PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE

ESCUELA DE INGENIERIA

FINANCIAL DISLOCATIONS IN WORLD INDEX FUTURES

ENRIQUE ALONSO FRANCISCO SEPULVEDA ARAYA

Thesis submitted to the Office of Research and Graduate Studies in partial fulfillment of the requirements for the Degree of Master of Science in Engineering

Advisor:

GONZALO CORTAZAR SANZ

Santiago, Chile, (August, 2013)

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A Anita, quien me enseñó a alcanzar lo imposible.

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RESUMEN

En esta investigación se estudia empíricamente las desviaciones con respecto a la paridad *future-cash* para 14 índices accionarios de Europa, América y Asia para el periodo de tiempo entre el año 2001 al 2012. Se encuentra evidencia empírica que las desviaciones en futuros de índices accionarios se transmiten a través de los mercados de diferentes países que difieren en grado de sofisticación y zona geográfica. Utilizando tanto un análisis de componentes principales como un modelo con factor dinámico, se descubre que las desviaciones son conducidas por un factor común. El análisis empírico muestra que este factor refleja presiones de demanda para índices accionarios, sentimiento mundial de mercado y costos de cobertura. Además, se realiza un análisis de rezagos para Asia, Europa y América del Norte y se descubre evidencia de la existencia de contagio de las desviaciones con respecto al *fair-value* en las regiones estudiadas. Esta investigación no solamente es el primero en estudiar estas desviaciones internacionalmente, sino que también abre nuevas posibilidades de investigación en el entendimiento de la valorización de derivados en un mundo globalizado.

Keywords: *Dislocaciones de mercado, Paridad future-cash, Límites al arbitraje, Mercados internacionales*

ABSTRACT

In this paper we empirically study deviations from the standard textbook no-arbitrage relationship of 14 index futures from Europe, America and Asia between 2001 to 2012. We find strong empirical evidence that such deviations are pervasive across different countries that differ both in terms of sophistication and location. By using both a principal components analysis and a dynamic factor model, we find that deviations are driven by a common factor. Our empirical analysis shows that this factor reflects demand pressure for index futures, world market sentiment, and hedging costs. Furthermore, we perform a lead-lag analysis for Asia, Europe and North America, and find evidence of contagion in deviations from fair-value across different regions. Our research not only is the first to study such deviations internationally, but also opens new venues of research in understanding the pricing of derivatives in a globalized world.

Keywords: *Market Dislocations, Futures-Cash Parity, Limits to Arbitrage, International Markets*

1. ARTICLE BACKGROUND

1.1. Introduction

Financial dislocations are deviations between the market price and the theoretical price of an asset (Pasquiarello, 2013). The classical financial theory proposes that an asset can only have a unique price, if not, an arbitrage opportunity will appear and an arbitrager will be correct the deviation. Nevertheless, under certain conditions, deviations from theoretical prices have been found and in occasions, these deviations do not disappear easily and remain in time.

These deviations happen more often in times of financial stress. Dislocations have occurred during the Asian crisis, the U.S. housing bubble, the 2007-2009 financial crisis and the recent crisis due to the European debt, among others. Because of this, it is becoming increasingly necessary to understand how financial dislocations affect the market, are transmitted from market to market and end up affecting the real sector of economy (Hubrich & Tetlow, 2011). This, in turn, affects the decision makers of financial policies, as well as the investors, who must take into consideration this phenomenon when making future decisions.

Different authors postulate that there is propagation in several markets, especially in times of financial stress. Pasquairello, 2013, shows propagation in deviations of 3 different arbitrage activities (ADR, interest rate coverage and triangular parity). Baker & Wurgler, 2006 and Baker & Wurgler, 2012 show propagation in investor sentiment in major world markets; Fleckenstein, 2011 proposes the existence of a correlation in the movement of future-cash dislocations; Longstaff, et al., 2012, show correlation between TIPS and T-Bonds deviations in the U.S. and other markets.

The literature provided several answers to the existence of these dislocations, associating them to transaction restrictions, investors' sentiment, slow-moving capital, a non-synchronous trading or a liquidity problem. However, this paper does not seek for a definite explanation to this phenomenon, but a description of the existence of these dislocations. In the study, it is stated that not only dislocations occur in each market, but that these deviations are correlated among different world markets, and that they have a common dynamics that makes them move according to a certain pattern, linked to financial distress and stress periods. Furthermore, it is proposed that this dynamics could propagate between markets of different geographical places, being this contagion even more intense in financial stress periods.

In order to study financial dislocations, deviations between the theoretical price and the market price of the future-cash parity of 14 indices belonging to different geographical zones (Europe, Asia and North America) were analyzed. A correlations' study was made and an unobservable variable was found, common to all these dislocations, which represented the co-movement of these detours along the market. This variable was obtained through two methods: a) the estimation of the first principal component common to the deviations of the 14 future-cash parities of the stock indices; and b) the dynamic models calibrated through the Kalman filter, in which the state variable corresponds to the co-movement factor of the 14 studied dislocations.

In order to see if there was contagion among the dislocations, a dynamic model was estimated, calibrated through the Kalman filter, however this time with four state variables: one that represents the global co-movement of the index deviations and three that represent the local co-movement for each region. These last three state variables represent the common index deviations among indices of a same geographical area.

Finally, the global co-movement factor was linked to several previous hypotheses of the literature, as the cost of debt, the cost of short sale, the demand pressures and the investors' sentiment. For that purpose, linear regressions were made in level and first differences, adjusted according to the heteroskedasticity and correlation, using the Newey-West method, in which proxies previously used in short sale cost literature, demand pressures and sentiment were used as explanatory variables.

The results signal the existence of the financial dislocation phenomenon and the existence of a common pattern that leads the movement along with these deviations. As a matter of fact, a positive (and significant) correlation was found among the dislocations of the different studied markets. Furthermore, the global co-movement factors that were obtained through principal components and the Kalman filter give indication of an unobservable variable that leads the dislocations' movement (curiously enough, this variable turns more negative in financial stress periods). Apart from this, there is a contagion among the dislocations of markets in different geographical areas. And finally, the explanatory variables that represent debt cost, short sale cost, demand pressures and sentiment are significant, despite the fact that the R^2 of regressions is not so high, which indicates that there are additional factors that explain the dislocations.

These results are important because they show the existence of a phenomenon that affects the financial markets directly and that has become evident especially in the last financial crises. For example, the crisis of 2007-2008 began with the U.S. subprime crisis, and then it expanded to the world markets. Several authors have shown how these dislocations become deeper when there is financial stress. Therefore, this paper is a contribution to the studies on deviations with respect to the one price law and the arbitrage theory. It is not the purpose of this paper to dispute the classical valorization theory, but to give a step forward in the comprehension of the financial dislocation phenomenon, so that the classical financial theory can be complemented with this phenomenon increasingly recognized but not yet thoroughly understood.

This thesis is structured in two Sections in the following way: In Section 1 an introduction to the research is shown. Specifically in Section 1.2, a description of the goals of the thesis is done, in Section 1.3 a brief bibliographic review on previous studies related to deviations of the one price law and the arbitrage limits. In Section 1.4 a future research is proposed. Section 2 presents our research. Section 2.1 presents an introduction to the paper, 2. 2 describes the data and methodology that we use to build our measure of dislocation in index-futures contracts. In Section 2.3 we document empirically the co-movement in index futures dislocations while Section 2.4 explores contagion effects. Section 2.5 examines potential drivers of co-movement in dislocations. Section 2.6 concludes.

1.2. Main Objective

This thesis studies the financial dislocations of the future-cash parity of different indices and how these are pervasive through the different markets, being more intense in times of financial stress. This research shows that these dislocations have a common movement in world markets, proves that dislocations really are transmitted from market to market –being more intense in times of crisis– and relates these dislocations with different explanations mentioned in the literature. In order to do this, the future-cash parity of 14 indices belonging to different geographical zones (Europe, Asia and North America) are analyzed, along with their correlation.

The goal is to find a common local factor that rules the overall movement of the indices that belong to a same geographical area, and a common global factor that rules the movement of the dislocations of all studied markets. This last goal was obtained by means of two different methods: principal components and a dynamic model calibrated through the Kalman filter, in which the state variables represent the local and global co-movement factors. Furthermore, we seek to show that dislocations in one region predict dislocations in other regions.

Finally, we partly explain the global co-movement variable with causes studied previously in literature, specifically with the debt costs, short sale costs, demand pressures and investors sentiment.

1.3. Literature Review

Market dislocations occur when, under certain circumstances, there is a deviation in the theoretical price and the market price of a financial asset (Pasquariello, 2013). These deviations pose problem to the classical valorization theory, which postulates that an asset must have a unique market price, otherwise there is a chance for arbitrage and the very same arbitrators will immediately be the ones to correct the asset price. The recent financial crisis requires the understanding of how these dislocations happen, how these are spread in the different global markets and how they finally end up affecting the real sector of economy (Hubrich & Tetlow, 2011).

1.3.1. Identified deviations in the Literature

Several studies have shown situations in which there are differences in prices of a same asset, without necessarily meaning an arbitrage opportunity. Pasquariello, 2013, studies dislocations of prices in 3 simple arbitrage activities described in books: in ADR (actions) arbitrage activities, triangular parity (currencies) and coverage parity of interest rates (rates); Campbell et al, 2009 and Fleckenstein, Longstaff, 2012, discover trespasses to the one price law among the TIP swap and the T-bonds of the U.S. market. Furthermore, other authors describe deviations in other kind of arbitrage activities. For instance, in the Siamese parity (Mitchell et al., 2002), CDS-Bond yield parity (Duffie, 2010; Garleanu & Pedersen, 2011), Treasury Bond-note off the run parity (Musto et al., 2011), Future-cash parity (Naranjo, 2011; Roll et al., 2007), in the interest parity coverage (Akram et al.,2008; Coffey et al., 2009; Griffoli & Ranaldo, 2011), put call parity(Lamont & Thealer, 2003; Ofek et al., 2004), closed-end funds parity (Pontiff, 1996), convertible bonds parity (Mitchel & Pulvino, 2010), exchange funds parity (Chacko et al., 2012) and in the triangular arbitrage activity (Lyons & Moore, 2009; Kozhan & Tham, 2012)

1.3.2. Explanations to the deviations

The literature has suggested several causes that can be attributed to these deviations. Pasquariello, 2013, proposes that in times of financial stress, these dislocations become bigger and more persistent. The last financial crisis of 2007-2009 is a good example on how the financial stress causes bigger dislocations (Matvus & Seru, 2011). Duffie, 2010, shows how during the Lehman Brothers' fall, the CDS Rate-Par Bond Yield Spread was significantly different from 0, and kept like that during a period of time, demonstrating that the arbitrage to correct the process was not possible during that period of time.

Literature states that one of the possible dislocation causes is the arbitrage constraints of the market. One of the first studies on the reasons of these deviations is Mackinlay and Ramaswamy (1989) who studied the behavior of the S&P 500's time series of future prices and index prices in a period of time between 1982 and 1989. They defined the mispricing as:

$$X_{t,T} = \frac{\left[F_{t,T} - S_t e^{(r-d)(T-t)}\right]}{S_t} \qquad (1.1)$$

where $X_{t,T}$ is the mispricing in the moment t, $F_{t,T}$ is the price of the future contract with maturity in T in the moment t, S_t is the prices of the index in the moment t, r the risk free rate and d the dividend yield. Mackinlay and Ramaswamy (1989) propose that this mispricing is almost always different to zero and it moves inside a band delimited by cost of transaction. Given the no-arbitrage theory, the mispricing absolute value should not be higher than the limits imposed by band, however sometimes mispricing breaks this law and start to move outside the band.

Mackinlay and Ramaswamy associate this strange behavior of the mispricing to 3 possible causes: the greater the time remaining to maturity of futures contract, a greater probability of unexpected changes in the dividend policy; the difference between forward and futures prices can due be to costs or gains to the marking to market of future cash flows, an arbitration with a portfolio approximate to the original portfolio (i.e. index) can induce errors because it is not a good index tracking.

Miller et al. (1994) study the violations of the law of non-arbitrage phenomenon associating this to the non-trading, non-synchronous trading and lack of liquidity of the assets studied. There is evidence in the literature of the existence of mean reversion in the basis between future contracts and the underlying. There is a line of research that suggests that the observed mean reversion in basis changes in index and stock futures trading is due to arbitrage. Nevertheless, and based on the time series of S & P500 futures and stock index prices, Miller et al. (1994) propose that arbitrage does not always exist and that mean reversion is a statistical illusion because the index has illiquid shares that incorporate market information slower than most liquid stocks and that their index futures contracts.

Roll et al. (2007) suggests that liquidity affects prices deviations from the no-arbitrage relationship, because if there is liquidity then arbitrage is easier. On the other hand, a wider band of the basis triggers more arbitrage, leading to greater liquidity. Using prices data and indexes of NYSE futures, Roll et al. examine the dynamic relationship between market liquidity and the basis of the future-cash parity. Through an autoregressive vector model and the Granger causality test applied to time series of future and underlying basis at different maturities. It is concluded that basis could affect the liquidity in the short-term and, on the other hand, you have a long term relationship where the liquidity affects basis.

Naranjo (2011) examines theoretically and empirically how the cost of short sale and debt costs affect the valuation of futures in the S&P 500 index. In the presence of these costs, it is not possible for an agent to hedge for a 100%, mostly if he is exposed to external demand shocks. Naranjo (2011) assumes two types of agents in the market, speculators and arbitrageurs. Arbitrageurs provide liquidity to the market, taking the opposite position to speculators. When speculators take long positions in the futures, arbitrageurs take short and hedge taking long positions in the underlying, financing through debt, using debt costs. Moreover, when speculators take short positions in the futures, the arbitrageurs take long positions in the futures and short sale the underlying, facing short sale costs. Both debt costs and short sale costs makes arbitrageurs see a different price for the futures, generating demand pressures in the futures market. Through dynamic models, Naranjo (2011) theoretically test the existence of a risk premium that arbitrageurs require to provide liquidity. Moreover, Naranjo (2011) finds a latent demand factor, which through regression models relates to short sale costs, debt costs, investor demand pressures and sentiment. But Naranjo is not the only one who studies how demand imbalances can affect the valuation of derivatives. Vayanos & Vila (2007) study how these imbalances affect the structure of term in the short and long term and Galeanu et al. (2007) shows how demand pressures should be incorporated into the valuation of options since traditional valuation models fail to capture this effect.

The literature explores various causes that explain the deviations. Within causes mentioned in the literature but not analyzed in this thesis, are the price staleness (Ahn et al. 2008) and slowing capital moving (Brunnermeir & Pedersen, 2008; Duffie, 2009; Fleckenstein, Longstaff et al. 2012; Gromb & Vayanos, 2010). These latest drivers can be incorporated in future research

1.3.3. Dislocations are pervasive through different markets in the world

Other authors have also noticed how the dislocations are pervasive through different markets, being bigger and longer in financial stress periods. Naranjo (2011) describes those dislocations among future-cash and call-put parity of different U.S. indices positively correlate. Baker & Wurgler (2012), study how the sentiment is transmitted through the different markets of several countries, and how that sentiment can predict the market return. Using different proxies for sentiment, Baker & Wurgler (2012) get a world sentiment index and show how this index affects the performance of different assets in the world. Longstaff et al. (2012), show that parity trespasses among TIPS and T-Bonds correlate with other trespasses in other US markets. In fact, Longstaff et al. (2012) attribute dislocation in TIPS and T-Bonds parity to slow motion capital and say that the dislocation could be drive by a common factor in many different markets. Hubrich & Tetlow (2011), describe how the financial stress is pervasive through different world markets. Specifically, Hubrich & Tetlow (2011) describe the implication that shocks in the real economy have for financial stress. Pasquiariello (2013) finds a correlation among the parity trespasses of ADR, interest rate coverage and triangular parity, being this one stronger in times of financial stress. Based on the standardized log difference between the current price and the theoretical price, Pasquiarello (2013) builds an index to measure the degree of dislocation that exists in the market. This index turns out to be cyclical and has co-movement with the degree of financial stress or financial market distress.

1.4. Future Research

The methodology developed in this thesis is general and applicable to other violations of parity. Following the same methodology, this research can be expanded through 3 lines:

The first line of research considers finding a common factor to other parity relations using the methodology described in this work. As mentioned above, violations of the no-arbitrage law has been found in the literature and in different asset classes. An interesting case study could be study dislocations in the call-put parity through a dynamic model. It could be interesting because options are commonly traded assets in the market as also correlation has been found between deviations from different markets. It would also be interesting to expand the research by Pasquarello (2013) and find a common factor to ADR parity, interest coverage rate parity and triangular parity.

The second line of research is to study how deviations from the call-put parity are pervasive in different markets following the same methodology of this thesis. The same can be expanded to deviations of the 3 parity relations described by Pasquiarello (2013). It is hoped that if dislocations in the future-cash parity is disseminated, dislocations in the rest of parities would be too.

Finally tests can be done on whether the explanatory factors studied in this thesis (cost of debt, cost of short selling, investor demand pressures and sentiment) also explain deviations in other parities. A good idea is to find local proxies of investor sentiment for each region studied or used liquidity proxies such as the margin requirement. Another factor that would be interesting to test is the asymmetry of information, for which the open interest could be used as a proxy.

It’s worth mentioning that this work neither seeks a definite explanation to the existence of financial dislocations, nor disputes the classical valorization theory. The idea of this research is to contribute to the arbitrage literature, showing the existence of a phenomenon each day more important and recognized in literature, given the events occurred in the last years regarding the U.S. financial crisis and the European debt crisis.

2. FINANCIAL DISLOCATIONS IN WORLD INDEX FUTURES

2.1. Introduction

The futures-cash parity is a well-known and established relation between a futures contract and its underlying asset. In a frictionless world, deviations from this parity would induce arbitrage opportunities. Nevertheless, a number of empirical studies in finance[1] have found that index futures might deviate temporarily from this simple no-arbitrage relationship. Up to now, however, these studies have focused only on the U.S. market.

In this paper we study deviations from the standard textbook no-arbitrage relationship of 14 index futures from Asia, Europe, and North America between 2001 and 2012. We find strong empirical evidence that such deviations are pervasive across different countries that differ in terms of sophistication and location. By using both a principal component analysis and a dynamic factor model, we find that deviations are driven by a common factor. Our empirical analysis shows that this factor reflects U.S. and world market sentiment, hedging costs, and international capital flows. Furthermore, we perform a lead-lag analysis for Asia, Europe and North America, and find evidence of contagion in deviations from fair-value across different regions.[2] Our research not only is the first to study such deviations internationally, but also opens new venues of research in understanding the pricing of derivatives in a globalized world.

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[1] For example, Cornell and French (1983), Modest and Sundaresan (1983), Figlewski (1984a, 1984b), Arditti et al. (1986), Mackinlay and Ramaswamy (1988), and Merrick (1988, 1989) document the existence of substantial and sustained deviations between actual stock index futures and theoretical values, i.e. the futures-cash basis, in the U.S. market.

[2] In a similar spirit, Baker et al. (2012) study how market sentiment is transmitted worldwide, whereas Hubrich and Tetlow (2011) describe how financial stress is propagated in different world markets.

Even though some people might interpret these deviations from fair-value as an arbitrage opportunity, we follow Pasquariello (2013) and use the term **dislocation** for deviations that might occur because of market frictions that impose limits to arbitrage (Shleifer and Vishny, 1997) impeding arbitrageurs to move prices quickly towards their fundamental values.[3] Since frictions are more prominent during economic crises and times of market stress, we expect dislocations to be more pronounced during periods of economic unrest such as the financial crisis of 2007-2008.

Dislocations are not exclusive to index futures markets. There is now a wide body of literature in finance that has studied the deviations from fair-value in several seemingly unrelated financial markets. For example, a recent paper by Pasquariello (2013) studies deviations from no-arbitrage of ADRs, currency forwards and currency pairs. Fleckenstein (2013) analyzes the mispricing between nominal and inflation-linked bonds in G7 countries. Fleckenstein et al. (2012) study the correlation between TIPS and T-Bonds' price deviations from fair-value in the U.S. and other markets. These studies also provide empirical evidence of commonality in deviations.[4] However, to the best of our knowledge, no previous studies have looked at dislocations in index futures across different countries. [5]

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[3] Reasons that would impose limits-to-arbitrage on index futures include transaction costs (Mackinlay and Ramaswamy, 1988), non-synchronous trading (Lo and Mackinlay, 1990; Miller et al., 1994), price staleness (Ahn et al., 2002), market liquidity (Roll et al., 2007), demand imbalance (Garleanu et al., 2009; Vayanos and Vila, 2009; Naranjo, 2011), investor sentiment (Baker and Wurgler, 2006; Baker et al., 2012) and slow moving capital (Brunnermeier et al., 2009; Duffie, 2010; Fleckenstein et al., 2013; Gromb and Vayanos, 2010).

[4] Naranjo (2011) also describes how dislocations in U.S. index futures and put-call parity relations for index options are positively correlated.

[5] Deviations from fair-value have also been found in other markets: relative pricing of parent and subsidiary companies (Mitchell et al., 2002), CDS-Bond yield parity (Duffie, 2010; Garleanu and Pedersen, 2011), Treasury Bond-Note off-the-run parity (Musto et al., 2011), futures-cash parity in U.S. index futures (Roll et al., 2007), covered interest parity (Akram et al., 2008; Baba and Packer, 2009; Fong

We focus on index futures rather than futures written on other underlying assets for several reasons. First, index futures are among the most liquid exchange-traded derivatives in many countries around the world. Second, the no-arbitrage valuation of index futures is straightforward, reducing the concerns that our results might be driven by model misspecification. Third, these futures are widely used by fund managers for diversification and speculative purposes, so results are not driven by the presence of unsophisticated investors. Finally, open positions in index futures have been shown to contain important information about future market expectations (Han, 2008; Hong and Yogo, 2012).

Our study is organized as follows. In the next section we describe the data and methodology that we use to build our measure of dislocation in index futures contracts. In Section 3 we use a principal component analysis and a dynamic factor model to estimate a common factor in dislocations. Section 4 examines potential drivers of co-movement in dislocations such as market sentiment, hedging costs, and international capital flows. In Section 5 we explore contagion effects. Section 6 finally concludes.

2.2. Building the Dislocation Measure

Our measure of dislocation in index futures is derived from the no-arbitrage futures price:

$$F_{t,\tau} = \left(S_t - PV(D)_{t,\tau}\right)e^{r_{t,\tau}(\tau-t)} \tag{1}$$

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et al., 2010), put-call parity (Lamont and Thaler, 2003; Ofek et al., 2004), closed-end funds parity (Pontiff, 1996), convertible bonds parity (Mitchel and Pulvino, 2012), exchange-traded funds parity (Chacko et al., 2012) and triangular arbitrage parity (Lyons and Moore, 2009; Kozhan and Tham, 2012).

where $F_{t,\tau}$ is the theoretical futures price; τ corresponds to the expiration date of the futures contract; S_t is the closing spot price; $PV(D)_{t,\tau}$ is the present value of all expected dividend payments from date t to τ; and $r_{t,\tau}$ is the annualized interest rate.

Table 1 presents a description of the data that includes the stock indices, the interbank and overnight rates and the day-count conventions. We collect closing index prices, daily futures prices, short-term interest rates, and daily dividends for a period of more than 10 years that begins in December 2001 and extends to August 2012. The data source is Bloomberg.

Our list of indices follows Ahn et al. (2002) and includes 14 stock market indices from Belgium (BEL 20), Canada (S&P TSX 60), France (CAC 40), Germany (DAX), Hong Kong (HSI), Japan (NIKKEI, TOPIX), Korea (KOSPI), Netherlands (AEX), Spain (IBEX), UK (FTSE 100), and the U.S. (S&P 500, DOW JONES, NASDAQ). For each index we obtain the price of the nearest maturity futures contract, the maturity date, and the corresponding spot price.

We obtain information for the 3-month interbank offered rate and the overnight rate of the currency corresponding to each index. For most markets we use the corresponding overnight interbank offered rate as a proxy for the overnight rate. However, we use the gensaki rate for Japan, the overnight call rate for Korea, the EONIA for the Euro zone, and the federal funds rate for the U.S. For each date t, we compute by linear interpolation the corresponding interest rate $r_{t,\tau}$ for a contract expiring at date τ:

$$r_{t,\tau} = r_{ON}(t) + \frac{d_{t,\tau}}{360}(r_{3M}(t) - r_{ON}(t)) \tag{2}$$

where $r_{ON}(t)$ is the corresponding overnight rate; $r_{3M}(t)$ is the three-month interest rate; and $d_{t,\tau}$ is the number of days elapsed between dates t and τ[6].

Table 2 reports the dividend yield, the dividend-price ratio, and the number of days per year in which there are no dividend payments for each index. The dividend yield is computed as the sum of dividends paid during the year, divided by the index price at the beginning of the year. The dividend-price ratio is computed as the cumulated dividends during each year, divided by the index price at the end of the year. Bloomberg does not report dividend data for the DAX since dividends are reinvested in the index.

We can observe that on average dividend-yields are comparable to dividend-price ratios. It is also interesting to note that there are differences in the magnitude of dividend yields across regions. European indices pay on average dividend yields around 3.5%. In Asia, dividend yields are on average close to 1.5%, except for the HSI which pays dividend yields closer to European levels. North American indices pay dividend yields in between, with the exception of Nasdaq that contains many growth firms that do not pay dividends. Finally, it is interesting to note that all indices but the S&P 500 pay dividends rather infrequently. Hence, it seems important to incorporate the precise timing of dividend payments when pricing index futures contracts. Using a dividend yield could lead to inaccuracies in computing futures prices, since dividend payments come in lump-sums.

In the paper we only focus on the most liquid futures contract for each index which corresponds to the closest-to-maturity contract which is always less than three months. To estimate expected dividends for each contract, we follow Roll et al. (2007) and assume that investors can perfectly forecast future dividends payments. Hence, we

[6] For UK, Hong Kong and Japan we divide by 365 instead of 360. See Table 1 for details on the day-count conventions used for all currencies.

estimate the present value of expected dividends $PV(D)_{t,\tau}$ as the sum of discounted realized dividends:[7]

$$PV(D)_{t,\tau} = \sum_{t<u\leq\tau} D_u e^{-r_{t,u}(u-t)} \tag{3}$$

where D_u is the dividend paid at date u; $r_{t,u}$ is the continuously compounded interest rate at date t corresponding to the tenor $u-t$. Since we are assuming that dividends are known by investors up to the expiration of the futures contract, we compute the present value using the risk-free rate for each currency.

Finally, for each index we compute daily index futures dislocations as follows:

$$Dislocation_t = \frac{1}{(\tau-t)} Ln\left(\frac{\hat{F}_{t,\tau}}{F_{t,\tau}}\right) \tag{4}$$

where $\hat{F}_{t,\tau}$ is the closing price at time t of the futures contract expiring at τ; and $F_{t,\tau}$ is the corresponding theoretical futures price. By combining Equations (1) and (4), the dislocation measure can be written as:

$$Dislocation_t = \frac{1}{(\tau-t)} Ln\left(\frac{\hat{F}_{t,\tau}}{S_t - PV(D)_{t,\tau}}\right) - r_{t,\tau}. \tag{5}$$

The measure is annualized so that we can compare dislocations for futures contracts with different maturities.[8]

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[7] We consider the dividend payment date when the stock becomes ex-dividend.

[8] Note that both the observed and theoretical futures prices are computed in the domestic currency of each index. However, since the dislocation measure is expressed as a percentage difference between the two prices, the measure is independent of currency variations.

Table 3 reports descriptive statistics for dislocations in each index. Even though on average dislocations are relatively small, they present high variability. Hence, dislocations in index futures are time-varying, a phenomenon that we explore in the rest of the paper. The Appendix presents index-by-index time-series plots of monthly averages of our dislocation measure. Overall, the figures show that dislocations are persistent over time and spike during periods of market stress. For example, in October 2008 European index futures were trading on average at an annualized cost-of-carry 3.5% lower than the one implied by interest rates and dividend payments. Therefore, the economic effect of dislocations should be a matter of relevant concern for hedgers, speculators and regulators.

It is interesting to note in Table 3 that dislocations tend to be on average more negative in Asia (-65 bp), slightly negative in Europe (-18 bp) and almost zero in North America (5 bp). We find a similar pattern using medians. A possible explanation for the bias could be that the true funding cost of the marginal investor is unobservable, and by using the local interest rate we do not fully capture the real cost of funds. For example, if the marginal investor in Japan is an investment bank located in the U.S., computing the dislocation using TIBOR instead of LIBOR USD might generate a bias. However, given that interest rates are significantly more persistent than our dislocation measure, this bias is unlikely to explain the high variability reported in Table 3. Moreover, the table shows that the variability in dislocations tends to be more pronounced in Asia (336 bp), than Europe (241 bp) and North America (168 bp). This dispersion in variability could be due to differences in market sophistication.

Table 4 reports pairwise correlations in daily index futures dislocations. We find that 72 out of 91 coefficients are positive, among which 44 are statistically significant at the 10% level. The average pairwise correlation is 0.09. This result provides preliminary evidence that index futures dislocations comove around the world. To analyze in more detail the time-varying strength of these correlations, in the next section we obtain a common factor that drives the results.

Furthermore, we find strong intra-regional correlations. Within each region, almost all coefficients are positive and significant, and the average pairwise correlation in index futures dislocations in Asia, Europe and North America are equal to 0.21, 0.12, and 0.60, respectively. This suggests that comovement is stronger within each region, a phenomenon that we study in the last section.

2.3. Finding a Common Factor in Dislocations

In this section we estimate a common factor in index futures dislocations using two standard methods: a principal component analysis (PCA) and a dynamic factor model.

Our first method to compute a common factor is to use a principal component analysis of the 14 index futures dislocations. We perform the PCA analysis using monthly averages since there are many days on which at least one dislocation is missing because of market holidays or data problems. We use the first principal component as the first proxy for the comovement factor.

Table 5 reports the results of the PCA analysis. Panel A shows that the first component captures about 22% of the variance. Ten factors capture more than 90% of the variation. Hence, even though there is some commonality among dislocations in different markets, there is also a considerable amount of idiosyncratic variation.

Panel B reports the weight that each index is assigned in the computation of each factor. For the computation of the first component, all weights are positive, although we can observe heterogeneity in the weights. The second component gives positive weights to all factors except the IBEX and North American indices. However, the weights for the U.S. stock market indices are significantly more negative than for the IBEX and

SPTSX60. These results suggest a decoupling between dislocations in U.S. index futures and dislocations in the rest of the world. We will see that this phenomenon is also present in the common factor obtained using the dynamic model.

Our second methodology is a dynamic factor model, in which the unobserved common factor is filtered from the data. Since this methodology can handle days on which we have missing observations for some indices, i.e. an unbalanced panel, the analysis is performed using daily data. The dynamic factor analysis with daily observations allows to use more data in the estimation of the common factor, and permits to perform a finer analysis of the dynamics in dislocations.

In this type of model the common factor is a latent variable orthogonal to all idiosyncratic shocks. The estimated model is the following:

$$y_{it} = \beta_{0i} + \beta_{1i} z_t + e_{it} \tag{6}$$

$$z_{t+1} = H z_t + \varepsilon_t \tag{7}$$

where y_{it} is the dislocation at time t for index i; e_{it} corresponds to idiosyncratic shocks in dislocations that are normally distributed, uncorrelated with each other and such that shocks within each region have the same variance[9]; z_t is a latent factor; and ε_t is a standardized normally distributed variable.

In terms of identification, the model is written in its minimal form so that all parameters can be estimated. The variance of innovations to the common factor z_t is normalized to one since the factor enters into the measurement equation (6) multiplied

[9] Formally, we assume that $Cov(e_{it}, e_{jt}) = 0$ whenever $i \neq j$, and $Var(e_{it}) = Var(e_{jt})$ when i and j are indices from the same region (Asia , Europe or North America).

by the loadings of dislocations in each market.[10] Also, the common factor is demeaned since the mean is captured by β_{0i}. However, the model is not fully identified because the sign of the latent factor z_t cannot be inferred from the dynamic analysis.[11] Without loss-of-generality, we choose exogenously the sign of z_t such that most loadings are positive.

Table 6 reports parameter estimates, z-statistics and p-values for coefficients in the model. We find all loadings to be positive and most of them statistically significant, which is consistent with the principal component analysis. We also find that the loadings on the U.S. market (Dow Jones, Nasdaq and S&P 500), Canada (SPTSX60) and Hong Kong (HSI) are not significant at the 10% level.

Figure 1 plots the common factor in index futures dislocations obtained from the principal component analysis and monthly averages of the dynamic factor model. The figure shows that the common factor obtained from the dynamic model is less volatile, which is expected given that the dynamic analysis smoothes out the noise. Nevertheless, the comovement in dislocations seems to be robust across the two methods since the correlation between both factors is 0.54.

We can observe from the figure that the common factor is negative in periods of financial stress, such as October 2008. It is positive in periods in which good news about the economy were released, such as April 2009 when the G20 meeting established the creation of the Financial Stability Board. Intuitively, a negative value for dislocations means that observed prices are lower than the cost-of-carrying forward the position, suggesting that selling pressure manifest into futures prices. This could occur, for

[10] In other words, if we multiply z_t by two and divide β_{1i} for all indices by two, the new model is observationally equivalent to the one presented by equations (6) and (7).

[11] We can always multiply z_t and β_{1i} by minus one and obtain a new model that is observationally equivalent to the one presented by equations (6) and (7).

example, when arbitrageurs are unable to align traded prices to fundamental values due to market frictions that could be more pronounced in times of market stress. We explore in more detail the determinants of index futures dislocations in the next section.

2.4. The Determinants of the Common Factor

Having uncovered evidence of global comovement in dislocations, in this section we study the potential drivers of the common factor. We average monthly the daily common factor estimated with the dynamic factor model to make it comparable with the PCA factor. By doing this, we also attenuate the concern that we might be capturing effects related to non-synchronous trading between futures contracts and the underlying index (Lo and MacKinlay, 1990; Miller and Muthuswamy, 1994). Hence, the analysis is performed at the monthly frequency.

Our rationale to include potential drivers in dislocations is as follows. Several papers (Figlewski, 1989; Green and Figlewski, 1999; Bollen and Whaley, 2004; Ofek et al., 2004; Han 2008) document limits to arbitrage in the options market and how market sentiment affect option prices. Hence, it is plausible that market sentiment also affects index futures prices. Additionally, hedging costs are also likely to intensify index futures dislocations since such frictions put constraints on market-makers and arbitrageurs to line-up prices with the cost of carrying positions forward (see e.g. Roll et al., 2007). Finally, we expect sudden changes in international capital flows to put pressure in international index futures (Hau and Rey, 2006). Therefore, we categorize potential sources of deviations into the following categories: U.S. and global market sentiment, hedging costs, and international capital flows.

We follow Han (2008) and proxy for U.S. market sentiment with the bull-bear spread in the U.S. market. Investors Intelligence classifies around 150 professional investment newsletters into three groups: bullish, neutral and bearish. The bull-bear spread is a measure that corresponds to the percentage of bullish minus the percentage of bearish writers.

Global market sentiment is estimated using the methodology of Baker and Wurgler (2006) and Baker et al. (2012). We collect from Bloomberg daily turnover for all stock indices in our sample for which this data is available. The turnover is computed as the trading volume divided by the total number of shares outstanding. Our measure of global sentiment is then computed as the first principal component of monthly turnover averages. Table 7 reports the correlation coefficients among all turnovers. We find that 40 out of 45 coefficients are positive and statistically significant at the 1% level. In order to avoid econometric problems related to multicolinearity, we extract the first principal component of turnovers. Table 8 reports the results from the principal component analysis. We find that the first component captures 67% of the variation and that all its loadings are positive.

To proxy for hedging costs, we look at variables that capture short-sales and funding constraints. We use monthly averages of quoted and effective spreads on the S&P 500 as proxies for short sales (Copeland and Galai, 1983; Diamond and Verrecchia, 1987; Saffi and Sigurdsson, 2011) and the LIBOR-OIS and TED spreads as proxies for funding constraints (Caballero et al., 2008; Brunnermeier, 2009). Table 9 reports the pairwise correlation coefficients of all four hedging costs variables. We find all variables positively correlated at the 1% level. As expected, the LIBOR-OIS and TED spreads, and the quoted and effective spreads, are highly correlated (0.92 and 0.80, respectively).

We extract the first principal component of these variables. The first component captures 67% of the variation as reported in Table 10. We can observe that the loadings of all variables on the first component are quite similar. We can also see that the loadings on the second factor have positive signs for quoted and effective spreads and negative signs for LIBOR-OIS and TED spreads, which is consistent with the correlations analyzed in Table 9.

Finally, we include the monthly return in USD of an equally-weighted portfolio of currencies including EUR, GBP, JPY, CAD, and AUD, as a proxy for capital flows between the U.S. and the rest of the world (Hau and Rey, 2006). This variable is negative when the USD appreciates and positive when the USD depreciates. We expect capital outflows from the U.S. in times of market exuberance, and capital inflows in times of market stress or flight-to-liquidity.

We now study the effect of these variables on index futures dislocations. We run the following specification in which the dependent variable is the common factor in dislocations constructed using the principal component analysis or the dynamic factor model:

$$\begin{aligned} Factor_t = \ & \beta_0 + \beta_1 BullBear_t + B_2 Hedge_t + \ \beta_3 Sent_t + \beta_4 FX_t \\ & + \beta_5 Factor_{t-1} + \ \varepsilon_t \end{aligned} \tag{8}$$

where $Factor_t$ corresponds to the monthly average of the common dislocation factor at date *t*; $BullBear_t$ is the monthly average value of the bull-bear spread; $Hedge_t$ is the principal component of the monthly average of hedging costs variables; $Sent_t$ is the principal component of the monthly average of world sentiment variables; and FX_t is the monthly return of an equally-weighted portfolio of EUR, GBP, JPY, CAD, and AUD denominated in USD. We control for persistence in dislocations by including the lagged dependent variable. In the regressions we also account for heteroskedasticity and autocorrelation by using the Newey-West error-correction method.

Table 11 reports the results. In Panel A the dependent variable is the common factor computed from the principal component analysis, whereas in Panel B the dependent variable is the latent factor obtained from the dynamic factor model described in equations (6) and (7). The results show no evidence of persistence in the common factor as the coefficients on $Factor_{t-1}$ are not significant in specifications (2) and (4).

In Panel A, the coefficients of $BullBear_t$, $Hedge_t$ and $Sent_t$ are significant at the 10% level. Both signs on $BullBear_t$ and $Sent_t$ are positive, suggesting that in good economic times (as perceived by market participants), the demand pressure for index futures is positive, and that in bad times the pressure is negative. On the other hand, the sign on $Hedge_t$ is negative. This suggests that funding costs rather than short-selling costs are more important in explaining dislocations. Borrowing costs are relevant for arbitrageurs when there is selling pressure in the futures market, whereas short-selling costs are important when there is buying pressure. Hence, a negative sign on the coefficient reveals that arbitrageurs have more difficulty exploiting arbitrage opportunities when there is selling pressure rather than buying pressure in index futures. The sign on FX_t is positive, implying buying pressure in index futures when the dollar depreciates and selling pressure when the dollar appreciates with respect to other major currencies. In Panel B, $Hedge_t$, $Sent_t$ and FX_t are significant at the 10% level, and the signs in all variables remain unchanged. It is reassuring that we obtain the same signs on both sets of regressions.

In conclusion, we find substantive empirical evidence of a relation between the common world factor in dislocations, U.S. and global market sentiment, hedging costs, and international capital flows.

2.5. Regional Common Factors and Contagion in Dislocations

In this section we estimate regional common factors in index futures dislocations and analyze whether the common factor in one region propagates to other regions through a process that we interpret as contagion. To capture the potential lead-lag effect of regional common factors in dislocations, we expand the dynamic factor model in (6) and (7) into three latent factors, each one of them capturing the comovement in dislocations within each region. Our model specification is the following:

$$y_{it} = \begin{cases} \alpha_i + \beta_i z_t^{asia} + e_{it} & \text{if } i \text{ is an index in Asia} \\ \alpha_i + \beta_i z_t^{eur} + e_{it} & \text{if } i \text{ is an index in Europe} \\ \alpha_i + \beta_i z_t^{amer} + e_{it} & \text{if } i \text{ is an index in N. America} \end{cases} \tag{9}$$

$$\begin{pmatrix} z_t^{asia} \\ z_t^{eur} \\ z_t^{amer} \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix} \begin{pmatrix} z_{t-1}^{asia} \\ z_{t-1}^{eur} \\ z_{t-1}^{amer} \end{pmatrix} + \begin{pmatrix} \varepsilon_t^{asia} \\ \varepsilon_t^{eur} \\ \varepsilon_t^{amer} \end{pmatrix} \tag{10}$$

where y_{it} corresponds to dislocations in index futures *i* at time *t*; z_t^{asia}, z_t^{eur} and z_t^{amer} are three regional latent factors; e_{it} corresponds to idiosyncratic shocks in dislocations uncorrelated with the latent factors and with each other, such that shocks within each region have the same variance; h_{ij} are latent factor loadings; ε_t^{asia}, ε_t^{eur} and ε_t^{amer} are correlated standardized normally distributed idiosyncratic shocks to the latent factors. Therefore, the dynamics of the three latent regional factors are driven by the coefficients h_{ij} for $i, j = 1, 2, 3$. The factor loadings h_{11}, h_{22} and h_{33} capture the persistence of each regional latent factor, while the factor loadings h_{ij} for $i \neq j$ capture how shocks in dislocations propagate from region j to region i.

Table 12 reports the results of the estimation of the model presented in (9) and (10). Panel A reports coefficient estimates for the loadings of each index in their respective regional factor. We find that there is strong regional comovement in dislocations, with all loadings being significant and positive. Panel B reports parameter estimates of matrix H that contains information about the time-series dynamics of the regional factors. Interestingly, we find that dislocations in Asia and Europe are influenced by lagged dislocations in North America. However, we also find that dislocations in North America are not preceded by dislocations in Asia or Europe. Our results are similar to the ones reported by Rapach et al. (2013), who find that lagged U.S. returns significantly predict returns in numerous non-U.S. industrialized countries, while lagged non-U.S. returns display limited predictive ability with respect to U.S. returns. The authors find that their results are consistent with a gradual information diffusion phenomenon, which could also be the source of our findings.

Finally, the table shows that autocorrelation in Asia (0.76) is higher than in Europe (0.49), which in turn is higher than in North America (0.07). Therefore, dislocations revert much faster in North America, a result that is consistent with the degree of market sophistication.

2.6. Concluding Remarks

In the paper we analyze deviations from the futures-cash parity for 14 stock index futures from Asia, Europe, and North America from 2001 to 2012. We find that dislocations in world index futures are pervasive across different regions around the world. Our results are consistent with recent findings for other asset classes such as Pasquariello (2013) who studies dislocations in ADRs, currency pairs and currency forwards. We contribute to this literature by showing that dislocations in index futures are present in many countries.

Our principal component analysis suggests the existence of a world common factor in dislocations. However, the dynamic factor analysis shows that index futures dislocations in North America appear decoupled from the rest of the world. This geographical segmentation is only apparent, since our regional dynamic analysis reveals that dislocations in North America are important predictors of dislocations in other regions such as Asia or Europe. Therefore, we uncover a phenomenon in dislocations that is akin to contagion.

We also contribute to the literature by studying potential drivers for dislocations in index futures. Our analysis reveals that U.S. and global market sentiment, hedging costs, and international capital flows play a prominent role in explaining the phenomenon. This is interesting since it suggests that both demand and supply factors seem to interplay at the global level in generating dislocations in index futures.

Overall, we believe that our findings are relevant for academics interested in understanding how market imperfections interact with demand pressure, for practitioners who actively use financial derivatives for hedging and speculative purposes, and for regulators interested in understanding how dislocations propagate throughout the world.

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APPENDIX

The appendix presents index-by-index time-series plots of monthly averages of our dislocation measure. Figures 3, 4 and 5 plot index futures dislocations for Asia, Europe, and North America, respectively.

Figure 1: Common Factor in Index Futures Dislocations

The figure plots the common factor in index futures dislocations obtained from the principal component analysis and monthly averages of the dynamic factor model. The sample period is 12/2001-08/2012.

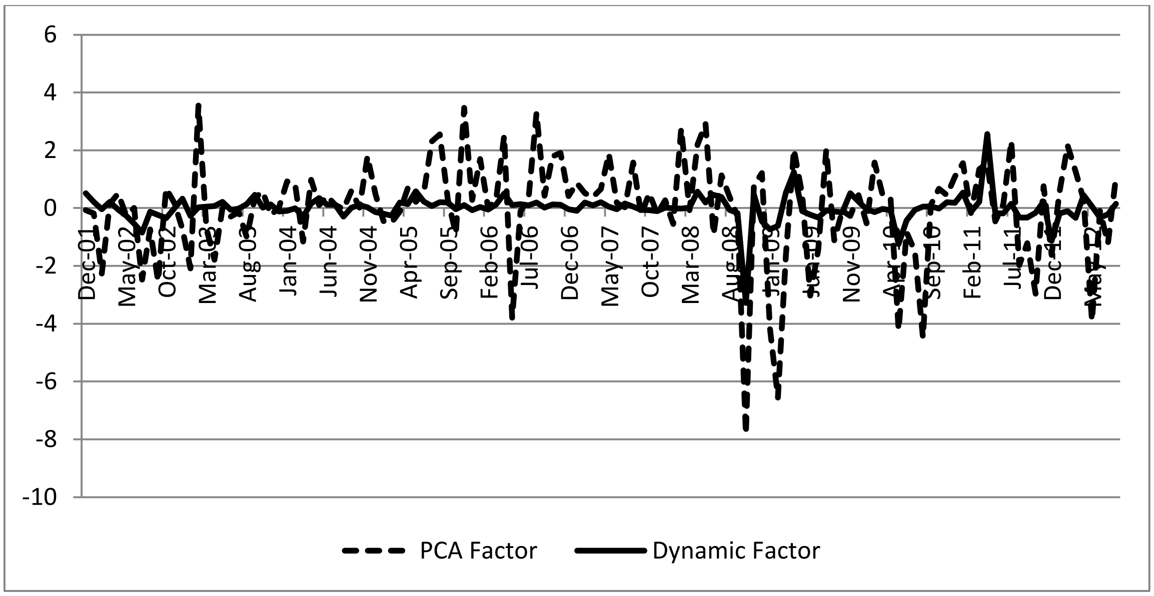


Figure 2: Regional Common Factors in Index Futures Dislocations

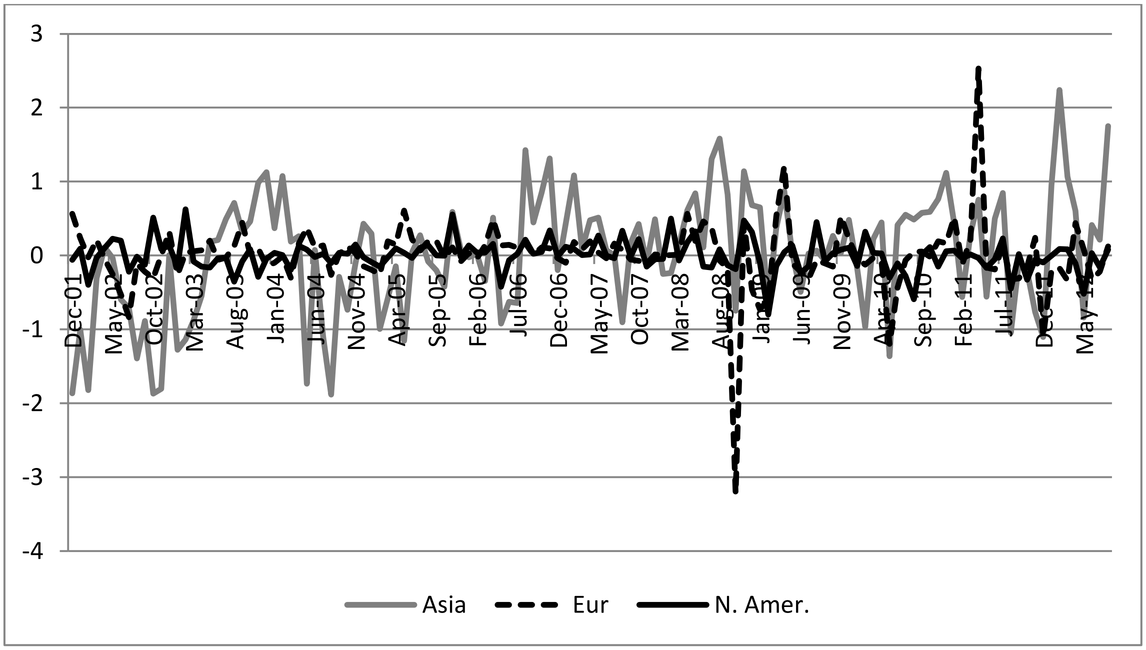


Figure 3: Dislocations in Asian Index Futures

The figure plots monthly dislocations in Asian index futures. We report in parenthesis the corresponding stock market index on which the futures contract is traded. Notice that the y-axis values of different indices have different scales to better appreciate the time-series variations of dislocations. The sample period is 12/2001-08/2012.

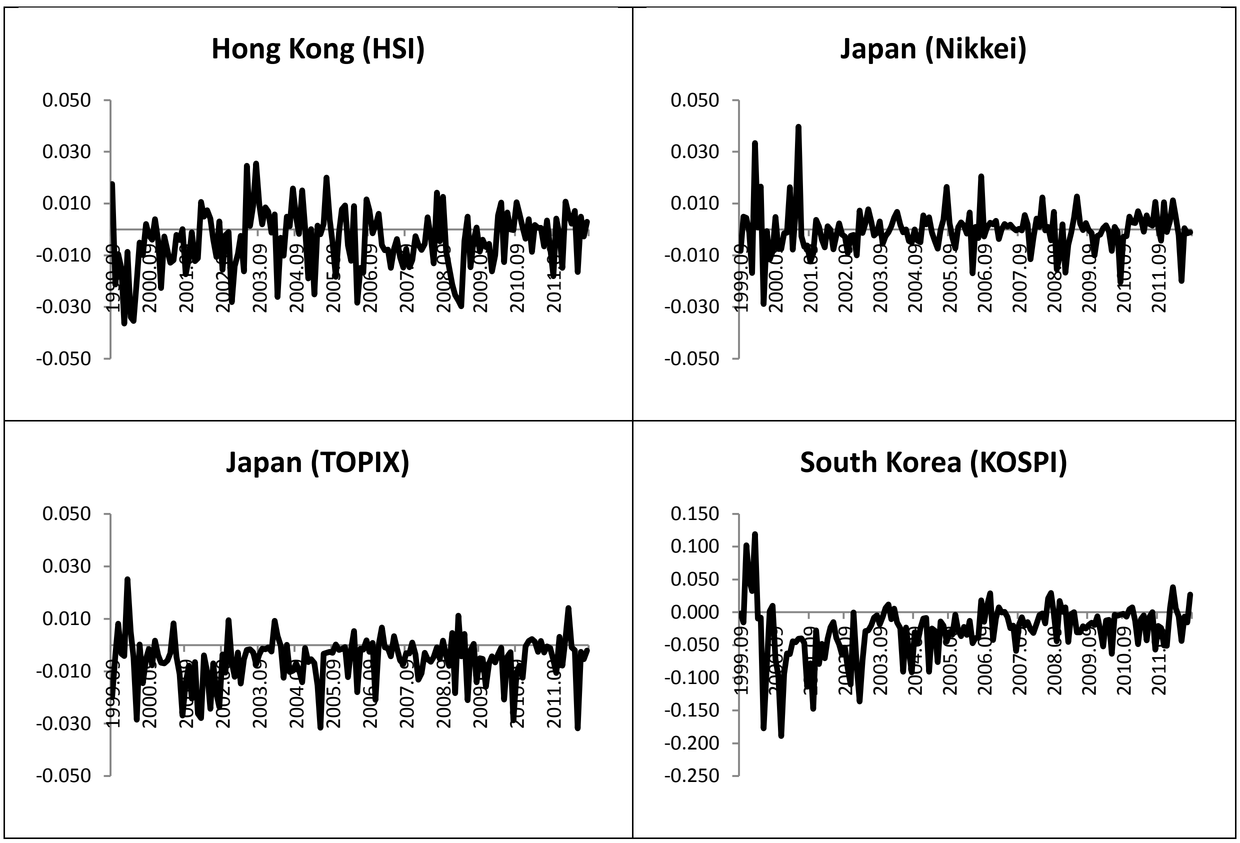
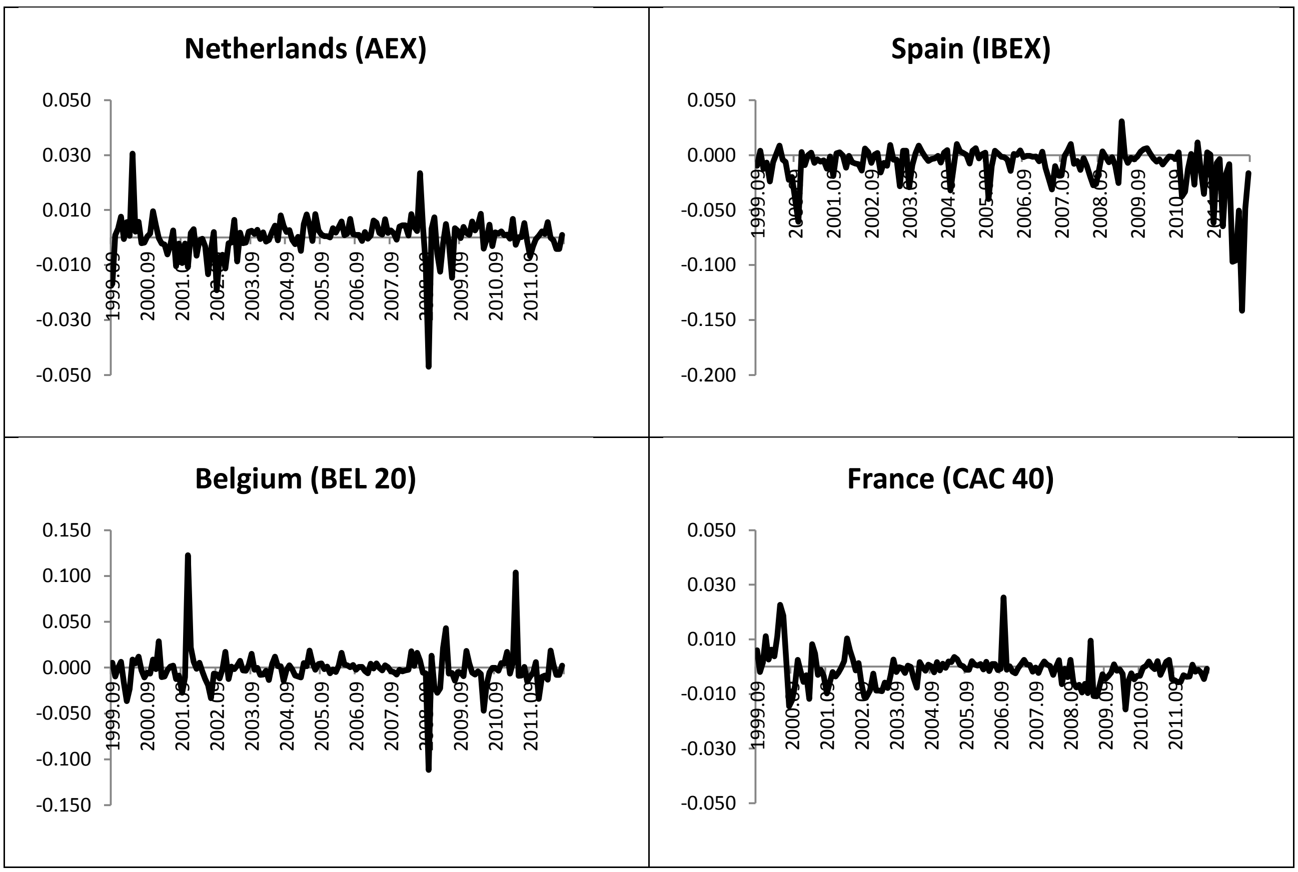
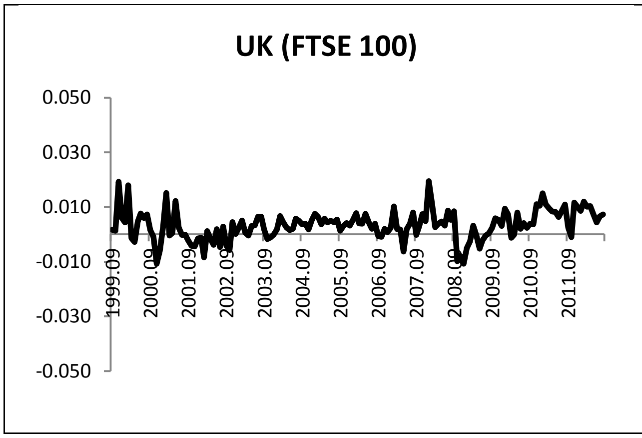


Figure 4: Dislocations in European Index Futures

The figure plots monthly dislocations in European index futures. We report in parenthesis the corresponding stock market index on which the futures contract is written. Notice that the y-axis values of different indices have different scales to better appreciate the time-series variations of dislocations. The sample period is 12/2001-08/2012.





UK (FTSE 100)
0.050
0.030
0.010
-0.010
-0.030
-0.050
1999.09
2000.09
2001.09
2002.09
2003.09
2004.09
2005.09
2006.09
2007.09
2008.09
2009.09
2010.09
2011.09

Figure 5: Dislocations in North American Index Futures

The figure plots monthly dislocations in North American index futures. We report in parenthesis the corresponding stock market index on which the futures contract is traded. The sample period is 12/2001-08/2012.

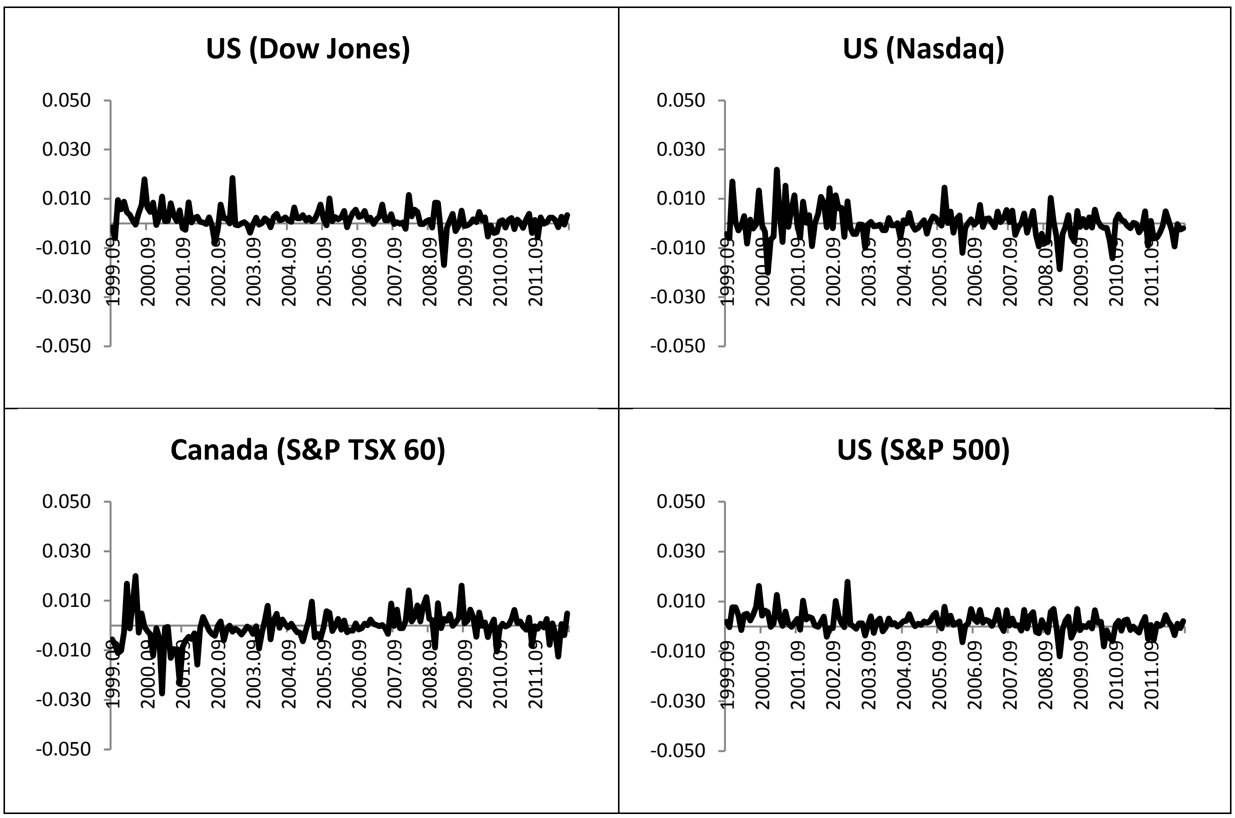


Table 1: Sample Description

The table reports information on the indices used in our study, the overnight and three-month interbank rates used to compute cost-of-carry prices, as well as the day-count conventions used for each interest rate. The sample period is 12/2001-08/2012.

Region	Country	Index	Overnight Rate	Interbank Rate	Day Convention
Asia	Hong Kong	Hang Seng (HSI)	HIBOR O/N	HIBOR	ACT/365
	Japan	NIKKEI (NKY)	GENSAKI RATE	TIBOR	ACT/365
	Japan	TOPIX (TPX)	GENSAKI RATE	TIBOR	ACT/365
	Korea	KOSPI	CALL OVERNIGHT RATE	KORIBOR	ACT/360
Europe	Belgium	BEL 20	EONIA	EURIBOR	ACT/360
	France	CAC 40	EONIA	EURIBOR	ACT/360
	Germany	DAX	EONIA	EURIBOR	ACT/360
	Netherlands	AEX	EONIA	EURIBOR	ACT/360
	Spain	IBEX	EONIA	EURIBOR	ACT/360
	UK	FTSE 100 (UKX)	BBA GBP LIBOR 1 week	BBA GBP LIBOR	ACT/365
North America	Canada	S&P TSX 100 (SPTSX60)	BBA CAD LIBOR	BBA CAD LIBOR	ACT/360
	USA	NASDAQ (NKY)	FED CALL O/N RATE	BBA USD LIBOR	ACT/360
	USA	Dow Jones (INDU)	FED CALL O/N RATE	BBA USD LIBOR	ACT/360
	USA	S&P 500 (SPX)	FED CALL O/N RATE	BBA USD LIBOR	ACT/360

Table 2: Descriptive Statistic for Index Dividends

The table reports descriptive statistics of dividends corresponding to each stock index. Dividend data is obtained from Bloomberg. The dividend yield is computed as the cumulated dividends during each year divided by the index price at the beginning of the year. The dividend-price ratio is computed as the cumulated dividends during each year divided by the index price at the end of the year. Note that Bloomberg does not provide dividend information for the DAX since dividends are capitalized into the index. The sample period is 12/2001-08/2012.

		Dividend Yield			Dividend-Price Ratio			Days per Year Without Dividend Payments		
Region	Index	Avg.	Min	Max	Avg.	Min	Max	Avg.	Min	Max
Asia	HSI	0.033	0.023	0.051	0.034	0.027	0.048	192.4	183	202
	KOSPI	0.016	0.001	0.028	0.017	0.001	0.030	245.6	243	249
	NKY	0.013	0.007	0.024	0.012	0.007	0.018	234.3	231	240
	TPX	0.014	0.007	0.024	0.013	0.009	0.020	219.3	215	229
Europe	AEX	0.037	0.030	0.072	0.034	0.025	0.042	228.4	225	236
	BEL20	0.039	0.027	0.081	0.035	0.031	0.042	238.1	236	242
	CAC40	0.033	0.020	0.058	0.031	0.020	0.043	223.2	212	230
	IBEX	0.038	0.022	0.061	0.036	0.019	0.064	208.5	199	215
	UKX	0.039	0.033	0.058	0.038	0.029	0.045	201.4	199	203
North America	INDU	0.024	0.020	0.036	0.024	0.019	0.031	173.5	169	181
	NKY	0.005	0.001	0.010	0.005	0.001	0.010	176.6	146	221
	SPTSX60	0.023	0.017	0.035	0.023	0.018	0.033	139.8	128	152
	SPX	0.019	0.016	0.031	0.019	0.014	0.024	28.7	22	35

Table 3: Descriptive Statistics for Index Futures Dislocations

The table reports descriptive statistics for daily dislocations in index futures. We compute the dislocation measure as follows:

$$Dislocation_t = \frac{1}{(\tau - t)} Ln\left(\frac{\hat{F}_{t,\tau}}{S_t - PV(D)_{t,\tau}}\right) - r_{t,\tau}$$

where τ corresponds to the expiration date of the futures contract; $\hat{F}_{t,\tau}$ is the closing price at time t of the futures contract expiring at τ; $PV(D)_{t,\tau}$ is the present value of all expected dividend payments from date t until maturity τ; S_t is the closing spot price, and $r_{t,\tau}$ is the annualized interest rate. Descriptive statistics are reported in basis points. The sample period is 12/2001-08/2012. Note that KOSPI has fewer observations than other indices because of missing Koribor rates.

Region	Index	Average	Median	Maximum	Minimum	Std. Dev.	Obs.
Asia	HSI	-30.64	-15.83	1553.34	-1394.17	286.64	2651
	KOSPI	-204.20	-152.15	3290.33	-4015.43	454.02	2012
	NKY	-2.23	4.01	1554.37	-2228.48	270.11	2622
	TPX	-54.44	-33.79	2414.80	-2659.86	302.12	2622
	Region	**-64.67**	**-32.30**	**3290.33**	**-4015.43**	**335.57**	**9907**
Europe	AEX	3.53	11.84	2372.41	-3422.07	189.46	2753
	BEL20	-21.36	-6.50	3037.31	-5267.60	406.00	2753
	CAC40	-15.99	-13.17	620.35	-739.05	92.91	2753
	DAX	-10.63	-11.75	1668.09	-2459.41	201.04	2737
	IBEX	-98.13	-41.21	1740.83	-1973.39	267.18	2723
	UKX	35.38	35.03	799.51	-873.24	125.98	2714
	Region	**-17.85**	**-1.48**	**3037.31**	**-5267.60**	**240.55**	**16433**
North America	INDU	12.89	12.60	1245.19	-1320.84	136.75	2643
	NDX	-3.71	4.78	1889.77	-2209.44	201.41	2630
	SPTSX60	1.01	3.39	1511.08	-2726.57	181.44	2656
	SPX	11.07	11.70	1238.86	-1286.01	145.41	2645
	Region	**5.32**	**8.42**	**1889.77**	**-2726.57**	**168.41**	**10574**

Table 4: Correlations in Index Futures Dislocations

The table reports pairwise correlations in daily dislocations during the period 11/2001 to 08/2012. We compute the dislocation measure as follows:

$$Dislocation_t = \frac{1}{(\tau - t)} Ln\left(\frac{\hat{F}_{t,\tau}}{S_t - PV(D)_{t,\tau}}\right) - r_{t,\tau}$$

where τ corresponds to the expiration date of the futures contract; $\hat{F}_{t,\tau}$ is the closing price at time *t* of the futures contract expiring at τ; $PV(D)_{t,\tau}$ is the present value of all expected dividend payments from date t until maturity τ; S_t is the closing spot price, and $r_{t,\tau}$ is the annualized interest rate. All correlations within a region are highlighted in gray. Coefficients in bold indicate significance at the 10% level.

		Asia				Europe						North America			
Region	Index	HSI	KOSPI	NKY	TPX	AEX	BEL20	CAC	DAX	IBEX	UKX	INDU	NDX	SPTSX60	SPX
Asia	HSI	1.000													
	KOSPI	**0.129**	1.000												
	NKY	**0.050**	**0.119**	1.000											
	TPX	0.037	**0.137**	**0.736**	1.000										
Europe	AEX	0.007	0.037	0.125	0.118	1.000									
	BEL20	0.016	0.071	0.057	0.047	**0.414**	1.000								
	CAC	0.071	0.075	0.089	0.068	**0.206**	**0.080**	1.000							
	DAX	0.047	0.007	-0.064	-0.031	**0.119**	**0.121**	**0.045**	1.000						
	IBEX	0.028	-0.047	0.049	0.047	**0.058**	**0.046**	**0.096**	0.001	1.000					
	UKX	0.088	0.086	0.048	0.017	**0.063**	**0.089**	**0.172**	**0.318**	**-0.061**	1.000				
North America	INDU	0.003	0.021	0.045	0.042	0.017	0.016	0.041	-0.049	0.014	-0.014	1.000			
	NDX	-0.001	-0.004	-0.014	0.016	0.011	0.028	0.020	-0.069	0.006	-0.062	**0.716**	1.000		
	SPTSX60	0.053	-0.001	-0.018	-0.019	-0.056	-0.067	0.011	-0.019	-0.011	0.082	**0.426**	**0.345**	1.000	
	SPX	0.021	0.024	0.021	0.048	0.022	0.019	0.007	0.004	0.024	-0.021	**0.902**	**0.724**	**0.456**	1.000

Table 5: Principal Component Analysis of Average Monthly Dislocations

The table reports the principal component analysis of average monthly dislocations. Panel A reports the explanatory power while Panel B presents the loadings (weights) of each factor. The sample period is 12/2001-08/2012.

		PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10	PC 11	PC 12	PC 13	PC 14
Panel A															
	Value	3.07	2.14	1.53	1.15	1.07	1.03	0.86	0.72	0.64	0.50	0.48	0.41	0.32	0.09
	Difference	0.94	0.60	0.38	0.08	0.04	0.17	0.14	0.08	0.14	0.02	0.07	0.10	0.23	---
	Percent	0.22	0.15	0.11	0.08	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.02	0.01
	Cumulative Value	3.07	5.21	6.74	7.89	8.96	9.99	10.85	11.56	12.20	12.70	13.18	13.60	13.91	14.00
	Cumulative Percent	0.22	0.37	0.48	0.56	0.64	0.71	0.77	0.83	0.87	0.91	0.94	0.97	0.99	1.00
Panel B															
Asia	HSI	0.22	0.15	-0.02	0.37	0.29	-0.49	0.09	-0.60	0.07	-0.11	0.22	0.07	-0.17	0.03
	KOSPI	0.13	0.26	0.30	-0.09	0.52	0.09	-0.56	0.01	0.09	0.37	0.03	0.01	0.29	-0.01
	NKY	0.31	0.10	0.42	0.31	-0.25	-0.08	0.11	0.05	-0.14	-0.12	-0.19	-0.59	0.36	0.03
	TPX	0.17	0.14	0.60	0.21	-0.19	0.12	-0.04	0.25	0.14	-0.13	0.02	0.45	-0.44	0.00
Europe	AEX	0.33	0.31	-0.22	-0.13	-0.05	0.12	-0.07	-0.23	-0.23	0.12	-0.69	0.02	-0.32	-0.06
	BEL20	0.28	0.26	-0.27	-0.03	-0.21	0.22	-0.40	0.04	-0.38	-0.31	0.53	-0.09	-0.08	-0.01
	CAC	0.19	0.20	-0.17	0.04	0.57	-0.11	0.36	0.58	-0.16	-0.24	-0.04	0.02	-0.01	-0.06
	DAX	0.17	0.35	-0.35	0.13	-0.22	0.05	-0.03	0.10	0.72	-0.15	-0.08	0.12	0.29	0.06
	IBEX	0.03	-0.09	-0.20	0.66	0.07	0.52	0.18	-0.03	-0.13	0.41	0.08	0.09	0.05	0.02
	UKX	0.14	0.40	0.06	-0.31	-0.26	-0.17	0.43	0.04	-0.09	0.56	0.31	0.09	0.07	-0.03
North America	INDU	0.42	-0.35	-0.03	-0.11	-0.04	-0.09	-0.01	0.00	-0.19	-0.02	-0.06	0.41	0.31	0.61
	NDX	0.37	-0.33	-0.11	-0.07	0.05	-0.05	-0.08	0.20	0.34	0.29	0.14	-0.45	-0.47	0.21
	SPTSX60	0.18	-0.01	0.20	-0.35	0.23	0.58	0.38	-0.37	0.19	-0.26	0.13	-0.10	0.03	0.05
	SPX	0.43	-0.40	-0.03	-0.05	-0.06	-0.06	-0.02	-0.01	0.04	0.02	0.02	0.19	0.18	-0.76

Table 6: Estimates of the Dynamics Factor Model

The table reports the estimates from the following specification:

$$y_{it} = \alpha_i + \beta_i z_t + e_{it}$$
$$z_{t+1} = H z_t + \varepsilon_t$$

where y_{it} is the value of financial dislocations at time t for index i; e_{it} corresponds to idiosyncratic shocks in dislocations that are normally distributed, uncorrelated with each other and such that shocks within each region have the same variance; z_t is a latent factor; and ε_t is a standardized normally distributed variable. The sample period is 12/2001-08/2012.

		α_i			β_i		
Region	Index	value	z-stat	p-value	value	z-stat	p-value
Asia	HSI	**-0.0031**	-4.1424	0.0000	0.0010	1.4696	0.1417
	KOSPI	**-0.0204**	-35.5196	0.0000	**0.0027**	5.5501	0.0000
	NKY	-0.0002	-0.2028	0.8393	**0.0017**	1.7126	0.0868
	TPX	**-0.0054**	-5.4616	0.0000	**0.0016**	1.9161	0.0554
Europe	AEX	0.0004	0.6491	0.5163	**0.0064**	52.9173	0.0000
	BEL20	-0.0021	-1.4543	0.1459	**0.0313**	152.7754	0.0000
	CAC	**-0.0016**	-2.1738	0.0297	**0.0009**	1.9784	0.0479
	DAX	**-0.0011**	-2.9514	0.0032	**0.0024**	7.9092	0.0000
	IBEX	**-0.0098**	-35.8590	0.0000	**0.0014**	6.1695	0.0000
	UKX	**0.0035**	6.4072	0.0000	**0.0011**	2.5394	0.0111
North America	INDU	0.0013	1.3868	0.1655	0.0000	0.0659	0.9474
	NDX	-0.0004	-0.9290	0.3529	0.0003	0.9883	0.3230
	SPTSX60	**-0.0012**	-4.6467	0.0000	0.0001	0.2991	0.7648
	SPX	0.0011	1.1881	0.2348	0.0000	0.0400	0.9681

Table 7: Correlation Matrix of Indices Turnover

The table reports pairwise correlations for among country specific indices turnover. Coefficients in bold are statistically significant at the 1% level. The sample period is 12/2001-08/2012.

	BEL20	CAC	DAX	HK	IBEX	INDU	NKY	SPX	TPX	UKX
BEL20	1.000									
CAC	**0.814**	1.000								
DAX	**0.805**	**0.978**	1.000							
HK	**0.845**	**0.679**	**0.674**	1.000						
IBEX	**0.803**	**0.875**	**0.873**	**0.762**	1.000					
INDU	0.084	**0.530**	**0.507**	-0.080	**0.315**	1.000				
NKY	**0.808**	**0.820**	**0.814**	**0.708**	**0.808**	**0.259**	1.000			
SPX	0.129	**0.596**	**0.579**	-0.010	**0.397**	**0.962**	**0.354**	1.000		
TPX	**0.769**	**0.807**	**0.799**	**0.667**	**0.794**	**0.289**	**0.993**	**0.392**	1.000	
UKX	**0.333**	**0.728**	**0.724**	0.214	**0.603**	**0.754**	**0.558**	**0.824**	**0.604**	1.000

Table 8: Estimating a Common Factor in Sentiment Using Principal Component Analysis

The table reports the principal component analysis of average monthly turnovers. Panel A reports the explanatory power while Panel B presents the loadings (weights) of each factor. The sample period is 12/2001-08/2012.

	Panel A									
	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
Value	6.699	2.248	0.423	0.226	0.161	0.124	0.071	0.025	0.020	0.003
Difference	4.450	1.826	0.196	0.065	0.037	0.053	0.046	0.005	0.017	---
Percent	0.670	0.225	0.042	0.023	0.016	0.012	0.007	0.003	0.002	0.000
Cumulative Value	6.699	8.947	9.370	9.596	9.757	9.880	9.952	9.977	9.997	10.000
Cumulative Percent	0.670	0.895	0.937	0.960	0.976	0.988	0.995	0.998	1.000	1.000
	Panel B									
BEL20	0.318	-0.311	0.214	0.377	-0.385	0.066	0.630	0.243	0.079	0.019
CAC	0.375	0.019	0.227	0.073	-0.274	0.069	-0.329	-0.130	-0.772	-0.029
DAX	0.372	0.012	0.227	0.008	-0.347	0.065	-0.543	-0.041	0.619	-0.073
HK	0.275	-0.394	0.332	-0.074	0.674	0.442	-0.018	-0.055	0.032	-0.015
IBEX	0.352	-0.119	0.194	-0.449	0.147	-0.764	0.132	0.008	0.005	0.006
INDU	0.199	0.545	0.160	0.384	0.217	-0.100	0.246	-0.597	0.106	-0.070
NKY	0.349	-0.155	-0.532	0.183	0.085	-0.054	-0.098	-0.129	0.029	0.708
SPX	0.230	0.521	0.051	0.183	0.283	-0.024	-0.093	0.737	-0.032	0.079
TPX	0.347	-0.119	-0.607	0.101	0.101	-0.023	-0.011	0.024	-0.015	-0.689
UKX	0.292	0.357	-0.154	-0.649	-0.189	0.441	0.323	-0.051	0.018	0.077

Table 9: Correlations Matrix of Proxies for Hedging Costs

The table reports pairwise correlations for hedging costs proxies: quoted and effective spread on the S&P500, Libor-OIS spread, and TED spread. All coefficients are statistically significant at the 1% level. The sample period is 12/2001-08/2012.

	Quoted Spread	Effective Spread	LIBOR – OIS Spread	TED Spread
Quoted Spread	1.000			
Effective Spread	**0.802**	1.000		
LIBOR – OIS Spread	**0.342**	**0.525**	1.000	
TED Spread	**0.285**	**0.495**	**0.921**	1.000

Table 10: Estimating a Common Factor in Hedging Cost using Principal Component Analysis

The table reports the principal component analysis from monthly averages of hedging costs proxies (quoted and effective spreads for S&P500, Libor-OIS spread and TED spread). Panel A reports the result of the analysis and Panel B reports the loadings (weights) of each factor on each component. The sample period is 12/2001-08/2012.

Panel A				
	PC 1	PC 2	PC 3	PC 4
Value	2.695	1.058	0.170	0.077
Difference	1.637	0.887	0.094	---
Percent	0.674	0.264	0.043	0.019
Cumulative Value	2.695	3.753	3.923	4.000
Cumulative Percent	0.674	0.938	0.981	1.000
Panel B				
Quoted Spread	0.438	0.625	0.639	0.095
Effective Spread	0.519	0.410	-0.748	-0.060
LIBOR – OIS Spread	0.527	-0.445	0.178	-0.702
TED Spread	0.511	-0.494	0.029	0.703

Table 11: Explaining Comovement in Dislocations

The table reports the estimates of the following specification:

$$Factor_t = \beta_0 + \beta_1 BullBear_t + B_2 Hedge_t + \beta_3 Sent_t + \beta_4 FX_t + \beta_5 Factor_{t-1} + \varepsilon_t$$

where $Factor_t$ corresponds to the monthly average of the common dislocation factor at date *t*, $BullBear_t$, is the monthly average of the bull-bear spread, $Hedge_t$ is the principal component of the monthly average of hedging costs variables, and $Sent_t$ is the principal component of the monthly average of global sentiment variables, and FX_t is the monthly return of an equally-weighted portfolio of EUR, GBP, JPY, CAD, and AUD denominated in USD. We control for persistence in dislocations by including the lagged dependent variable. In the regressions we also account for heteroskedasticity and autocorrelation by using Newey-West standard errors. The sample period is 12/2001-08/2012. Coefficients in bold denote coefficients significant at the 10% level.

Panel A: Principal Component Analysis						
	Model 1			Model 2		
	Value	t-stat	p-value	Value	t-stat	p-value
Constant	-0.262	-1.535	0.127	-0.259	-1.678	0.096
BullBear	**0.033**	2.717	0.008	**0.033**	2.475	0.015
Hedge	**-0.225**	-1.898	0.060	**-0.224**	-2.678	0.008
Sent	**0.198**	3.966	0.000	**0.200**	4.207	0.000
FX	10.323	1.099	0.274	10.129	1.235	0.219
$Factor_{t-1}$				-0.035	-0.597	0.552
R^2	0.211			0.213		
Adjusted R^2	0.186			0.180		
Panel B: Dynamic Factor Model						
	Model 3			Model 4		
	Value	t-stat	p-value	Value	t-stat	p-value
Constant	-0.035	-0.699	0.486	-0.037	-0.737	0.463
BullBear	0.002	0.833	0.407	0.002	0.688	0.493
Hedge	**-0.082**	-1.730	0.086	**-0.083**	-1.843	0.068
Sent	0.022	1.630	0.106	**0.023**	1.733	0.086
FX	**5.117**	1.967	0.051	**5.275**	1.895	0.061
$Factor_{t-1}$				-0.001	-0.006	0.995
R^2	0.169			0.170		
Adjusted R^2	0.142			0.136		

Table 12: Exploring Contagion Effects in Dislocations in Index Futures

The table reports parameter estimates, z-statistics and corresponding p-values from the following dynamic factor model:

$$y_{it} = \begin{cases} \alpha_i + \beta_i z_t^{asia} + e_{it} & if\ i \text{ is an index in Asia} \\ \alpha_i + \beta_i z_t^{eur} + e_{it} & if\ i \text{ is an index in Europe} \\ \alpha_i + \beta_i z_t^{amer} + e_{it} & if\ i \text{ is an index in North America} \end{cases}$$

$$\begin{pmatrix} z_t^{asia} \\ z_t^{eur} \\ z_t^{amer} \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix} \begin{pmatrix} z_{t-1}^{asia} \\ z_{t-1}^{eur} \\ z_{t-1}^{amer} \end{pmatrix} + \begin{pmatrix} \varepsilon_t^{asia} \\ \varepsilon_t^{eur} \\ \varepsilon_t^{amer} \end{pmatrix}$$

where y_{it} corresponds to dislocations in index futures i at time t; z_t^{asia}, z_t^{eur} and z_t^{amer} are three regional latent factors; e_{it} corresponds to idiosyncratic shocks in dislocations uncorrelated with the latent factors and with each other, such that shocks within each region have the same variance; h_{ij} are latent factor loadings; ε_t^{asia}, ε_t^{eur} and ε_t^{amer} are correlated standardized normally distributed idiosyncratic shocks to the latent factors. Panel A reports coefficient estimates for dislocations in each index. Panel B reports parameter estimates of latent factor loadings h_{ij} for $i, j = 1, 2, 3$. The sample period is 12/2001-08/2012.

Panel A

		α_i			β_i		
Region	Index	value	z-stat	p-value	value	z-stat	p-value
Asia	HSI	**-0.0031**	-4.9135	0.0000	**0.0032**	7.7531	0.0000
	KOSPI	**-0.0225**	-10.8637	0.0000	**0.0225**	50.1302	0.0000
	NKY	-0.0002	-0.2544	0.7992	**0.0027**	6.6977	0.0000
	TPX	**-0.0054**	-6.6077	0.0000	**0.0038**	11.7951	0.0000
Europe	AEX	0.0004	0.6355	0.5251	**0.0064**	56.3686	0.0000
	BEL20	-0.0021	-1.4903	0.1361	**0.0313**	145.8361	0.0000
	CAC	**-0.0016**	-2.1693	0.0301	**0.0009**	1.9937	0.0462
	DAX	**-0.0011**	-2.9405	0.0033	**0.0025**	9.6229	0.0000
	IBEX	**-0.0098**	-35.6049	0.0000	**0.0013**	5.9757	0.0000
	UKX	**0.0035**	6.2357	0.0000	**0.0011**	2.6614	0.0078
North America	INDU	**0.0013**	2.5097	0.0121	**0.0110**	43.8625	0.0000
	NDX	-0.0004	-0.9658	0.3341	**0.0167**	112.6568	0.0000
	SPTSX60	0.0001	0.3520	0.7249	**0.0103**	102.3167	0.0000
	SPX	**0.0011**	2.1299	0.0332	**0.0120**	46.4282	0.0000

Panel B

	Asia			Europe			North America		
	value	z-stat	p-value	value	z-stat	p-value	value	z-stat	p-value
Asia	**0.7643**	68.1453	0.0000	0.0350	1.3926	0.1637	**0.0789**	3.6397	0.0003
Europe	0.0050	0.3047	**0.7606**	0.4944	74.5403	0.0000	**0.0429**	2.6059	0.0092
North America	0.0225	1.5045	0.1324	-0.0283	-1.5040	0.1326	**0.0721**	5.5485	0.0000