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Central Clearing and Asset Prices

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Abstract

We investigate the effects of introducing a central clearing counterparty (CCP) on securities prices by adopting as an experimental construct the 2009 CCP reform in three Nordic markets. We find that, relative to other European economies, these countries experience market-adjusted equity returns of -1.08% per month during a 16-month announcement window. We also find negative effects on price-earnings ratios. The decrease in prices is less pronounced for stocks with low number of counterparties and, consistent with the margin-CAPM, more pronounced for stocks with higher margins. Our results suggest that introducing a CCP may have unintended negative consequences for public corporations.

1 Introduction

A central element of any financial market is its clearing system, which turns promises into actual transfers of assets between investors. In the aftermath of the recent global financial crisis, a growing consensus has emerged on the fragility of bilateral clearing designs and on the benefits of a central clearing counterparty (CCP). Both the Dodd-Frank act in the U.S. and the EMIR act in Europe, for example, mandate the central clearing of large classes of derivatives products.[1] The rationale behind this policy response is compelling: a CCP pools and diversifies settlement risks associated with transactions between multiple participants thus reducing counterparty default probabilities.

Although the systemic risk benefits of a CCP are well recognized in the literature, it is less clear how the introduction of a CCP may directly affect asset prices. On the one hand, given that default risk cannot be fully eliminated, lower counterparty default risks should lead to higher asset prices in equilibrium (e.g., Dubey, Geanakoplos, and Shubik (2005)). On the other hand, reducing these risks may be costly. In order to manage risk exposure, CCPs utilize a number of safeguards that affect financial institutions such as collateral requirements and securities margining. Recent academic research suggests that equilibrium asset prices should reflect the effect of such margins through trading capital (e.g., Garleanu and Pedersen (2011)). Intuitively, when trading capital is scarce, securities with higher margin requirements should trade at relatively lower prices. Because a CCP may require higher collateral than alternative clearing regimes, its introduction could in principle exert negative pressure on securities prices. Whether the introduction of a CCP reduces default risk sufficiently to offset collateral costs is thus central to understanding the effect of clearing on asset prices.

Empirical investigation of this issue is challenging for several reasons. First, clearing

[1] Regulations in the U.S. and in Europe reflect the spirit of the communiqué of the G20 Summit in Pittsburgh in September 2009, which states that "*All standardized OTC derivative contracts should be traded on exchanges or electronic trading platforms, where appropriate, and cleared through central counterparties...*"

reforms may take place simultaneously with other significant market design changes. An important example is the creation of the Chicago Board Options Exchange in 1973, where the clearing house and the exchange were created simultaneously. In the case of the post-Dodd-Frank U.S. swap market reform, contracts that were previously traded in over-the-counter markets (OTC) experience a complex process of "futurisation" so as to begin trading on exchanges. Second, the transition from bilateral to CCP clearing is typically gradual, with a relatively small proportion of assets affected, and/or multiple clearing systems coexisting for extended periods. Under such circumstances, issues such as selection biases and loss of identification power may arise. Third, the timing of the introduction of a CCP in a given asset market may be endogenous. This is of particular concern when the timing is related to the asset price evolution.

In this paper we address these challenges by using as an experimental construct the 2009 introduction of a CCP for equities in Denmark, Finland, and Sweden (the Nordics, hereafter). Equities in these Nordic countries were traditionally cleared bilaterally through a given local Central Securities Depository (CSD). In October 2009, however, stocks in these markets started clearing centrally through the European clearing house EMCF. This quasi-experimental setting has several attractive features. First, endogeneity of timing concerns are in this case mitigated; the chief trigger of the reform was the default of Lehman Brothers, a global financial institution, on September 15th, 2008.[2] Second, all frequently traded securities in these three markets were affected simultaneously, making this reform unusually comprehensive. Third, in contrast to the reforms in derivatives markets, the affected securities traded at organized exchanges (NASDAQ OMX) throughout the announcement

[2]Also important is the fact that the event is fairly recent. This is particularly relevant given the major transformations (technological, regulatory, etc.) in financial markets experienced over the last three decades. In contrast, Case et al. (2013) look at a clearing reform at the NYSE in 1892. It is more difficult to extrapolate asset prices responses given that asset prices are also affected by other economic institutions that may have changed since then.

and implementation of the reform. Fourth, focusing on equities eliminates pressing concerns that would arise with derivatives, related to simultaneous changes in transparency standards and/or contract specifics.[3] Fifth, these markets transitioned from a purely bilateral system to central clearing with a single CCP, reducing additional concerns related to competition between CCPs.[4]

To analyze the effect of the transition on equity prices we consider a quasi-experimental differences-in-differences approach. In our design, certain European economies that did not experience a clearing reform during the same period serve as a control sample. We consider a broad group of 17 European economies and, for robustness, subgroups based on their equity clearing systems. We consider an event window that includes the public announcement of the clearing reform, October 2008, and a short pre-event period in which information about the reform may have leaked.

During the 16-month period between the announcement and implementation of the CCP, stock market indices in the three Nordic countries in our sample experience abnormal returns of -1.08% per month (-17.30% total), on average, relative to a broad set of European economies. This decline in Nordic equity prices is statistically significant and controls for comovements with broad European stock indices. We also analyze the effect of the reform on price-earnings (PE) ratios over the same period and find that, consistent with our previous result, PE ratios in the Nordic decrease by 19% relative to the European control group.

Having analyzed the *total* effect of the clearing reform on equity returns, we next

[3]In contrast to the reform considered in this paper, the introduction of CCP services in the U.S. swap market is taking place contemporaneously with several other key changes mandated by the Dodd-Frank Act: (i) ex post price transparency through swap data repositories, (ii) standardization of products that were previously customized, (iii) electronic trading and ex ante price transparency through Swap Execution Facilities (SEF), and (iv) clearing house competition and differentiation of clearing protocols.

[4]For example, Duffie and Zhu (2011) highlight that netting inefficiencies may occur with multiple CCPs. Their argument is valid even within a single asset class, provided that the competing CCPs are not fully inter-operational. An additional concern with multiple CCPs would be whether competition leads to a deterioration of required credit standards for clearing members (see, for example, Santos and Scheinkman (2001)).

explore what are plausible economic channels that may drive this strong negative response. To accomplish this, we analyze the cross-sectional behavior of the affected stocks by exploiting a proprietary clearing data set. In particular, we are interested in two key dimensions of the clearing reform: the effect of securities margins and that of counterparty default risk. To account for margins, we develop an empirical measure that closely approximates EMCF's proprietary margin algorithm. At the same time, we unfortunately cannot observe the amount of counterparty risk associated with trading a given stock. We instead rely on two empirical measures that aim to capture the degree of counterparty diversity, which we assume is negatively related to counterparty-default-risk premium. The first is a clearing-member-level volume concentration index. The second is the number of clearing members trading that stock.[5]

The cross-sectional analysis shows that price declines are more pronounced for securities with higher margins.[6] To interpret this result, it is important to understand whether margins and collateral costs change after the reform. In the considered event, the answer is unequivocal - total costs increased. Under bilateral clearing, risk management protocols were weak at best, and in most cases non-existent. This feature is not exclusive to the Nordics' clearing reform. Collateral costs are often lower under bilateral clearing since it can be too costly for market participants to set and enforce decentralized systems. This sometimes leads to arrangements based on "mutual trust" or "market discipline" as a way to provide incentives against default (Koeppl, 2012). Our finding on the effect of margin impact is thus consistent with a fundamental prediction of the margin-CAPM of Garleanu and Pedersen (2011): given

[5]Although our measures are not directly reported by the clearing house, we argue in Section 5 that the high level of transparency in Nordic equity trading allow investors to learn a fair amount about counterparty diversification.

[6]EMCF computes margin requirements for a given investor using a portfolio risk approach, not on a stock-by-stock basis. This procedure is standard in modern clearing houses and typically based on the SPAN methodology developed by the Chicago Mercantile Exchange (CME). For this reason, in Section 5 we consider an empirical measure that captures individual securities' marginal effect on total margin requirements.

that collateral costs increased following the reform, everything else being constant, expected returns should increase, rationalizing the initial price decline.

If the CCP reform is successful in reducing counterparty risk, we should observe higher stock prices afterwards.[7] We find that securities traded by a larger number of clearing members, and securities with lower clearing member volume concentration, experience less pronounced return declines. Under the assumed negative relation between investor diversification and counterparty risk, the evidence is consistent with the price increase conjecture.

Moreover, the literature suggest that an increase in margins can (i) increase securities market betas (as in Garleanu and Pedersen (2011)), and (ii) negatively affect market liquidity (as in Brunnermeier and Pedersen (2009)). Thus, a plausible possibility is that price declines are strengthened through these indirect channels. We explicitly test these predictions. For 161 of the 178 stocks in our sample, we find no evidence of changes in market betas following the CCP reform. However, we find that relative to the control sample groups, the introduction of CCP clearing decreases trading turnover and increases the value of Amihud's illiquidity for Nordic markets.

At first, the size of the total price effect may seem high. Although attributing the total price response to individual risk factors would require a structural empirical model, we attempt to assess the relative importance of margins. As a first step, we compute a time-series of average (initial) margin requirements for the first year following the CCP introduction (see Figure 1). Average margin levels are about 6% and margin jump risk is evident; average levels reach a range of 15-20% twice per year in our sample (these values do not include the contributions to the clearing house default fund).[8] Interestingly, the figure suggests that large

[7]Even with a CCP, investors arguably still face the counterparty risk of the clearing house itself. In practice, a systemically important clearing house is often seen as implicitly insured by a given central bank (see Bernanke (1990)).

[8]These margin values correspond to an aggregate margin of approximately 200 million Euros on average, and about one billion Euros for the peaks. Using 2009 figures, and considering that exchange-traded equity volume was nearly 42 times higher in the U.S. than in the Nordics, the equivalent amount of aggregate margin

jumps can occur not only following macro uncertainty but also firm news. According to the margin-CAPM, the tightness of the margin constraint depends not only on margin levels but also on the shadow cost of funding, which as documented by Garleanu and Pedersen (2011), increased dramatically in the months that followed the collapse of Lehman Brothers. Investors were then pricing the effect of the reform at a time of high volatility and high shadow cost of funding.

We conduct several robustness tests to ensure that the results reflect the effect of the clearing reform. First, given that the considered event takes places during a time of financial turmoil, one concern is then that Nordic countries may respond differently to international financial shocks. We identify two recent international shocks to financial markets and find that Nordic prices exhibit no statistically significant reaction to placebo interventions. Second, we investigate whether the negative effect on equity prices is driven by any particular industry. We find that the price effect is shared by virtually all economic sectors. Third, we check different sources of financial news in order to ensure that during the event period the Nordic economies were not subject to any significant region-specific macro event (one that did not affect other European economies). Fourth, we establish the econometric robustness on the event window, standard errors, and estimation approach.

Our empirical results have several practical consequences. First, they stress that the process of moving a given asset class from bilateral clearing to a CCP is not without concerns. Even when a CCP reduces systemic risk and enhances transparency, it may have negative consequences on equity prices, investor portfolio decisions and, in the case of securities markets, on public corporations' cost of capital. They also highlight the importance of the (often overlooked) link between risk management safeguards and asset prices. Second, our results contribute to the current discussion around the optimal way of clearing OTC

at the peaks for U.S. equity markets would be 29.4 billion dollars.

derivatives, which for the most part lacks reliable evidence. Although there are important differences between the clearing of securities and derivatives, the nature of the counterparty credit risk that arises prior to settlement is essentially the same for both asset classes (Bliss and Steigerwald, 2006).[9] Similarly, industry standards for risk management such as portfolio margining are also shared. Understanding the connections between these key features of the clearing process and prices can provide valuable insights regarding the most effective policy tools to address market failure, and to reduce default risk in financial markets at large.

Our paper is related to the relatively limited recent literature that analyzes the clearing of financial assets. Duffie and Zhu (2011) show that, under fairly general conditions in asset markets, systemic risk is minimized by operating a single CCP which allows for joint clearing of different asset classes. Koeppl, Monnet, and Temzelides (2012) develop a model of clearing for financial trades and show under which conditions a central clearing house is socially superior to bilateral clearing (see also Pirrong (2009), Cruz Lopez, Harris, and Perignon (2010), and Biais, Heider, and Hoerova (2012)). These studies, however, do not consider the effect of clearing on asset prices. We contribute to this literature by introducing this key element. The relation between margin and securities prices has recently been studied by Garleanu and Pedersen (2011), Coen-Pirani (2005), and Hedegaard (2012). An important earlier contribution is made by Chowdhry and Nanda (1998). By explicitly analyzing the change in risk management safeguards due to a clearing reform, our analysis provides additional evidence on this important relation. Our paper is also related to the theoretical literature that analyzes the economic role of collateral in general equilibrium (e.g., Dubey et al. (2005) and the references therein), as well as counterparty risk externalities (Acharya and Bisin (2011) and Acemoglu et al. (2013)). The economics in these papers is useful for understanding the

[9] Of course, the relative importance of this factor is likely to differ across different asset classes. When extrapolating our results to different asset classes, one should take into account that the positive valuation effect due to lower counterparty risk is likely to be lower in the case of equities than in the case of OTC derivatives (for example, due to the length of time between execution of a transaction and settlement).

underlying forces that link default risks and asset prices that we stress in our empirical study.

The remainder of this paper is organized as follows. Section 2 discusses the specifics of the Nordic clearing reform and introduces the main empirical questions. Section 3 describes the data sources as well as the empirical methodology. Section 4 analyzes the total effect of the reform on equity prices and PE ratios. The potential mechanisms that generate the valuation effects are discussed in Section 5. Section 6 addresses several robustness tests and Section 7 concludes. The Appendix contains further details on the clearing reform. [10]

2 The Clearing Reform and Empirical Questions

2.1 The Clearing Reform

Equities in Denmark, Finland and Sweden were traditionally cleared bilaterally by a given national CSD. There was no default fund and banks did not post collateral with the CSD. Although the clearing system in these three countries shared most features, the specific rules were not identical. In particular, the delivery system was $T + 3$ in Sweden and $T + 2.5$ in Denmark and Finland.[11] In all cases, cash was used to settle.

The CSDs were owned by local banks and most large domestic banks were clearing members as well. Local clearing members offered indirect clearing access to some small domestic and foreign banks. The system worked quite efficiently, though non-clearing members paid much higher fees compared to those set post-reform (non-members such as Lehman Brothers could pay up to ten times as much). Only a few defaults were observed in the recent history before the reform. The most recent local bank failure occurred in 1991. More recent failures include Lehman Brothers and the three largest Icelandic banks (Glitnir,

[10] All unreported empirical results are available upon request.

[11] The expression $T + j$ denotes that settlement (the delivery of securities to net buyers and payments of money to net sellers) takes place j days after the trade day T.

Kaupthing, and Landsbanki) in 2008.

In the aftermath of the international financial crisis, particularly following the collapse of Lehman Brothers, bilateral clearing was called into question by a significant portion of the international community. On October 16th, 2008, NASDAQ OMX, the most important incumbent stock market, first announced a plan to introduce CCP services through the European clearing house EMCF.[12] The announced timeline specified January 2009 as the target month for an optional CCP clearing program, but the optional program effectively started in February 2009. The initial announcement also specified June 2009 as the target month for mandatory CCP clearing. However, mandatory CCP clearing was not instituted until October 19th, 2009 in Sweden and Denmark, and November 16th, 2009 in Finland. All frequently traded securities were included in the mandatory CCP regime.[13] We provide more details about the specifics of the transition in the Appendix.

The introduction of EMCF as the single clearing house in the Nordics represented the most important clearing reform in the history of these economies. As a CCP, EMCF began acting as the counterparty for both buyers and sellers of securities. Importantly, EMCF also required that all clearing members post collateral based on their yet-to-settle trade portfolio. Collateral requirements were marked-to-market and revised daily. To hedge against extreme tail events, members were also required to contribute to a default fund.[14] These changes are

[12]A small and nascent exchange, Chi-X, began trading and clearing through EMCF a limited number of Nordic stocks earlier in 2008. At the time of the NASDAQ announcement in October 2008, Chi-X market share was less than 5% of trading volume.

[13]A number of highly illiquid stocks continued clearing bilaterally. Although in principle these stocks would constitute a natural "control" group, we do not consider them as such, since there is a lack of random assignment. The strong illiquidity heterogeneity among these two groups further discourages a direct comparison.

[14]Based on EMCF Rulebook 2009, the contributions that clearing members are required to make to the clearing house default fund are: (i) base deposits of Euro 1,000,000 for a Direct Clearing Participant and Euro 3,000,000 for a General Clearing Participant. (ii) A percentage (nearly 15%) of a moving average of the end of day aggregate margin. In addition to changes in risk management costs, investors may face different operational costs after a clearing reform. We focus on risk management costs since, according to local experts, operational costs were relatively small before the reform. One exception is the case of foreign banks that were not direct clearing members and thus faced higher clearing costs. However, as the Appendix shows,

Table 1: Bilateral and CCP clearing in Nordic equity markets

Characteristics	Bilateral Clearing (before event)	CCP Clearing (after event)
Collateral	None	Marked-to-market
Counterparty	Anonymous investor	Clearing house (novation)
Default Fund	No	Yes
Settlement regime	T+3*	T+3

* Danish and Finnish markets operated with a T+2.5 settlement cycle.

summarized in Table 1.

2.2 Empirical Questions

In the general equilibrium world of Arrow-Debreu there is no role for central counter parties since all agents keep their promises (Dubey et al. (2005)). Instead, the economic and financial literature on clearing recognizes the important role that clearing houses have in real financial markets. However, the literature mainly focuses on the effect of a given clearing regime on financial stability or netting efficiency (e.g., Duffie and Zhu (2011)). In this paper, we focus on asset prices. To the best of our knowledge there is no equilibrium framework where asset prices can be directly linked to a given clearing system. From this perspective, our first question can be seen as empirically motivated and can be stated in a theory-agnostic fashion.

Question 1 (Baseline). *What effect does the introduction of a CCP have on asset prices?*

Arguably, the most widely cited benefit of a central counterparty is that it pools and diversifies settlement risks associated with transactions between multiple participants, thus reducing default risk.[15] Since bilateral default risk cannot be diversified away, lower default probabilities should lead to higher asset prices. Under a CCP regime, however, after a buyer

most global financial institutions actively operating in the Nordics were clearing members.

[15] Additional benefits may include independent valuation of trades and collateral, and enhanced monitoring of the credit-worthiness of clearing firms.

and seller agree to a trade on an exchange, the clearing house steps in and becomes the buyer to all sellers and the seller to all buyers. During the period between the agreement to trade and the time when the securities are moved out of the seller's account and into the buyer's account, the CCP has taken on the default risk of the trading parties. If a clearing reform is a positive force in reducing default risk, it is natural to hypothesize that CCP clearing raises asset prices. This theoretical consideration provides the intuition for our second question.

Question 2 (Central counterparty). *Do the prices of securities with higher counterparty risk exhibit stronger positive reactions to the introduction of the CCP?*

To mitigate default risks and help enforce that promises are kept, clearing houses ask participants to post collateral - in fact, EMCF requires clearing members to maintain margin accounts. Obviously, posting collateral is costly for financial institutions that are subject to margin calls. In fact, recent academic research by Garleanu and Pedersen (2011) suggests that equilibrium asset prices should reflect the effect of such margins through trading capital. Intuitively, when trading capital is scarce, securities with higher margin requirements should trade at relatively lower prices in their equilibrium margin-CAPM. A given CCP may require higher collateral than alternative clearing arrangements. In the considered reform, for example, the introduction of the CCP increased margin requirements for securities overall since no margining system was previously in place. This observation motivates our third question.

Question 3 (margin-CAPM: returns). *Do the prices of securities with high margin requirements exhibit a stronger negative reaction to the introduction of the CCP?*

One additional prediction of the margin-CAPM is that the beta for a given security in equilibrium is an increasing function of the security's margin (Garleanu and Pedersen (2011), page 1998). We are also interested in studying the link between security betas and the CCP reform.

Question 4 (margin-CAPM: betas). *Do betas for securities with high margin requirements exhibit a stronger positive reaction to the introduction of the CCP?*

The recent literature acknowledges that changes in market and funding liquidity can affect asset prices in equilibrium (e.g., Acharya and Pedersen (2005) and Brunnermeier and Pedersen (2009)). Changes in risk management safeguards, such as margin requirements, can affect the funding liquidity constraints of market makers and other participants that provide liquidity to the market. These considerations motivate our fifth question.

Question 5 (Liquidity). *Is market liquidity affected by the introduction of the CCP?*

In some cases, it is conceivable that CCP clearing of a given asset class may potentially hurt overall netting among financial institutions, thus decreasing asset prices further. This would be the case if investors clear bilaterally across different asset classes before the CCP begins operating (Duffie and Zhu (2011)). However, there was no cross netting of equities with other asset classes, such as derivatives, in the Nordics' bilateral clearing system.

3 Data and Empirical Methodology

3.1 Data and Sample Selection

The main goal of our study is to assess the impact of the introduction of a CCP on asset prices. To this end, we use monthly stock and index returns from the Thompson Reuters Tick History and Datastream databases, adjusted for dividends and stock splits. The dataset encompasses the main blue chip indices in 20 European countries, including the three Nordic markets that we focus on (Sweden, Denmark, and Finland). For the stock-level analysis, we use monthly returns from Datastream for the 178 equities traded on NASDAQ OMX Nordic at the time of the event. We also use Datastream to compute PE ratios. We use the Euro-converted risk-free interest rates from Kenneth French's database. For European securities not denominated in Euros, we use monthly bilateral exchange rates from the European Central Bank.[16]

We compute two measures of trading counterparty diversity at the stock level. To this end, we use a proprietary dataset provided by EMCF that consists of detailed information on individual trades. This dataset spans the period from October 19, 2009 to September 10, 2010 and contains information on approximately 70 million trades, including a time stamp, trader ID (anonymized), transaction price, quantity, and a buy/sell indicator.

Since we concentrate on the effect of the introduction of a CCP, which takes place over a number of months, our analysis faces some of the challenges of long-run event studies. One potential concern is related to the sensitivity of abnormal returns to the choice of the event window (the one that characterizes the time between the announcement and implementation of the reform). The official announcement of mandatory clearing services was made by NASDAQ OMX on October 16, 2008, while the implementation took place a year later (on October 19, 2009 for Denmark and Sweden and on November 16, 2009 for Finland). Errunza and Miller (2000) argue that the event window should begin before the announcement date of a policy intervention. This is because information about the event may already have been disseminated in the market prior to the official announcement. To account for this possibility we consider an event period that starts the month before the official announcement, that is September 2008. We also extend the end of the event window one month after the implementation, December 2009, to capture the potential delayed response of infrequent market participants, as well as potential learning-like effects. Thus, our event window spans

[16] These alternative currencies include the Swedish/Danish/Norwegian krona, Swiss franc, British pound, Hungarian forint, Romanian leu, Polish zloty and Czech krona.

a total of 16 months.

The sample that we use for the differences-in-differences (DD) analysis ranges from January 2008 to January 2011. In choosing our estimation window, a trade-off exists between having enough observations and, on the other hand, avoiding contaminating factors such as additional policy interventions, which may bias the results over a longer sample. More specifically, our sample begins shortly after the implementation of MIFID 1 in November 2007. We also take into consideration the fact that the share of high-frequency trading activity in the Nordic markets increased significantly in 2011 (from around 8% to 16%). To avoid potential biases due to the latter, we do not include 2011 in our estimation sample.

3.2 Empirical Methodology

Our main approach is based on a quasi-experimental DD design, where Denmark, Finland, and Sweden represent the "treatment" group that experiences the reform. Various groups of European economies serve as "control" groups. We define a dummy variable d_{ccp} that takes the value one for the three countries that undertake the clearing reform, and a dummy variable d_T that takes the value one for the months of the event window. Let Y_{it} be the variable of analysis, typically monthly log returns. The general specification of our empirical tests is given by

$$Y_{it} = \text{constant} + \gamma_T d_T + \gamma_{ccp} d_{ccp} + \delta \left(d_T \cdot d_{ccp} \right) + \text{error}_{it}. \tag{1}$$

The estimated impact of the reform is then the estimate $\hat{\delta}$.

One common concern in quasi-experimental studies is the issue of endogeneity of the intervention. Endogeneity concerns in this case are mitigated by the fact the key driving factor behind the timing of the reform in the Nordics was the global financial crisis and the

Table 2: Countries in control groups

Group	Description	Countries
EUR	Pan-European group	All listed below
CCP	Functional CCP for equities in 2009	Germany, France, UK, Italy, the Netherlands, Belgium, Austria, Portugal, Ireland, Switzerland, Hungary
NCCP	No CCP	Spain, Poland, Greece, Norway, Czech Republic, Romania

collapse of Lehman Brothers, a global financial player.

Our baseline control group includes the top 15 EU economies by GDP (excluding the treated countries), as well as Norway and Switzerland (which are not members of the EU). We refer to this set of countries as the European (EUR) group (the complete list of countries and stock market indices appears in Table 3). Given the lack of a laboratory setting, we believe these countries represent a reasonable control group. First, both groups have similar economic institutions. Second, these European countries are exposed to similar economic and financial shocks (e.g., European Central Bank (ECB) interventions, capital flows, terms of trade). Third, as Table 4 illustrates, firms in the treated and control groups exhibited similar financials before the event announcement (e.g., market cap, PE ratios, and Price/Book ratios). Furthermore, in the months prior to the reform announcement, Nordic equities do not exhibit a distinctive price a trend relative to the control samples.

Although we argue that the EUR group is a natural choice as a control sample, for robustness purposes we construct additional groups. Given the nature of the reform, one may consider as a plausible control group those countries without a CCP for equities at the time of the announcement. We thus consider countries in the EUR group that did not have a fully functional CCP for equities clearing during 2009, the year of the reform implementation. We label this group as NCCP, and the remaining countries as CCP. The countries in each of these groups are summarized in Table 2.

Estimation and standard errors. One concern in the design of our estimation procedure is the presence of heteroskedasticity in monthly returns, which is particularly important in this context given that the sample includes the financial crisis of 2008. To address this issue, we follow Chandra and Balachandran (1992) and Harrington and Shrider (2007) and use weighted least squares (WLS) approach to estimate the regression models.[17] In all regression specifications, the observations are weighted down by the standard deviation of residuals on a particular month and country[18] (or security in the case of individual-stocks tests). The WLS estimates are similar in magnitude to those from simple OLS regressions.

To obtain the correct inference from the regression analysis, we follow Gentry et al. (2003) and Maksimovic and Phillips (2002) and use robust standard errors alongside the WLS estimation procedure. We employ the double-clustering methodology proposed by Cameron et al. (2006) and Petersen (2009), allowing residuals for all cross-sectional units (indices or stocks) to be correlated on a particular date, and also allowing residuals for a single cross-sectional unit to be correlated across all dates in the sample. Residuals for separate cross-sectional units on different dates are assumed to be uncorrelated. This approach yields more conservative tests results than standard robust alternatives such as Huber-White and Newey-West estimators.

[17] As several asset pricing studies recognize, OLS is generally less efficient than WLS in the presence of heteroskedasticity leading to under-rejection of null hypotheses (see, for example, Keim (1983), Dewenter (1995), and Naranjo et al. (2000)).

[18] Econometrically, this is done by regressing squared residuals on month and country dummies: $error_{it}^2 = \delta_i + \gamma_t + \varepsilon_{it}$.

4 Clearing and Stock Market Indices: Empirical Results

This section presents findings regarding the behavior of aggregate abnormal stock returns around the event window. To compute abnormal returns, we take residuals from estimating a single-index model using stock market indices as the dependent variable and the EURO STOXX 500 as the market index, adjusted for dividends and denominated in Euros.[19] In particular, the CAR for country group j is given by

$$CAR_{j,t} = \frac{1}{N_j} \sum_{i=1}^{N_j} \sum_{s=1}^{t} \left(Return_{it} - \hat{\alpha}_i - \hat{\beta}_i Return_{STOXX,t} \right), \tag{2}$$

where i is an index of country-specific stock market indices and N_j represents the number of indices in group j. We follow Henry (2000) and estimate market betas for each index using full sample data (from January 2008 to January 2011), although our results are robust to estimating betas using only post-event data, as discussed in Section 6.

Table 5 presents the effect of the introduction of CCP services on aggregate equity returns. The empirical specification is as in equation 1, where the treatment is the introduction of CCP services. The results show that, compared to the EUR group, Nordic equity returns decrease by 1.08% on a monthly basis during the event period (approximately −17.3% for the entire period). The effect is also significant relative to the control groups of countries with and without CCP for equities.

Having computed the average monthly effect of the reform on stock returns, we seek to gain insight on its dynamics. Figure 3 shows the evolution of the difference between the CAR

[19] Alternative European and U.S. indices were also considered. We choose the one most closely correlated with the Nordic markets (correlation between 60% and 70%). In contrast, the Fama-French market factor correlation with Nordic indices is only between 27% and 40%.

of the Nordic and EUR groups over the event window using cumulative DD monthly effects.[20]

We can observe that the effect of the reform is gradual, consistent with the idea that economic agents face uncertainty on the final implementation of the reform and/or its specifics (e.g., Henry (2000)).[21]

We also test the effect of the reform using PE ratios as the dependent variable in equation 1.[22] The results are presented in Table 6. Relative to the EUR group, the Nordic group shows an effect of -19.6% during the event window period. The negative effect on valuations is significant for all considered control groups and the explanatory power of the reform is significantly higher than in the case of returns (the adjusted R^2 is at least one order of magnitude higher).

5 The Channels: Margins, Counterparty Risks, Market Betas, and Liquidity

The results in Section 4 show that adopting CCP services has a strong negative valuation effect on Nordic equities. In this section, we seek to understand the potential channels behind this valuation effect. In particular, we investigate the empirical questions posed in Section 2. To this end, Section 5.1 lays out a simple asset-pricing framework that allows returns to be affected by the key clearing reform features listed in Section 2.1. We develop a methodology

[20]The specification is as follows

$$AbnormalReturn_{it} = \text{constant} + \gamma_T d_T + \gamma_{ccp} d_{ccp} + \delta_s \left(d_{month=s} \cdot d_{ccp}\right) + \text{error}_{it}.$$

Figure 3 displays the evolution of $\sum_{s \leq t} \delta_s$.

[21]During our conversation with experts in the Nordic markets, we learned that a previous attempt to introduce CCP clearing in 2003 was blocked by local banks and thus failed.

[22]We also considered price-dividend ratios. However, coorporate dividend policies in the Nordic were highly influenced by the 2008 crisis, making this measure less appealing than PE ratios. As an illustration, 11 out of the 20 top Nordic firms by market capitalization reduced their dividends in 2009 by 20% or more, and 5 of these firms reduced their dividends by 75% or more.

for computing empirical measures of the marginal impact on margin requirements for each security as well as proxies for counterparty diversity in Section 5.2. We analyze the empirical results in Sections 5.3 to 5.6.

5.1 Asset-Pricing Framework

To explore the drivers of the valuation effect, we consider an asset-pricing framework in the spirit of the margin-CAPM in Garleanu and Pedersen (2011). These authors develop a model in which securities' margins have equilibrium pricing implications. Intuitively, when trading capital is scarce, securities with higher margin requirements should trade at relatively lower prices. The price impact of margins depend on the cost of funding for investors, which in turn affects the so-called margin premium. The margin premium is positive when margin constraints are binding for at least one investor, and zero otherwise. This framework is a natural point of reference given the key role that margins and collateral requirements play under CCP clearing. We further consider the possibility that the change in clearing regime affects the probability of a counterparty default. More specifically, we consider asset i's required return under clearing regime c, either bilateral clearing (bc) or central clearing (ccp), to be given by

$$E\left(R_i^c\right) = R^{\text{risk-free}} + \beta_i^c \times \text{covariance RP} + m_i^c \times \text{margin premium} + \xi_i^c, \tag{3}$$

where m_i^c denotes asset i's margin requirement and RP stands for risk premium. Note that in our formulation betas are indexed by the clearing regime, a connection that is micro-founded in the model of Garleanu and Pedersen (2011). The last term of the RHS of equation 3, ξ_i^c, represents the value of a price premium due to the exposure to counterparty default risk. This term is not present in the margin-CAPM of Garleanu and Pedersen since default is not possible in their model. Counterparty risk is, however, a key concern behind any clearing reform. We assume that both the covariance and margin premiums are determined independently of the clearing regime for equities, and are driven by factors such as macroeconomic conditions and risk preferences.

We see the transition from bilateral to CCP clearing as an intervention that can affect asset prices in equilibrium through changes in each of the terms in equation 3. The reform induced change in required returns in then given by[23]

$$E\left(R_i^{ccp}\right) - E\left(R_i^{bc}\right) = \left(\beta_i^{ccp} - \beta_i^{bc}\right) \times \text{covariance RP} + \left(m_i^{ccp} - m_i^{bc}\right) \times \text{margin premium} + \left(\xi_i^{ccp} - \xi_i^{bc}\right). \quad (4)$$

The interpretation of the equation is straightforward. Following the introduction of CCP services, required returns can change due to: changes in betas, changes in securities' margins, or changes in the default risk discount. In light of our previous observations, we generate the following hypotheses based on the empirical questions of Section 2.2.

- (Q2) Based on the rationale of the reform (that is, to reduce default risk), we expect that $\left(\xi_i^{ccp} - \xi_i^{bc}\right) < 0$.
- (Q3) Margins were introduced as a result of CCP services. Thus, for each security i we have $\left(m_i^{ccp} - m_i^{bc}\right) > 0$.
- (Q4) In the margin-CAPM, securities' betas are increasing in margins, which leads us to hypothesize that $\left(\beta_i^{ccp} - \beta_i^{bc}\right) > 0$.

The clearing reform thus gives rise to two forces that lower equity prices (the increase in margins and betas) and one force that would increase asset prices (the decrease in counterparty

[23]Equation 4 is analogous to equation 33 in Garleanu and Pedersen (2011), which is used to study the effect of the Federal Reserve's TARP program.

risk).

5.2 Empirical Proxies and Cross-Sectional Tests

The CCP requires margins that are based on a member's (yet-to-settle) trade portfolio, not on individual security basis, which makes the calculation of a stock-specific margin proxy non-trivial. The margining technology that EMCF uses, the in-house correlation haircut model (CoH), is similar in spirit to the now standard SPAN methodology of the CME, but remains proprietary and mostly opaque. The most detailed public description of the CoH model available is in a report by the Dutch Central Bank (De Nederlandsche Bank, 2011), which states that the computation of the margin requirement for a given investor: (i) takes into account the correlation between the various products that are part of the investor portfolio, (ii) determines the risk factors that have the greatest impact on the portfolio, (iii) shifts these components to find worst case scenario (maximum loss), and (iv) attribute back the contribution per product in the determined worst case.

The natural first step in developing a stock-specific margin requirement measure is to consider a representative investor who trades the market portfolio. The "maximum loss" is taken to be proportional to the standard deviation of the portfolio return. The margin requirement for individual securities is computed by changing portfolio weights marginally to capture each security's marginal risk contribution. Formally, let the market portfolio contain I securities with weights given by the column vector n. We assume that the return of each security can be represented by the sum of a single market return process and an uncorrelated idiosyncratic component. The variance matrix of returns, Σ, then has generic elements given by

$$\sigma_{ii} = \beta_i^2 \sigma_M^2 + \psi_i \tag{5}$$

$$\sigma_{ij} = \beta_i \beta_j \sigma_M^2 \tag{6}$$

where ψ_i represents the idiosyncratic variance component of securities' returns. The variance of the market portfolio can be written as $n^T \Sigma n$, and the marginal impact of security i on total portfolio risk is given by

$$\frac{\partial}{\partial n_i} \sqrt{n^T \Sigma n} = \frac{n_i \sigma_{ii} + \sum_{j \neq i} n_j \sigma_{ij}}{\sqrt{n^T \Sigma n}}. \tag{7}$$

We then define security i's marginal impact on margin requirements ($MIMR$) by re-expressing the LHS of equation 7 (using equations 5 and 6) and multiplying by a factor of seven.[24]

$$MIMR_i = 7 \left(\sigma_M \beta_i + n_i \frac{\psi_i}{\sigma_M} \right) \tag{8}$$

Intuitively, as the individual weight of each security in the portfolio approaches zero, margins are only affected by the systematic components of securities returns.[25] The risk measure in equation 8 finds a natural empirical counterpart by replacing each term in the RHS with the corresponding estimate.[26] As in Section 4, the Euro STOXX 500 index proxies for the market

[24]The value seven is mentioned by Fortis (EMCF's main owner at the time) in its 2009 annual report.

[25]Indeed, the first component of $MIMR$ is much larger than the second in our sample. The empirical mean of MIMR across all securities is 7.49 cents per Euro position, while the first component of the above sum has a mean of 7.42 cents per Euro position. The relative contribution of the second term ranges from virtually 0 to a maximum of 18% of $MIMR$, with a mean and a median around 0.5%.

[26]The total margin in real markets is the sum of two components: an 'initial margin' and a 'variation margin.' The initial margin helps the CCP to hedge against future price changes. The variation margin reflects realized profits or loses on a yet-to-settle portfolio. The proxy $MIMR$ replicates the initial margin component, since the variation margin is on aggregate equal to zero. As an illustration, consider a single-security example where clearing member XYZ buys one unit of a stock at price \$100. The following day, the security price drops to \$90 and XYZ buys one more unit. Suppose volatility is 3% and the CCP uses seven standard deviations to insure itself. Thus, XYZ needs to post $2 \times \$90 \times (7 \times 0.03)$ initial margin, plus $\$100 - \$90 = \$10$

portfolio.

We now turn to the construction of proxies for counterparty default risk. In an idealized context, a researcher would be able to observe, for any given transaction, the default probability distribution across all participating investors. Given that this type of information is not available, we rely on two empirical measures that are informative about the degree of counterparty diversity for a given security. The first measure, $NumberCP$, is simply the average number of clearing counterparties that traded a given security in a given month. The second measure, counterparty concentration or CPC, is computed for each security i as the time average of the square root Herfindahl-Hirshman index, as follows[27]

$$CPC_i = \frac{1}{T}\sum_{t=1}^{T}\sqrt{\sum_j\left(\frac{Volume_{ijt}}{\sum_j Volume_{ijt}}\right)^2}. \tag{9}$$

In equation 9, $\frac{Volume_{ijt}}{\sum_j Volume_{ijt}}$ represents the relative volume that counterparty j traded on security i in a given month. Intuitively, securities for which a single investor accounts for a large proportion of trade volume have CPC values close to one. In order to compute these measures, we exploit a proprietary data set of cleared transactions provided by EMCF. This dataset encompasses the first post-implementation year, October 2009 through September 2010, and contains anonymized clearing member identifiers for each transaction.[28]

The rationale of both counterparty diversity measures is based on the premise that when a stock's trade volume is concentrated among a few investors, those investors are exposed to

variation margin, adding to \$47.8. Intuitively, this amount represents the 'replacement value' for the CCP. That is, if the CCP took over the XYZ's commitment, it would spend \$190 two buy two units, which will then be re-sold at an unknown future value (potentially seven standard deviations lower).

[27]Several alternative concentration measures were constructed, including concentration ratios, entropy, the Gini coefficient, and the exponent of a generalized Zipf law. All these measures yield very similar results in the cross-sectional tests.

[28]Jones and Perignon (2012) also use clearing data to infer default risk. Their approach is different from ours since they aim to compute default risk for a given clearing member. We are instead interested in the risk of trading a given security, and thus consider the trades of all clearing members that invest in such security.

relatively larger monetary losses should a counterparty default occur. Everything else held constant, trading such stocks would be considered less attractive by risk-averse investors.[29]

Our measures of risk and investor concentration are admittedly imperfect. The single-index model we consider here, for example, represents a simple first-order approximation to the margin algorithm used by the CCP. To verify the accuracy of the proxy, for each trader and day in the sample period, the CCP computed the amount of additional margin that a trader had to post if a security position was changed marginally. These additional (true) margins were averaged across days and traders and the overall average was given to us in order to compare to our empirical proxy. The resulting distributions are shown in Figure 2. We can observe that the distribution implied by $MIMR$ does a remarkably good job approximating the one generated using EMCF's proprietary algorithm (Spearman rank correlation of 0.83).

Turning to counterparty diversity, one concern is whether the measures we consider can, to some extent, be observed by investors and thus priced. The institutions of trading in the considered Nordic countries, with a higher emphasis on transparency than in most developed markets, provide support for this notion. The NASDAQ OMX, for example, provides full post-trade transparency including trading counterparties identities at the end of each trading day.[30]

[29] For concreteness, consider the following illustrative example. A large number of investors trading one security are each subject to an i.i.d probability of defaulting on his or her position equal to $p \in (0, 1)$. Suppose that an investor taking a position of value D expects N counterparties on a given stock, each holding a position worth D/N dollars. A simple calculation shows that if investors have von Neumann–Morgenstern utility, expected utility increases in N as volatility declines.

[30] According to the NASDAQ OMX Nordic Market Model, (anonymous) executed trades are published in real time via the public data feed while trade counterparties are disclosed after the market close. However, we identify a temporary exception to this rule. Between June 2008 and April 2009, post-trade anonymity was in force for all Helsinki stocks and the five most traded stocks in Stockholm.

Cross sectional tests. For each empirical measure Z, we estimate the following panel regression

$$AbnormalReturn_{it} = \text{controls} + \gamma_T d_T + \gamma_z Z_i + \delta_z \left(d_T \cdot Z_i\right) + \text{error}_{it}. \tag{10}$$

The coefficient δ_z captures cross-sectional heterogeneity related to our MIMR and counterparty diversity measures. Based on our discussion in Subsection 5.1, and the definition of the empirical proxies in this section, economic intuition suggests that this coefficient should be: (i) negative for $MIMR$, (ii) negative for $NumberCP$, and (iii) positive for CPC.

5.3 Margins and Stock Returns (Q2)

Panel (a) of Figure 4 shows the evolution of the CAR over the event window for two portfolios of Nordic stocks sorted by $MIMR$. The figure suggests that the introduction of the CCP has a larger negative effect on the valuation of high-$MIMR$ securities. This finding is consistent with the prediction of the margin-CAPM that high margin securities carry higher expected returns. The fact that the introduction of the CCP increased margin requirements across all securities rationalizes the observed initial price decline. This behavior is consistent with the cross-sectional results presented in Table 7. Stocks with higher $MIMR$ values display a stronger price decline than securities with lower margin impact. Controlling for firm size and the number of counterparties, a one standard deviation increase in the value of $MIMR$ induces an additional average monthly decline in abnormal equity returns of 41 bps over the event period (24 bps when controlling for CPC).

5.4 Counterparties Concentration and Stock Returns (Q3)

Panel (b) of Figure 4 shows the evolution of the CAR over the event window for two portfolios of Nordic stocks sorted by CPC. The figure suggests that the introduction of the CCP has a larger negative effect on the valuation of low-CPC securities. This behavior is consistent with the cross-sectional results presented in Table 7 for the two measures of counterparty diversity. First, the returns of stocks with a higher number of counterparties decrease relatively more than returns of stocks with fewer traders. Second, stocks that display a higher concentration of volume across traders, as measured by CPC, display lower price declines than stocks with a low concentration of volume. In particular, a one-standard-deviation increase in the value of CPC induces a 56 bps increase in monthly abnormal returns across the event period. The effect of both counterparty diversity measures remain highly significant after controlling for firm size and $MIMR$.

The economic interpretation of these results is that the considered measures are correlated with traders' perceived counterparty default risk. The results then suggest that the introduction of the CCP may have decrease default-related return premiums prevalent under bilateral clearing (that is, $\xi^{BC} - \xi^{CCP} > 0$ in equation 4). In other words, the introduction of the CCP increases the relative valuation of securities with low counterparty concentration, which investors may have previously perceived as riskier to trade.

5.5 Do Betas Change? (Q4)

This subsection explores whether the implementation of CCP services in the Nordic markets affects individual securities' betas. To this end, the following panel regression is estimated

$$Return_{it} = \text{constant}_i + \left(\beta_i + \Delta_i \times d_{\{t>T\}}\right) \times Return_{STOXX,t} + \text{error}_{it}, \tag{11}$$

where the dummy variable $d_{\{t>T\}}$ is one for the post-event period (after December 2009). Thus, the coefficient Δ_i captures the potential change in market betas following the introduction of CCP services. We find that for 161 of the 178 securities in our sample the coefficient Δ is not significantly different from zero.

To gain further insight into the potential change in betas, and whether margins interact with such changes, we construct five market-cap-weighted portfolios, which correspond to the cross-sectional quintiles of the $MIMR$ measure. Regressions estimated are similar to equation 11 but with betas that can also vary across the margin-sorted portfolios. Similarly, we do not find evidence of changes in beta in this case either.

5.6 Is Market Liquidity Affected? (Q5)

The considered clearing reform increases margin requirements thus tightening funding liquidity for investors. The framework of Brunnermeier and Pedersen (2009) implies that such negative shocks to trading capital should lead to a reduction in market liquidity (see Proposition 5 there). In this section, we test this prediction explicitly by studying the effect of the reform on two widely used measures of market liquidity: turnover and Amihud's ILLIQ (Amihud (2002)).

For the 20 indices in our sample, turnover is calculated as the ratio of trade volume[31] to market capitalization. Table 8 reports of the baseline DD regression model (equation 1), with turnover as the dependent variable. The results suggest that the reform has a negative and highly significant effect on turnover in the Nordics. For example, average monthly turnover decreases by 16% relative to the EUR group.

In order to construct a measure of market illiquidity, we follow Acharya and Pedersen

[31] Traded volumes on Chi-X and BATS, the two largest European MTFs by market share, are included in this measure.

(2005) and normalize, for each stock i and month t, Amihud's ILLIQ measure as follows

$$c_{i,t} = \min\left(0.25 + 0.30 ILLIQ_{i,t} P^M_{t-1}, 30\right), \tag{12}$$

where P^M_{t-1} is the ratio of the capitalizations of the market portfolio at the end of month $t-1$ and of the market portfolio at the end of December 2007 (the pre-sample value).[32] Next, the market-wide illiquidity measure for index j, $c^j_{i,t}$, is computed simply as

$$c^j_{i,t} = \sum_{i=1}^{N_j} \omega^j_i c_{i,t}, \tag{13}$$

where N_j represents the number of securities in index j, and ω^j_i is the value-based weight of security i in portfolio j.

Table 9 reports the DD regression results, where market-wide illiquidity is the dependent variable. Consistent with the turnover result, the CCP reform significantly increases market illiquidity in the Nordics: relative to the EUR group, illiquidity in the Nordics increased 16.86%.

6 Alternative Explanations and Robustness

Section 4 presented evidence that the introduction of CCP services in the Nordics decreased asset prices. Section 5 relates this finding to some of the key features of the clearing reform. This section addresses alternative explanations that may account for the behavior of stock returns during the event period. Section 6.1 discusses whether Nordic countries react differently to external shocks relative to other European economies. Sections 6.2 and 6.3

[32] Our sample contains approximately 600 stocks that are part of the different indices. Volume is calculated by adding transaction values. Due to data limitations, volume for German securities is computed by summing across the number of shares transacted and then multiplying by the end-of-day price.

discuss whether a macro shock in the Nordics or an industry-specific event, respectively, may be driving the stock return findings. Finally, we discuss econometric robustness in Section 6.4.

6.1 Do Nordic Markets Behave Differently?

Given the period in which the event takes place, one may be concerned that the introduction of the CCP occurs contemporaneously with the international financial crisis. At the most fundamental level, we address this issue by taking a DD approach and thus remove common time effects. However, the question remains whether the countries that undertake the reform react to external shocks in a different fashion. This would be especially worrisome if, following negative external shocks, prices in the Nordic markets had a systematic tendency to decline more sharply than the control groups. To address this possibility, we search for additional negative financial shocks that hit European markets and then contrast stock price responses in the Nordic countries and in the control groups. In effect, we study the response of Nordic markets to a "placebo" treatment.

We identify two recent financial shocks. The first event begins on June 15, 2011, when Moody's downgraded three important French banks (BNP Baripas, Credit Agricole, and Societe Generale). The second begins on August 6^{th} of the same year, when the U.S. sovereign bonds lost their AAA rating at Standard&Poors. The U.S. bond rating downgrade occurred nearly at the same time with rumors of a French debt downgrade. The evolution of European equity prices around these two events can be seen in Figure 5. No additional abnormal negative effect is observed in the Nordic markets. Although we cannot fully rule out the alternative hypothesis considered here, our placebo analysis provides evidence against it.

Yet, an additional consideration we analyze is the sensitivity of the effect on returns to selecting an alternative event window that does not include the month of Lehman Brothers default. As discussed in Section 4, although the effect of the clearing reform within the event period is gradual, there is a non-negligible response of Nordic CAR relative to the EUR control group in September 2008. Such reponse is typical in a broad market reform whenever agents anticipate the initial announcement, based on leaked information, initial conversations with exchange officials, or simply market rumors. Yet, we contemplate an alternative view where there is no anticipation whatsoever and eliminate September 2008 from the sample.[33] We find that the effect on returns is negative and significant, but decreases in magnitude from -1.08% to -0.95% per month.

6.2 Does a Macro Event in the Nordics Drive the Asset Prices Results?

An additional concern is whether a region-specific macro event during the event period might have led to a significant price decline in the Nordics. We investigate this possibility using the macroeconomic reports of the Nordic central banks, the LexisNexis Academic News service for English-written news on Sweden, Denmark, and Finland, as well as the Bloomberg News Research service. In short, we find no evidence of significant macro events that might affect the Nordics but not our control group sample.[34] The most significant events correspond to interest rate cuts by central banks. For example, in line with the ECB and the U.S. Federal Reserve, the Swedish central bank cut the interest rate from 3.75% to 0.5% between December 2008 and April 2009.

[33]An additional alternative view is that the initial decrease in September 2008 is due to the fact that Nordic countries, unlike most European counterparts, did not have a CCP at the moment of Lehman's default. However, we also observe the clearing reform effect when considering the control group NCCP of countries that, like the Nordic group, did not have a CCP in 2008 (see Table 5).

[34]The main regional risk factor is the larger than average exposure to Baltic and Icelandic assets on part of Swedish and Danish banks. The crisis in the Baltics thus led to losses and credit rating downgrades for banks such as Swedbank and SEB. The crisis, however, had "little impact on solvency" according to Standard&Poor's ("Baltic storms threaten to undermine Swedish lenders", Financial Times, April 23 2009).

6.3 Does an Industry Effect Drive the Asset Prices Results?

Yet another concern is whether a given industry in the Nordic economies experienced a large non-clearing-related shock during the event period, which may drive the results. To explore this possibility, we assign one of the ten Datastream industry codes to each of the 178 stocks in our sample. We then run a regression like the one in equation 10 but using industry dummies that interact with the event dummy. In brief, we find a significantly negative effect on stock prices during the event period for seven out of ten of the considered industries: energy, industrials, financials, basic materials, healthcare, and telecom stocks. We therefore find no evidence that an idiosyncratic single-sector shock drives our results.

6.4 Additional Robustness Checks

We conduct several robustness tests on the empirical approach. First, the results are robust when using OLS as the estimation method. The sign of the estimated coefficients remains unchanged, and their magnitude is similar. In order to formally assess the validity of the WLS estimator, we follow Wooldridge (2008) and compare the OLS and WLS estimates using Hausman tests. We find no evidence of misspecification. Second, t-statistics associated to the effects of the CCP reform do not decrease in value when considering alternative robust estimators of the covariance matrix such as Huber-White and Newey-West. Third, results hold when we compute abnormal returns based on post-event estimation of the covariance with the market factor, as in Kothari and Warner (2004).

7 Concluding Remarks

To the best of our knowledge, this paper provides the first empirical analysis of how a switch from bilateral clearing to a CCP affects asset prices. The evidence shows that both equity prices and price-to-earning ratios respond negatively to the clearing reform. We investigate plausible reform-related channels behind this market-wide effect and find that: (i) The negative valuation effect is stronger for high margin stocks; we argue that this price effect operates through tightening funding constraints for investors. (ii) The negative valuation effect is less pronounced for stocks with low diversity of counterparties. (iii) There is no evidence of changes in securities market betas. (iv) There is a negative impact on market-wide liquidity.

Although some of the specifics of the Nordics' experience may differ from those of other clearing reforms, many of our conclusions are useful in understanding potential consequences of instituting a CCP. For instance, Heller and Vause (2012) show that, under several alternative scenarios, margins in previously-decentralized interest rate and credit default swaps markets are significantly higher after the introduction of CCP clearing. One can then infer that the margins channel would play in such markets in a similar fashion, that is, everything else being constant, introducing a CCP would lower the relative valuation of high-margin assets.

There are, however, several limitations in extending our results directly to the context of derivatives. We abstracted from important dimensions such as information dissemination, standardization of contracts, and transparency. Moreover, the relative scope for default risk reduction through netting and novation is in theory higher for derivative contracts given the length of time between the execution and settlement of a transaction.[35] Although the qualitative effects of default risk reduction are the same in both cases, future research could study this relation quantitatively for different derivatives.

[35] Interestingly, Arora, Gandhi, and Longstaff (2012) provide evidence that in an inter-dealer CDS market counterparty risk is priced but its quantitative effect is modest.

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Appendix: More Details on the Clearing Reform

Timeline

October 16, 2008. The incumbent market, NASDAQ OMX, first announces the plan to introduce CCP services. January 2009 is the target date for optional CCP clearing and June 2009 for mandatory CCP clearing. The interim period between the "optional" and "mandatory" phases allowed members to prepare for the migration. A memorandum of understanding is signed with central counterparty clearinghouse EMCF, stating that counterparty risk reduction is the first sought-after benefit of the reform. NASDAQ OMX announces that plans to take an equity stake in EMCF, and outsourcing CCP services to EMCF is made contingent on the equity stake completion.

January 26, 2009. NASDAQ OMX announces an agreement with the Nordic Securities Association on the CCP introduction. An updated timetable mentions February 2009 for the start of optional CCP clearing and October 9, 2009 for mandatory CCP clearing.

October 9, 2009. CCP Soft Launch: Nine mid-cap stocks (three Danish stocks, three Finnish stocks, and three Swedish stocks) start clearing centrally through EMCF.

Oct 19, 2009. CCP Full Launch: All index stocks from Denmark and Sweden move to full CCP clearing.[36]

Oct 23, 2009. Full CCP launch announced for Finland. Target implementation date is Nov 16, 2009.

Nov 16, 2009. Full CCP launch for Finland.

[36] A small of fraction of very illiquid stocks continued to clear bilaterally. Jointly, these stocks represented a negligible amount of trading volume in the Nordic markets

Further comments. The voluntary clearing stage was introduced primarily for market participants to prepare for the transition to full CCP clearing. EMCF estimated that technical procedures would take 2-3 months. Market participants who were ready and indicated they would "voluntary clear" would only obtain EMCF clearing services (i.e., insurance) if they were matched with a counterparty who also had the "voluntary clear" status. However, this was a random event as the matching was done through anonymous electronic order markets. As a consequence, the period ahead of the full launch did not only observe bilateral: there was a chance that a trade would clear through EMCF if both counterparties had voluntary clearing status.

Conversations with local experts indicated that the delayed response of Finnish stocks was not related to price response considerations, the focus of the empirical tests in the paper. Instead, it was due to concerns on the part of the Finnish dealers' association regarding operational risks associated with the new clearing protocols.

Clearing Members

De Nederlandsche Bank (2011, p.53-54) lists the following financial institutions as EMCF members as per December 2010.[37]

General clearing participants

General Clearing Participant are those authorized to clear trades which have been dealt for its own account or have been concluded for the account of clients or for other trading participants. EMCF's general clearing participants are:

- ABG Sundal Coller Norge
- ABN AMRO Clearing Bank N.V.
- BNP Paribas Securities Services S.A.
- Bank of America Merrill Lynch
- CACEIS Bank Deutschland
- Citibank Global Markets and Citibank International
- Citigroup
- Danske Bank
- Deutsche Bank (London Branch)
- Deutsche Bank AG
- DnB NOR Bank
- Goldman Sachs International
- HSBC Trinkaus & Burkhardt
- Interactive Brokers
- Instituto Centrale delle Banche Popolari Italiane SpA
- JPMorgan Securities Ltd.
- KAS BANK N.V.
- KBC Bank N.V.
- MF Global UK Ltd
- Nordea
- Parel S.A.
- Skandinaviska Enskilda Banken
- Swedbank

[37] De Nederlandsche Bank, 2011, Is there a race-to-the-bottom in central counter parties competition?, DNB Occasional Studies 9(6).

Direct clearing participants

Direct Clearing Participants are those authorized to clear trades which have been dealt for its own account or have been concluded for the account of its Clients. EMCF's direct participants are:

- ABG Sundal Coller Norge ASA
- Alandsbanken Abp
- Arbejdernes Landsbank
- Avanza Bank
- Barclays Capital Securities
- Carnegie Bank
- Credit Suisse Securities (Europe)
- Evli Bank
- FIM Bank
- GETCO
- Handelsbanken
- Instinet Europe.
- Jefferies International
- Lan & Spar Bank
- Landesbank Berlin
- Morgan Stanley International
- Morgan Stanley Securities
- Nomura International
- Nykredit
- Pohjola Bank
- RBC Europe Limited
- RBS Plc.
- Saxo Bank A/S
- Saxo PrivatBank A/S
- Spar Nord Bank
- Sparekassen Kronjylland
- Sparekassen Lolland A/S
- Tapiola Pankki
- UBS

Table 3: Stock market indices used in empirical tests

This table lists the stock market indices used in the construction of country groups.

Nordic Countries		Control Countries	
Country	Index	Country	Index
Sweden	OMXS30	Spain	IBEX
Denmark	OMXC20	Italy	MIB
Finland	OMXH25	Germany	DAX
		Netherlands	AEX
		Switzerland	SSMI
		Belgium	BFX
		France	CAC 40
		Norway	OBX
		Ireland	ISEQ
		UK	FTSE 100
		Austria	ATX
		Portugal	PSI 20
		Hungary	BUX
		Poland	WIG
		Greece	ATG
		Czech Rep.	Prague SE
		Romania	BETC

Table 4: Descriptive statistics

This table displays summary statistics (sample means) computed for the European indices used in the econometric tests. The sample consists of monthly data from January 2008 through June 2008, prior to the clearing reform announcement in the Nordics. EUR is a Pan-European control group. The control groups CCP and NCCP correspond, respectively, to countries with and without CCP clearing for equities in 2009, as defined in Table 2. Turnover is defined as the ratio between trade volume and total market capitalization. Standard deviations are reported in parentheses.

Variable	Nordic	CCP	NCCP	EUR
Six-month Pre-Event Return	−2.88	−3.91	−4.20	−4.02
	(7.51)	(7.08)	(9.42)	(8.03)
PE Ratio	13.12	11.46	14.47	12.59
	(1.61)	(1.84)	(3.84)	(3.11)
Turnover	9.94	6.88	7.23	6.52
	(3.59)	(4.03)	(4.45)	(4.13)
Market Beta	0.76	0.95	1.04	0.99
	(0.09)	(0.26)	(0.34)	(0.29)
Market Cap (M. Euro)	2082	2096	1349	1760
Price/Book Ratio	2.36	2.01	2.38	2.21
	(0.47)	(0.39)	(0.36)	(0.46)

Table 5: Equity returns reaction to the clearing reform

This table presents the results of the effect of the clearing reform on Nordic equity returns. The dependent variable is given by abnormal monthly equity indices returns. The independent variables are dummies for the event window September 2008-December 2009 (d_T), countries in the Nordic group (d_{ccp}), and the interaction term $d_T \times d_{ccp}$ which captures the differences-in-differences effect of the reform. EUR is a Pan-European control group. The control groups CCP and NCCP correspond, respectively, to countries with and without CCP clearing for equities in 2009, as defined in Table 2. The model is estimated using WLS, with weights given by the inverse monthly volatility of abnormal returns, as described in Section 3.2. Standard errors are double-clustered at country and month levels, following Petersen (2009). Robust t-statistics are reported in parentheses (significance levels are as follows: 1%$-^{***}$, 5%$-^{**}$, 10%$-^{*}$).

Control	CCP Group	NCCP Group	EUR Group
$d_T \times d_{ccp}$	-1.03^{**} -2.49	-1.58^{***} -2.97	-1.08^{***} -2.63
d_T	-0.08^{***} -3.42	0.47 0.72	-0.02 -0.49
d_{ccp}	0.16 0.43	0.22 0.58	0.21 0.73
Constant	0.08 0.43	0.03^{***} 16.57	0.03 0.74
R^2	6.02%	3.48%	1.42%
No. Obs.	472	303	675

Table 6: Price-earnings ratios reaction to the clearing reform

This table presents the results of the effect of the clearing reform on Nordic equity price-earnings ratios. The dependent variable is given by monthly equity indices' price-earnings ratios. The independent variables are dummies for the event window September 2008-December 2009 (d_T), countries in the Nordic group (d_{ccp}), and the interaction term $d_T \times d_{ccp}$ which captures the differences-in-differences effect of the reform. EUR is a Pan-European control group. The control groups CCP and NCCP correspond, respectively, to countries with and without CCP clearing for equities in 2009, as defined in Table 2. The relative effect of the clearing reform on PE is computed as: $\frac{(d_{ccp} \times d_T)}{Constant + d_{ccp}}$The model is estimated using WLS, with weights given by the inverse monthly volatility of abnormal returns, as described in Section 3.2. Standard errors are double-clustered at country and month levels, following Petersen (2009). Robust t-statistics are reported in parentheses (significance levels are as follows: 1%$-^{***}$, 5%$-^{**}$, 10%$-^{*}$).

Control	CCP Group	NCCP Group	EUR Group
$d_T \times d_{ccp}$	-2.91^{***} -31.83	-1.96^{***} -12.34	-2.61^{***} -15.82
d_T	-3.51^{***} -90.12	-4.29^{***} -48.47	-3.73^{***} -140.22
d_{ccp}	2.51^{***} 56.59	3.11^{***} 19.68	2.64^{***} 16.56
Constant	10.51^{***} 285.98	11.17^{***} 171.01	10.65^{***} 576.74
Relative effect	-22.35%	-13.73%	-19.64%
R^2	46.61%	45.71%	43.21%
No. Obs.	468	324	684

Table 7: The impact of margin and counterparty-diversity measures on Nordic equity returns

This table presents the results of the effect of margin and counterparty-diversity measures on Nordic stocks abnormal monthly returns. The independent variables are the marginal impact on margin requirements $MIMR$ (see equation (8)), two counterparty diversity measures: $NumberCP$ and CPC (see equation (9)), and the market capitalization of each stock's $MarketCap$. These regressors are normalized to have zero mean and unit variance. The effect of the reform is given by the interaction of d_T, the dummy variable for the event window September 2008-December 2009, with $MIMR$, $NumberCP$, and CPC. The model is estimated using WLS, with weights given by the inverse monthly volatility of abnormal returns, as described in Section 3.2. Standard errors are double-clustered at stock and month levels, following Petersen (2009). Robust t-statistics are reported in parentheses (significance levels are as follows: 1%–***, 5%–**, 10%–*).

	(1)	(2)	(3)	(4)	(5)	(6)
$d_T \times MIMR_i$		-0.41^{***} -22.78			-0.24^{***} -3.61	-0.17^{***} -3.71
$d_T \times CPC_i$			0.56^{***} 18.97		0.32^{***} 3.16	
$d_T \times NumberCP_i$				-0.62^{***} -22.67		-0.50^{***} -6.82
d_T	-0.74^{***} -14.83	-0.75^{***} -43.72	-0.77^{***} -21.53	-0.76^{***} -30.46	-0.76^{***} -20.18	-0.75^{***} -33.17
$MIMR_i$		0.16^{***} 11.05			0.09^{**} 1.99	0.06^{*} 1.97
CPC_i			-0.21^{***} -8.55		-0.15^{**} -2.29	
$NumberCP_i$				0.27^{***} 9.78		0.24^{***} 5.07
$MarketCap_i$		0.06^{***} 11.91	0.01 0.38	-0.01^{***} -4.43	0.02 1.02	-0.09^{***} -3.17
$d_T \times MarketCap_i$		0.01 0.21	0.11^{***} 3.07	0.27^{***} 2.58	0.11^{**} 2.17	0.29^{***} 5.16
Constant	0.32^{***} 16.12	0.36^{***} 21.68	0.37^{***} 10.79	0.35^{***} 14.94	0.36^{***} 16.26	0.38^{***} 21.45
R^2	0.15%	0.18%	0.22%	0.16%	0.13%	0.15%
No. Obs.	6372	6372	6372	6372	6372	6372

Table 8: Stock market turnover reaction to the clearing reform

This table presents the results of the effect of the clearing reform on equity indices' turnover. The dependent variable is the monthly turnover ratio, computed as the ratio of volume to market capitalization (both expressed in Euro). The independent variables are dummies for the post-event window $d_{t>T}$, equal to one after December 2009, countries in the Nordic group (d_{ccp}), and the interaction term $d_{t>T} \times d_{ccp}$ which captures the differences-in-differences effect of the reform. EUR is a Pan-European control group. The control groups CCP and NCCP correspond, respectively, to countries with and without CCP clearing for equities in 2009, as defined in Table 2. The relative effect of the clearing reform on turnover is computed as: $\frac{(d_{ccp} \times d_{t>T})}{Constant + d_{ccp}}$The model is estimated using WLS, with weights given by the inverse monthly volatility of abnormal returns, as described in Section 3.2. Standard errors are double-clustered at country and month levels, following Petersen (2009). Robust t-statistics are reported in parentheses (significance levels are as follows: 1%$-^{***}$, 5%$-^{**}$, 10%$-^{*}$).

Control	CCP Group	NCCP Group	EUR Group
$d_{t>T} \times d_{ccp}$	-1.49^{***} -20.64	-2.07^{***} -26.67	-1.70^{***} -24.01
$d_{t>T}$	-1.82^{***} -243.41	-1.24^{***} -65.98	-1.62^{***} -698.64
d_{ccp}	2.79^{***} 211.89	4.21^{***} 215.59	3.28^{***} 316.18
Constant	7.83^{***} 1034.21	6.41^{***} 421.85	7.34^{***} 308.27
Relative Effect	−14.07%	−19.52%	−16.00%
R^2	10.65%	12.44%	14.08%
No. Obs.	504	324	720

Table 9: Stock market illiquidity reaction to the clearing reform

This table presents the results of the effect of the clearing reform on European equity indices illiquidity. The dependent variable corresponds to Amihud's $ILLIQ$ measure, normalized as in Acharya and Pedersen (2005), and aggregated at the market level using market capitalizations as weights. The independent variables are dummies for the post-event window $d_{t>T}$, equal to one after December 2009, countries in the Nordic group (d_{ccp}), and the interaction term $d_T \times d_{ccp}$ which captures the differences-in-differences effect of the reform. EUR is a Pan-European control group. The control groups CCP and NCCP correspond, respectively, to countries with and without CCP clearing for equities in 2009, as defined in Table 2. The relative effect of the clearing reform on $ILLIQ$ is computed as: $\frac{(d_{ccp} \times d_{t>T})}{Constant + d_{ccp}}$The model is estimated using WLS, with weights given by the inverse monthly volatility of abnormal returns, as described in Section 3.2. Standard errors are double-clustered at country and month levels, following Petersen (2009). Robust t-statistics are reported in parentheses (significance levels are as follows: 1%−***, 5%−**, 10%−*).

Control	CCP Group	NCCP Group	EUR Group
$d_{t>T} \times d_{ccp}$	0.07^{***}	0.05^{*}	0.06^{**}
	2.51	1.79	2.23
$d_{t>T}$	0.02^{***}	0.04^{***}	0.03^{***}
	14.59	24.15	45.35
d_{ccp}	-0.11^{***}	-0.15^{***}	-0.12^{***}
	−4.11	−5.56	−4.78
Constant	0.45^{***}	0.49^{***}	0.46^{***}
	451.94	160.40	558.02
Relative Effect	19.23%	14.15%	16.86%
R^2	0.19%	6.72%	0.56%
No. Obs.	468	288	648

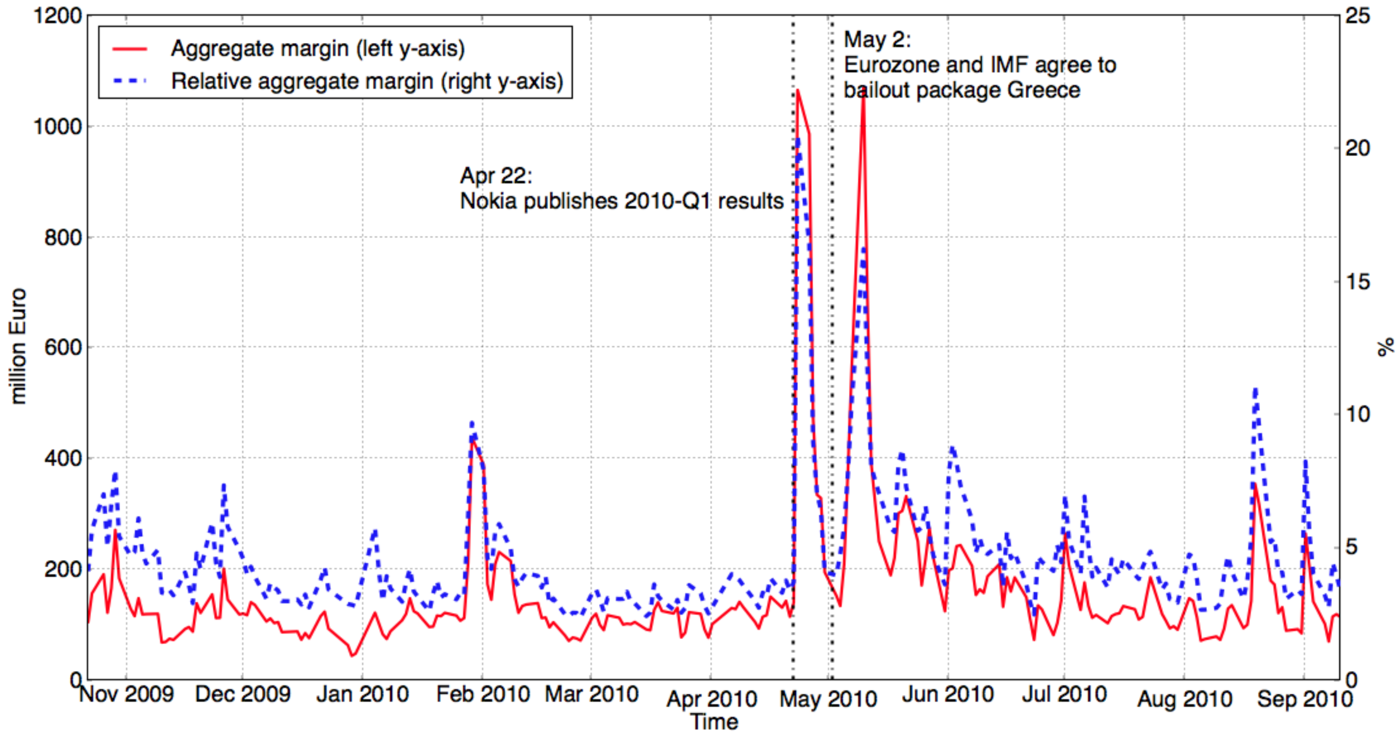
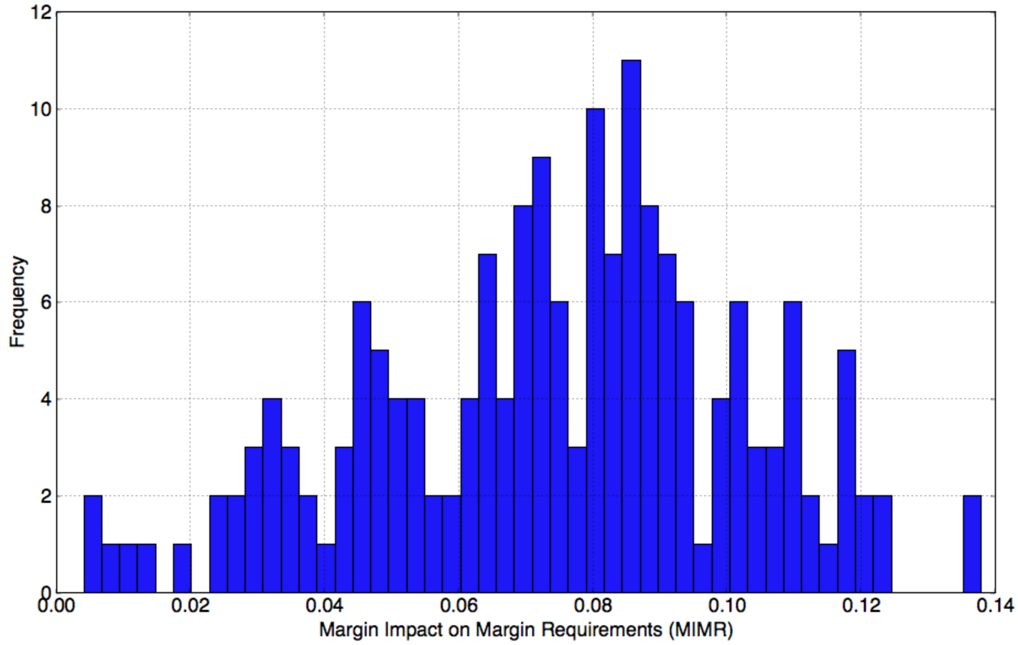
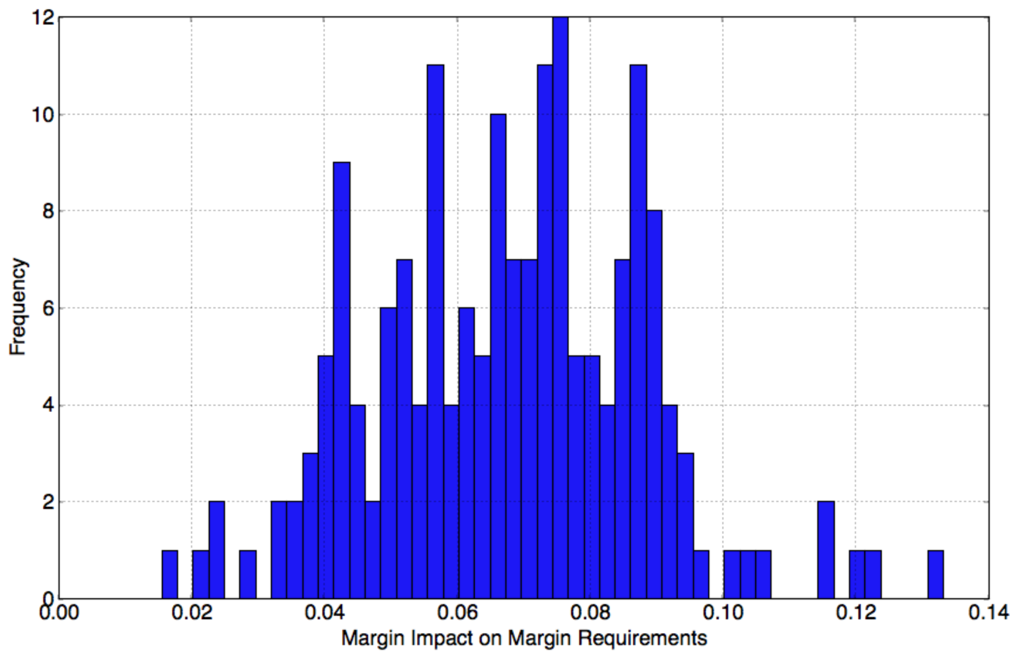


Figure 1: Aggregate realized margin requirements on Nordic equities
This figure plots, for each day in the sample, the margin required by EMCF, aggregated across all Nordic stocks and all clearing members. The evolution of aggregate margins over time is computed based on yet-to-settle portfolio positions data provided by EMCF. The relative aggregate margin is computed as the ratio of margin to the yet-to-settle portfolio values.



(a) Marginal impact on margins from the representative trader perspective



(b) Marginal impact on margins using actual traders portfolios

Figure 2: Cross-sectional distribution of $MIMR$ across securities

The top panel displays $MIMR$ as defined by equation (8). The bottom panel displays margins based on actual traders' portfolios, averaged across all clearing members and days in the clearing data sample October 2009-September 2010. The Spearman rank correlation between the two series is 0.83.

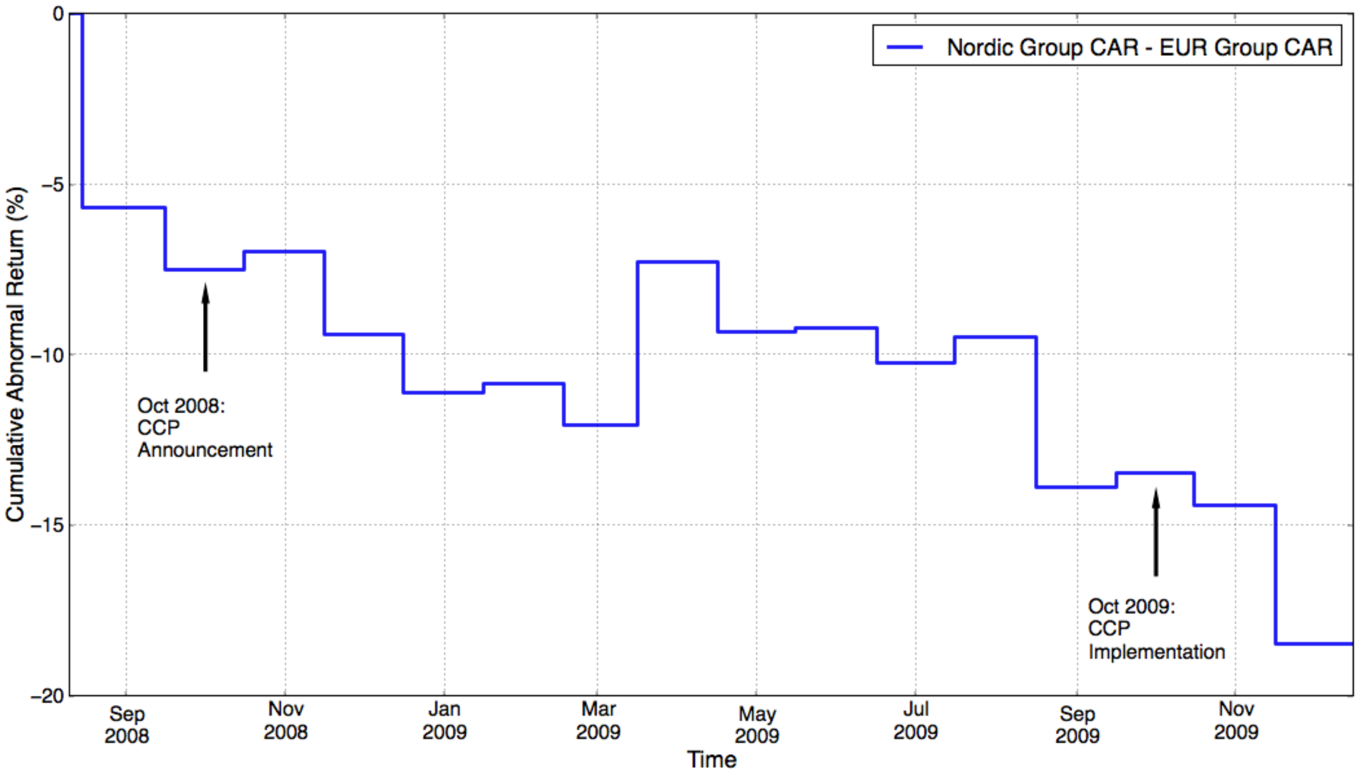


Figure 3: Difference in monthly CAR between Nordic and EUR equity indices
This figure displays the CAR difference between Nordic countries and the EUR control group in the event window. Abnormal returns are computed using a single factor model, with the STOXX Europe 500 index as the market portfolio. The abnormal return difference between the Nordics and the EUR group is computed as a cumulative monthly differences-in-differences effect, as described in Section 4. Changes in the series are plotted in the middle of the corresponding month.

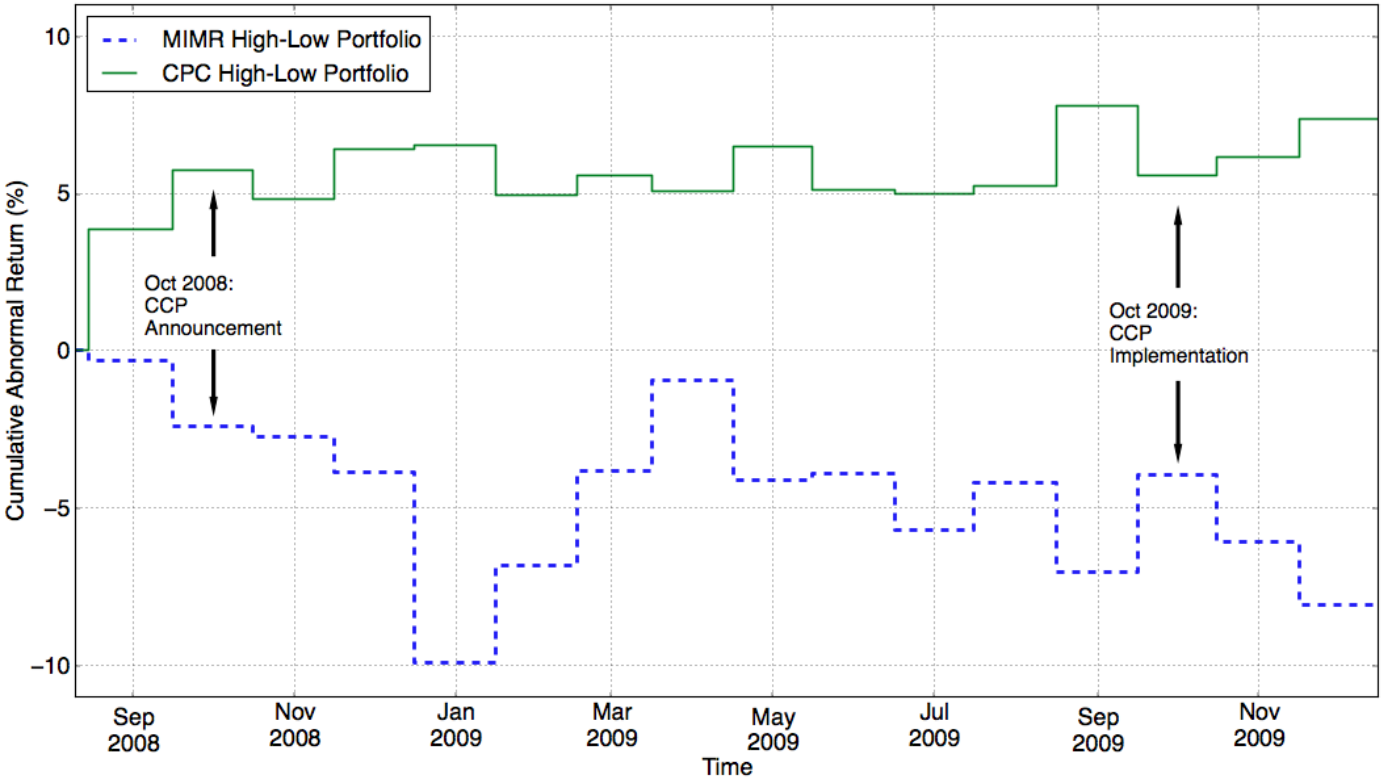


Figure 4: Monthly CAR for Nordic stock portfolios based on margin and counterparty diversity

This figure displays the CAR for Nordic stocks for two trading strategies based on margins, as captured by the empirical measure $MIMR$ (see equation (8)), and counterparty diversity, as captured by the empirical measure CPC (see equation (9)). High-low $MIMR$ correspond to a market-weighted portfolio that is long in high-$MIMR$ stocks and short in low-$MIMR$ stocks. High-low CPC correspond to a market-weighted portfolio that is long in high-CPC stocks and short in low-CPC stocks. Changes in the series are plotted in the middle of the corresponding month.

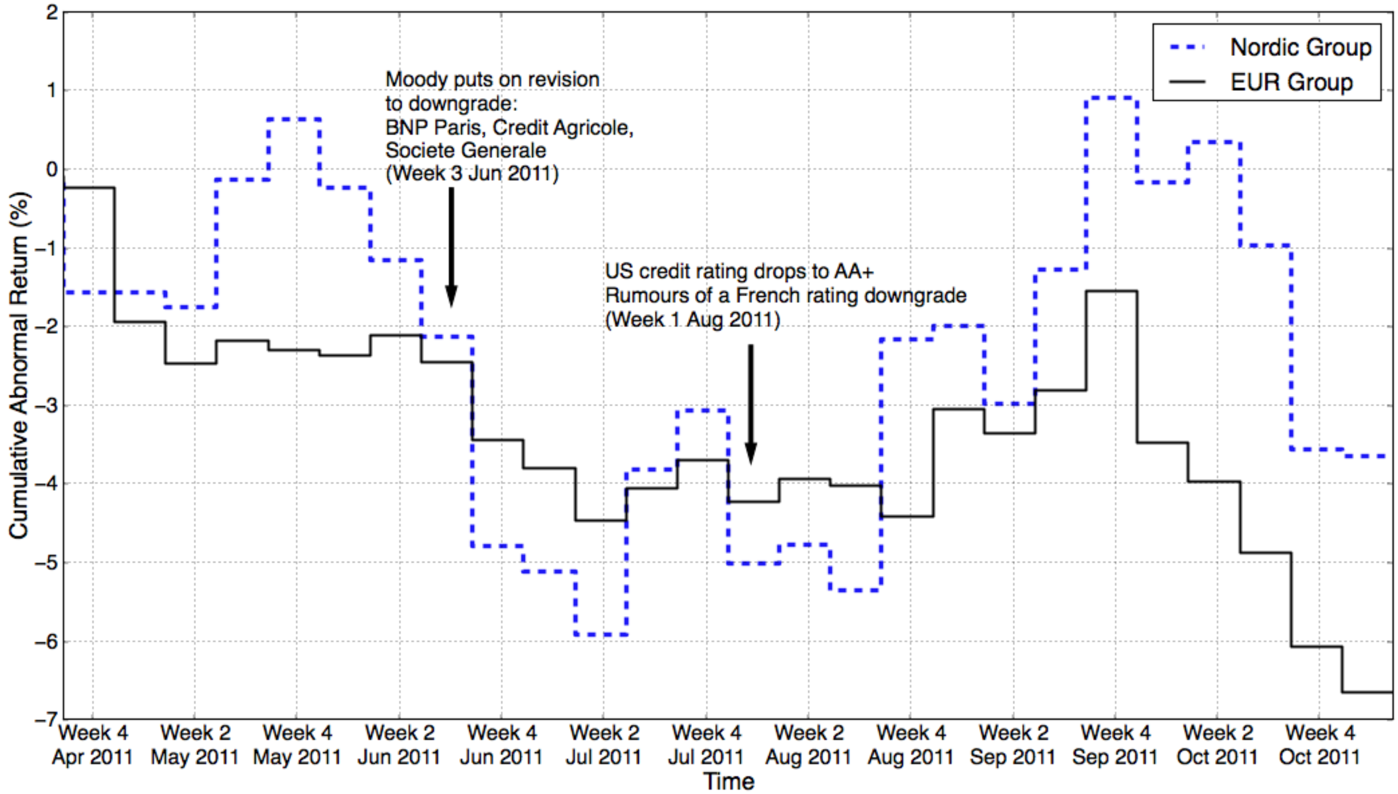


Figure 5: Weekly CAR for European equity indices around two financial shocks
This figure displays the CAR for the Nordic countries and the EUR control group around two financial shocks. The first event occurred on June 15, 2011, when Moodys put three large European banks (BNP Paris, Credit Agricole, and Societe Generale) on revision for downgrade. The second event occurred on August 15, 2011, when the U.S. credit rating was downgraded to AA+ by Standard & Poor's. Changes in the series are plotted in the middle of the corresponding month.