exhibit high leading or lagging return relationships. ▪ Two clusters of pairs of securities can be formed in terms of the statistical measures applied: The company's *country of origin* and the *U.S. marketplace* on which the depositary receipt is traded are major factors in distinguishing the inter-market pricing relationship.
Cointegration	▪ Almost all pairs of securities are systemically linked through **cointegration**. ▪ All price processes of depositary receipts and ordinary shares are stationary in first differences. ▪ The slope of the cointegrating regression equation is close to unity – except for five Korean Rule 144A ADR programs. Despite these exceptions, prices of depositary receipts do not move independently from prices of underlying ordinary shares in any sample case.
Satellite/ Dominance	▪ The relative importance of market places in terms of price-setting is **biased towards the U.S.** ▪ In the case of most OTC traded ADRs, the U.S. market is simply a price-taking satellite market, whereas most depositary receipts traded on U.S. exchanges exhibit own price processes and the U.S. market actively contributes to the price discovery process. ▪ In the case of <u>U.S. exchange-listed</u> ADRs, both markets react to deviations from equilibrium. This effect is independent of the U.S. market share of overall trading volume. However, the magnitude of domestic reactions to deviations from long-run equilibrium is increasing in the relative importance of the U.S. market (in terms of trading volume). ▪ For most <u>over-the-counter</u> DR programs, there is evidence that U.S. ADR returns do not cause domestic common stock returns. ▪ The higher the U.S. trading volume in ADRs, the more independent from the firm's home market do ADR prices move. ▪ With increasing U.S. ADR turnover, the U.S. becomes more important for the domestic market and the domestic market less important for the U.S. ADR market.
Price Transmission	▪ Price transmission from one market to the other varies by **geographical region**. ▪ European and African companies react more heavily to preceding price deviations than Asian and Australian firms. The same is true for U.S. market reactions to preceding price deviations. European markets react more heavily to preceding U.S. movements than any other geographical region. ▪ Price transmission from one market to the other varies by **ADR marketplace**. ▪ Information transfer from the ADR market to the home stock market is much stronger for exchange-traded than for over-the-counter traded depositary receipts. In the reverse direction, the link is much weaker for exchange-traded DRs than for OTC-traded DRs. ▪ Market organization itself and not liquidity is the key factor in this asymmetry.
Price Differences	▪ U.S. exchange listed ADRs exhibit significantly **positive long-run price differences** compared to underlying ordinary shares. Contemporaneous price differences may temporarily be substantial.
Risk Factors	▪ The influence of foreign exchange rates on ADR returns is low. ▪ Stocks dually-listed in the United States still trade domestically. Daily return correlations between ADRs and stock market indices are significantly higher with the corresponding home market index than with the S&P 500. Return correlations of ADRs are slightly lower with the domestic stock index and slightly higher with the S&P 500 than the respective figures of common shares.
Volatility	▪ ADR prices are empirically only few more volatile than the respective common shares. ▪ Market volatility has significant influence on inter-market price differentials. In times of high market volatility, volatility of price differences is also high.