Essays on Liquidity and Risk Management

by

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Abstract

This thesis consists of three independent essays on stock liquidity, corporate cash holdings, and financial institution earnings risk.

The first study examines the relationship between stock liquidity and the difference in domestic and foreign market prices for a sample of 650 international firms cross-listed on a U.S. stock exchange. The study exploits the 2001 change to decimalization pricing and the 2003 U.S. dividend tax cut as quasi-natural experiments and finds that ADR liquidity decreases the absolute value of the ADR premium. The paper documents a positive relationship between liquidity and price discovery as well as a liquidity effect on the price convergence between the ADRs and their underlying shares.

The second study focuses on corporate cash holdings as a mechanism of risk management. The paper documents a diversification effect on cash for a large sample of international firms, and examines the impact of agency costs, financial constraints and product market competition on the relationship between diversification and cash holdings. The results show that weak product market competition can weaken or even reverse the negative diversification effect on cash holdings. Weak country-level shareholder protection helps explain the weak diversification effect to a smaller degree, whereas financial constraints strengthen the diversification effect. Further, the competition effect is stronger for innovative, high R&D intensity firms and for firms with high uncertainty of sales and productivity growth.

The third study analyzes the impact of deposit insurance design on the earnings uncertainty of financial cooperatives. The 2008 amendment to the Financial Institutions Act in the province of British Columbia resulted in an economically and statistically significant decrease in the credit unions' earnings uncertainties. The policy spurred deposit growth, but instead of an increase in lending, credit unions grew their capital-to-asset ratio. The results support the hypothesis that an unlimited insurance coverage boosts depositors' confidence and increases the flow of funds to the insured cooperatives. The paper does not find support for the moral hazard hypothesis where full deposit insurance increases risk-taking and creates liquidity risk by attracting wholesale funds.

Keywords: Cross listing; Liquidity; Limits to arbitrage; Cash holdings; Diversification; Product market competition; Deposit insurance; Financial cooperatives; Earnings volatility

Dedication

To Lawrence.

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Chapter 1

Multi-market Trading and Liquidity: Evidence from Cross-listed Companies

1.1 Introduction

Over the past few decades an increasing number of companies have listed their equities on large international exchanges.[1] [2] It is now a well-documented fact that when a company's stock is listed on multiple exchanges, simultaneous trades in the home and foreign markets are often executed at different prices. For example, Kaul and Mehrotra (2007) provide evidence that economically significant price differences exist for Canadian stocks listed both in New York and Toronto. These differences are net of estimated transaction costs, i.e. traders have opportunities to save money or earn arbitrage profits by executing orders in the foreign (U.S.) market. Gagnon and Karolyi (2010) also report wide-ranging price differentials for pairs of stock prices of international firms that are cross-listed in the U.S. This deviation from the law of one price has generated considerable interest in both academia and the finance industry.

Non-U.S. stocks are listed in the U.S. as either American depositary receipts (ADRs) or ordinary equity.[3] Although numerous studies have analyzed the deviations from price parity for cross-listed stocks, the question of how liquidity affects the price convergence over time remains largely unexplored. The asset pricing literature suggests that illiquidity

[1]The paper in this chapter is published in the Journal of International Financial Markets, Institutions & Money. DOI: 10.1016/j.intfin.2017.09.015.

[2]As of 2013, there are over 500 non-U.S. firms listed on the New York Stock Exchange.

[3]ADRs are negotiable certificates that represent claims against the home market shares held by a custodian bank. In the case of a cross-listed ordinary, the asset traded in the U.S. is identical to the one traded in the home market.

depresses asset prices and leads to higher expected returns.[4] This implies that the U.S. and home market liquidity will have an opposite effect on the difference between the U.S. and the home market price, i.e. the ADR premium.[5] An increase in the U.S. market liquidity will increase the ADR price and thus the ADR premium. An increase in the home market liquidity will increase the price of the underlying asset and thus decrease the ADR premium. Chan et al. (2008) find support for the asset pricing hypothesis that high U.S. liquidity increases the ADR premium.

Roll et al. (2007) and Deville and Riva (2007), on the other hand, argue that illiquidity impedes arbitrage and in general trading is concentrated in more liquid assets. Similarly, Schultz and Shive (2010) find that one-sided trades correct most of the mispricing of dual-class shares. This is contrary to the conventional view that arbitrage trading (i.e. long-short trades) corrects most of the deviation from price parity. Schultz and Shive also show that most of the time, it is the more liquid share class that is responsible for the mispricing. In the context of cross listing, the home and foreign markets may play different roles in the price dynamics of the ADR and the underlying stock. In particular, illiquidity in both the U.S. and home markets may be associated with a larger and longer-lived deviation from price parity.

In this study, we examine the effect of liquidity on the dynamics of cross-listed stock-pair's prices for a large sample of international firms for the period from 2$^{\text{nd}}$ January 1997 to 29$^{\text{th}}$ December 2012. First, we examine the relationship between liquidity and the absolute value of the ADR premium. Controlling for endogeneity, we show that larger differences between the U.S. and home market prices of a cross-listed stock are associated with lower U.S. market liquidity, and the effect of home market liquidity is weak and/or insignificant. Our results are consistent with the limits to arbitrage hypothesis, i.e. the notion that illiquidity impedes arbitrage, and thus results in a larger absolute value of the ADR premium. Then, we examine the dynamics of price convergence. We document a large and significant positive effect of U.S. liquidity on the short-term correction to price parity. The effect of home market liquidity is also positive, albeit smaller and less significant. We obtain similar results using duration analysis with U.S. liquidity having a strong positive effect on the stock pair price convergence whereas the effect of home market liquidity being smaller and less significant.

Whether liquidity has a positive or negative effect on the size of the ADR premium has been difficult to test due to the simultaneity between liquidity and the ADR premium. Liquid assets may attract more arbitrage trades that reduce deviations from price parity, while arbitrage opportunities may attract more liquidity to the market. To address this

[4]For example, see Pastor and Stambaugh (2003), Amihud (2002), and Acharya and Pedersen (2005).

[5]We define the ADR premium as the percentage deviation of the U.S. price relative to the home market price, i.e. the ratio of the U.S. market price over the home market price minus one.

simultaneity, we run tests during periods surrounding exogenous shocks to liquidity using a difference-in-differences (hereafter, DiD) approach to estimate the effect of liquidity on the ADR premium. The first exogenous shock is the 2001 decimalization, i.e. the change in the minimum tick size. Prior to 2001, the minimum tick size for quotes and trades on the three major U.S. exchanges was $1/16. Previous research has documented evidence that decimalization has narrowed bid-ask spreads and lowered the price impact of trades in the U.S. stock market. We construct a treatment group (firms that experienced the largest improvement in their ADR liquidity after the introduction of the decimalization) and a control group (firms with the smallest or no improvement in their ADR liquidity). We show that firms in the treatment group experienced a larger decrease in the difference between their U.S. and home market prices after the decimalization relative to similar firms in the control group. For example, firms in the treatment group experienced on average a 2.12% bigger decrease in the difference between their U.S. and home market prices following the decimalization compared to firms in the control group. Our results are robust to alternative specifications, and to placebo and falsification tests.

The 2001 decimalization is identified as an exogenous shock to the U.S. market liquidity. In the second experiment, we use the 2003 U.S. tax cut as an exogenous shock to non-U.S. market liquidity. The tax cut applied to dividends received from U.S. companies as well as foreign companies in countries with tax treaties with the U.S.[6] Desai and Dharmapala (2010) and Wei (2010) show that following the tax cut, capital flows by foreign investors (the U.S. markets in our study) improved liquidity in domestic markets for dividend-paying stocks in countries that have tax treaties with the U.S. We use dividend paying firms from tax-treaty countries as the treatment group and non-dividend paying firms or firms from non-tax-treaty countries as the control group. We find that the treatment effect is insignificant, i.e. the treatment firms did not experience a significantly larger decrease in the size of the ADR premium than the control firms do after the tax cut. Overall our identification tests confirm our baseline results that U.S. market liquidity has a negative causal effect on the absolute value of the ADR premium, whereas home market liquidity does not have a causal effect on the size of the ADR premium.

Our second set of results examines the effect of U.S. and home market liquidity on the price discovery for our sample of cross-listed stocks. Previous studies have documented mixed results with respect to whether the price discovery occurs predominantly in the home market, with the prices in the foreign market adjusting to the home market. Su and Chong

[6]Dividend tax in the U.S. was reduced to a maximum of 15% in 2003 as part of the Jobs and Growth Tax Relief Reconciliation Act. This provision extends to dividends from companies located in certain foreign countries that have tax treaties with the U.S. Dividends from companies located in non-tax-treaty countries continued to be taxed at 35%. This policy change generated a reallocation of U.S. institutional capital and significantly increased liquidity in dividend-paying stocks domiciled in tax-treaty countries (see Desai and Dharmapala, 2010, for details).

(2007), for example, examine Chinese firms listed on both the Hong Kong Stock Exchange (SEHK) and the NYSE, and document an average information share of 89.4% for the SEHK. Eun and Sabherwal (2003), however, find that the U.S. stock market plays a significant role in the price discovery process for their sample of Canadian cross-listed stocks. Similarly, Frijns et al. (2010) examine cross-listings in Australia and New Zealand, and find that the larger, the Australian, exchange dominates the price discovery process.

We estimate the short-term correction coefficients obtained from a vector error-correction model for the price pairs of cross-listed firms. We show that, on average, the U.S. market contributes more than the home market to the price discovery. There is a significant positive effect of the U.S. market liquidity on the short-term correction coefficients, while the home market liquidity has a weaker effect both statistically and economically as our previous results. Other factors, such as stock's holding costs (proxied by the idiosyncratic volatility), supply for short selling (proxied by institutional holdings) and currency exchange rate volatility, also play an important role in explaining the cross-sectional variation in the price discovery for different firms.

Our third set of results comes from a duration analysis that examines the impact of liquidity on the conditional probability of the cross-listed stock-pair prices converging. We account for trading costs and document evidence that the duration of the deviation from price parity is shorter for more liquid stocks. We examine the effect of institutional ownership and stock's idiosyncratic volatility as possible channels through which liquidity affects price convergence. We find that high level of institutional ownership weakens the liquidity effect on price convergence, whereas the effect of liquidity is stronger for stocks with high idiosyncratic volatility. Similar to our previous analysis, the duration model results support the limits to arbitrage hypothesis. For stocks with high holding costs (high level of idiosyncratic volatility) liquidity is important as it allows traders to open and close positions with lower transaction costs. Similarly, shocks in supply for short selling (low level of institutional ownership) raise the cost of shorting stocks, in which case liquidity becomes more important.[7] Our results remain the same when we control for the effect of the Financial Crisis and the home market short-sale constraints in all our regression models. These results are also robust to alternative model specifications.

Our paper contributes to the literature that examines the relationship between cross listing and market liquidity. Cross listing is pursued for various reasons, e.g. improved access to larger capital markets and lower cost of capital, enhanced liquidity, as well as better corporate transparency and governance provisions (see Karolyi, 2006, for a survey of this literature). As previous studies suggest, however, cross listing does not guarantee

[7]Example of studies on short sale constraints as limits to arbitrage include Pontiff (1996), Chen et al. (2002), Ofek et al. (2004), Chang et al. (2007), and Gromb and Vayanos (2010). Others, for example, Shleifer and Vishny (1997), Pontiff (2006), and Duan et al. (2010), suggest idiosyncratic volatility as a proxy for holding costs.

a more liquid trading environment for the firm's shares nor does the new competition for order flow among different markets necessarily improves efficiency and price discovery. Often fragmentation between competing markets can lead to large deviations from price parity. The literature on the effect of liquidity in asset pricing has shed light on the size and variation of the ADR premium (see Chan et al., 2008, for cross-listed firms and Amihud et al., 2005, for a general survey).

Earlier studies also show that the cross-listing decision itself has a liquidity impact although the direction varies across markets and time periods. Noronha et al. (1996) examine the liquidity of NYSE/AMEX listed stocks and find that informed trading and trading activity increase after the stocks become listed overseas. However, spreads do not decrease because the increase in informed trading increases the cost to the specialist of providing liquidity. In contrast, Foerster and Karolyi (1999) find that spreads of stocks listed on the Toronto Stock Exchange become narrower in the domestic market after they cross list on a U.S. exchange. They attribute the decrease in trading costs to the increased competition from the U.S. market makers. Similarly, Moulton and Wei (2009) find narrower spreads and more competitive liquidity provision for European cross-listed stocks due to the availability of substitutes. In contrast, Berkman and Nguyen (2010) examine domestic liquidity after cross listing in the U.S. using a matched sample of non-cross-listed firms to control for contemporaneous changes in liquidity and find that there are no improvements in home market liquidity due to cross listing.

We also contribute to the literature on limits to arbitrage in international equity markets. Gagnon and Karolyi (2010) examine empirically whether the variation in the magnitude of the deviation from price parity for cross-listed stocks is related to arbitrage costs. Their findings suggest that the deviation is positively related to holding costs, especially idiosyncratic risk, which impedes arbitrage activities. Their study focuses on the magnitude of the deviation from price parity for cross-listed stock pairs. Our study, on the other hand, identifies the determinants of the persistence and the duration of such deviations.

Domowitz et al. (1998) show that the market quality of cross-listed stocks depends on the degree to which markets are linked informationally. For markets that are sufficiently segmented, trading costs are higher for cross-listed stocks due to greater adverse selection associated with arbitrageurs who exploit pricing differences across these segmented markets at the expense of less-informed liquidity providers. In addition, different trading rules and regulations across markets may have an impact on liquidity providers trading non-U.S. stocks. For example, affirmative and negative obligations imposed upon the NYSE specialist may be particularly burdensome for specialist trading non-U.S. stocks. Also, differences exist between U.S. and non-U.S. stocks in minimum tick size, priority rules, and insider trade restrictions. Our empirical results provide additional support to these findings.

The reminder of this paper is organized as follows. In Section 2, we describe our data sources, discuss sample selection and present summary statistics. Section 3 examines whether differences in liquidity in the U.S. and home markets have an effect on the stock-pair price differential. Section 4 begins with preliminary data analysis, including unit root and cointegration tests and then presents the estimates from a vector error correction model (VECM). Based on these estimates, we examine the cross-sectional variation in the price discovery process. In addition, we carry out a duration analysis of the convergence between a cross-listed stock's U.S. and home market prices and examine the mechanisms through which liquidity affects this convergence. In Section 5, we conduct robustness tests and exploit a pairs-trading strategy. Section 6 concludes.

1.2 Data and Summary Statistics

Our data sources are Datastream, CRSP, TAQ Consolidated Trades and Compustat databases. We identify the firms in our sample by searching the complete list of foreign companies listed on a domestic as well as a U.S. stock exchange as of January 2013. The foreign listings include both active and inactive issues at the time of the search, and are in the form of either American Depositary Receipt or ordinary equity. We remove issues without a home-market security code and issues that are described as preferred share, perpetual capital security, trust, unit, right, or fund. Our analysis includes only listed (Level II and Level III) ADRs and ordinaries.

We collect daily home market closing price from Datastream for the sample stocks.[8] We set the home market price as missing when there is no trading or no price reported for a particular trading day, or when a series becomes inactive in Datastream due to restructuring, delisting, or other events. We match each home market price with a U.S. market price. For some firms the U.S and home markets close at the same time, i.e. Canadian, Mexican and Brazilian stocks. We collect daily U.S. market closing prices from Datastream. For the other firms, however, the home market closes before the U.S. market does. To synchronize the home and U.S. market prices, we use the TAQ Consolidated Trades database to obtain the intraday trading prices on the U.S. market. We use the intraday U.S. price with time ticker closest to and within 30 minutes after the home market closes.[9] The synchronization is imperfect as trading hours of stock markets in Asian-Pacific countries and in the U.S. do not overlap with at least a 12-hour time difference between the two regions. For these firms, we use the U.S. market trading price closest to and within 30 minutes after the U.S.

[8] All variables are in U.S. dollars to avoid currency conversion when comparing the domestic values with their U.S. counterparts. In line with the previous literature, we treat exchange rates as exogenous.

[9] Gagnon and Karolyi (2010) use a similar methodology to synchronize home and U.S. market prices.

market opens, since stock markets in the Asian-Pacific region close before stock markets in the U.S. open.[10]

We adjust the U.S. market price by the ADR ratio so that it is comparable to the home market price of the underlying stock. We check the Bank of New York Mellon Corporation's DR Directory and J.P. Morgan adr.com as additional information sources to verify ADRs and fill in ADR ratios when these ratios are missing from Datastream. Since ADR ratios reported by the database are the values at the time when we construct the sample, i.e. the end of the sample period, we check the ADR premium/discount for each firm to spot abnormal patterns[11] that indicate possible ratio changes in the past. When we do, we search for news announcements and/or security filings to identify the events of ratio changes and manually input the historical ADR ratios. 13 firms are dropped from the sample as the ADR ratios are missing or we are not able to confirm ratio-changing events.

Further we remove stocks with less than 30 consecutive price observations during our sample period in order to obtain a long enough time series to estimate a vector error correction model. We also remove observations from countries with less than five cross-listed firms since we require some within-country cross-sectional variation to estimate the effect of country-level characteristics. Our final sample consists of 650 firms from 18 countries for the time period from 2nd January 1997 to 29th December 2012.

Next, we use Datastream to obtain the equity index for each home market in our sample (for example, Argentina Merval Index for Argentina, S&P TSX for Canada, Topix index for Japan etc.), as well as the S&P 500 as the equity index for the U.S. market. Finally, we obtain firm-level accounting data from Compustat, the number of price estimates by analysts from I/B/E/S, and U.S. institutional holdings from Thomson Reuters 13F. Table A.1 in the Appendix reports the distribution of sample firms by country and some county-level characteristics.

Table A.2 in the Appendix contains a description of the variables used in our empirical analysis. Panel A of Table 1 presents summary statistics for the cross-listed stocks in our sample. On average, ADRs are traded at a premium of 2.36% percent (the median ARD premium, however, is only 0.09%). The average (median) cross-listed firm has an ADR to home market shares outstanding ratio of 17.55% (3.73%). In terms of trading volume, however, typically more shares are traded in the U.S. market, although the variation in the ratio of U.S. to home market volume is very large.

Panel B presents the liquidity measures for the U.S. and home markets. We report descriptive statistics for the four most commonly used liquidity measures: (i) the natural

[10] Our main results are based on the full sample. In our robustness analysis, we exclude countries with non-overlapping trading hours with the U.S.

[11] For example, a sudden jump in the ADR premium to remain at a level that is the multiple of its previous level.

Table 1.1: Descriptive Statistics

The table presents descriptive statistics for the cross-listed firms. The sample consists of 650 cross-listed firms from 18 countries for the period from January 2, 1997 to December 29, 2012. When the U.S. and the home markets do not have any overlap in trading, we use the U.S. intraday price closest to and within 30 minutes after the U.S. market opens. Panel A presents security characteristics. Panel B presents descriptives for the liquidity measures; the p-values from paired mean comparison t-tests are reported in parentheses. *, **, and *** indicate 10%, 5% and 1% significance, respectively. Panel C presents firm-level characteristics.

Panel A: Cross-listed security characteristics					
	Mean	Median	Std Dev	5%	95%
Premium (Discount)	2.36%	0.09%	17.16%	-4.00%	13.81%
SO(ADR)/SO(HOME)	17.55%	3.73%	39.45%	0.17%	99.41%
Volume(ADR)/Volume(HOME)	11.4691	1.0846	44.1735	0.0110	47.6326
NYSE	0.5184	1.0000	0.5000	0.0000	1.0000
AMEX	0.1718	0.0000	0.3775	0.0000	1.0000
NASDAQ	0.3098	0.0000	0.4628	0.0000	1.0000

Panel B: Liquidity measures					
	U.S. market		Home market		
	Mean	Std Dev	Mean	Std Dev	T test
Spread	-4.9423	1.3200	-5.0187	1.2343	(0.000)***
Turnover	-6.4421	1.6255	-6.7788	1.4744	(0.000)***
Amihud	-17.2618	2.6917	-18.2194	3.1455	(0.000)***
Zeros	0.1570	0.1509	0.0959	0.1373	(0.000)***

Panel C: Firm characteristics					
	Mean	Median	Std Dev	5%	95%
Asset ($millions)	12,610	917	41,795	28	53,732
Sales ($millions)	6,618	506	23,951	0.0000	31,531
Debt to Asset	0.1599	0.1200	0.1632	0.0000	0.4615
Profitability	-0.0451	0.0110	0.1868	-0.3614	0.1099

logarithm of the ratio of the bid-ask spread over the bid-ask midpoint; (ii) the natural logarithm of daily volume over shares outstanding (log turnover); (iii) the natural logarithm of absolute daily return over dollar volume[12] (the Amihud illiquidity measure); and (iv) the number of zero-return days over the number of trading days (Lesmond et al., 1999). The measures are calculated using daily data, and are averaged to obtain monthly liquidity measures for each stock.[13] The paired mean comparison t-tests show that, for all liquidity measures, the level of U.S. market liquidity is significantly different from the home market liquidity at conventional levels. The difference in the bid-ask spreads, however, is not large or economically significant with the average spread of 2.37% in the U.S. market and 2.33% in the home market. The t statistic for turnover is consistent with the result on trading volume in Panel A, i.e. on average the U.S. market has higher turnover than the home market. The Amihud illiquidity and zero-return measures, on the other hand, suggest a (statistically and economically) higher liquidity for the home market. The home market is characterized by more consistent trading, as for the average cross-listed stock 9.59% of the trading days have no trading activity, whereas in the U.S. market, the percentage is 15.70%.

Panel C presents firm-level characteristics. The average firm has \$9,490 million in total assets and \$4,857 million in sales whereas the median firm has \$911 million in total assets and \$623 million in sales. Also, the average (median) cross-listed firm in our sample has a leverage ratio of 16.97% (13.83%) as measured by long-term debt-to-assets and a market-to-book ratio of 4.65 (2.84). The rest of the paper discusses our formal tests of the effect of liquidity on multi-market trading.

1.3 ADR Premium and Liquidity

This section examines the cross-sectional variation in the absolute value of the ADR premium and in particular the effect of liquidity. In our baseline model, we examine the cross-sectional differences in the magnitude of the ADR premium/discount and the effect of stock liquidity, firm and country characteristics. Our first regression model is:

$$|Premium_{i,t}| = \alpha_i + \gamma_1 Liquidity_{i,t} + \gamma_2 Firm\ factors_{i,t} + \gamma_3 Country\ factors_{i,t} + \gamma_4 Crisis_t + \epsilon_{i,t} \tag{1.1}$$

where $|Premium_{i,t}|$ is the absolute value of firm i's U.S. market price (adjusted for the ADR ratio and the currency exchange) at time t over its home market price minus one; $Liquidity_{i,t}$ is a vector of the U.S. and home market liquidity measures discussed in Section

[12]If the dollar volume is missing, we use the closing price multiplied by the number of shares traded as a proxy for the value of the dollar volume.

[13]The zero-return measure in the daily dataset is a dummy variable that is equal to one if the stock return is 0 or missing on that day, and zero otherwise. This measure in the monthly dataset is calculated as the number of zero-return days in a month over the number of trading days in the same month.

2. We use the monthly averages of the measures calculated with daily stock prices and volumes.

$Firm\ factors_{i,t}$ is a vector of firm-specific characteristics, including the natural logarithm of ADR size, analyst coverage (the number of price estimates by analysts) as a proxy for information asymmetry, U.S. institutional holding as a proxy for short-sale constraint in the U.S. market, and the idiosyncratic volatility as a proxy for the limits to arbitrage.[14]

$Country\ factors_{i,t}$ is a vector of country-specific characteristics. We use country dummy variables as a catch-all variable for all country-specific variables as well as a number of country-level characteristics. Investing in an ADR is effectively taking a position in foreign stock markets. Therefore, expectations of future exchange rate changes and foreign equity returns are potentially important factors in ADR (ordinaries) pricing.[15] We control for these factors using one-month forward exchange rate premium (discount), and the most recent one-month change in the return of the home-market equity index.[16] The one-month forward exchange rate premium (discount) is to proxy for expected exchange rate changes. All exchange rates are defined as the units of the foreign currency per U.S. dollar, i.e. a positive exchange rate change indicates a depreciation of the foreign currency, while a negative change indicates an appreciation. We also control for home market short-selling constraints using a dummy variable indicating when and where short-selling is illegal or temporarily prohibited (Jain et al., 2013). Finally, $Crisis_t$ is a dummy variable controlling for the effect of the 2008 financial crisis.

Table 2 reports the results from the estimation of equation (1.1).[17] All specifications are estimated as panel regressions with firm and year fixed effects. The coefficients of the liquidity measures have the expected sign and remain statistically significant when we control for information asymmetry, limits to arbitrage, foreign currency appreciation, and foreign equity market return. Larger U.S. market bid-ask spread, Amihud illiquidity and zero-return measures as well as smaller turnover are associated with larger absolute values of the ADR premium. For example in Panel B, one standard-deviation increase in the U.S. bid-ask spread results in an increase in the absolute ADR premium of 2.06%; one standard-deviation decrease in turnover results in an increase in the absolute ADR premium of 1.01%;

[14]To estimate equation (1.1) with panel data, we note that there is an important difference in the properties of the liquidity measures and firm and country factors. The variables that measure the liquidity of the stock-pairs vary from one month to the next, while some of the firm- and country-level controls vary less frequently.

[15]This argument presumes some transaction costs, currency restrictions or other frictions that make it costly or difficult to speculate directly or hedge the risk of exchange rate movements.

[16]We chose not to use the forward equity return as a possible proxy for expectations about the future stock market performance because of the relative stationarity of the interest rates. The proxy will be a scaled version of the spot return.

[17]We estimate equation (1.1) both in level and in differences in order to account for the persistence in the liquidity measures. The results are not materially different.

Table 1.2: ADR Premium and Liquidity

The table presents the estimation results for regression specification (1.1). The dependent variable is the absolute value of the ADR (ordinaries) premium. The liquidity measures and the control variables are as defined in Table A.2 in the Appendix. The reported coefficients are the estimates from panel regressions with firm fixed effects. Year dummies are included in all regressions. The numbers in parentheses are p-values. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	0.0033 (0.005)***	0.0009 (0.139)	0.0034 (0.000)***	-0.0074 (0.266)
	U.S.	0.0155 (0.000)***	-0.0065 (0.000)***	0.0044 (0.000)***	0.0288 (0.002)***
Firm-level controls					
Log ADR size		0.0166 (0.000)***	0.0148 (0.000)***	0.0217 (0.000)***	0.0135 (0.000)***
Idiosyncratic volatility	Home	-0.0680 (0.002)***	-0.0417 (0.020)**	-0.0524 (0.003)***	-0.0548 (0.002)***
	U.S.	0.0076 (0.693)	0.0411 (0.007)***	0.0198 (0.194)	0.0284 (0.065)*
Analyst coverage		-0.0021 (0.000)***	-0.0012 (0.000)***	-0.0011 (0.000)***	-0.0013 (0.000)***
Institutional holdings		-0.0425 (0.000)***	0.0212 (0.000)***	0.0203 (0.000)***	0.0163 (0.000)***
Financial crisis		-0.0081 (0.000)***	-0.0099 (0.000)***	-0.0088 (0.000)***	-0.0096 (0.000)***
Within R^2		2.43	6.86	6.95	6.42
Number of observations		23,218	32,224	32,127	32,227

Panel B: Country-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	0.0023 (0.049)**	0.0003 (0.695)	0.0039 (0.000)***	-0.0045 (0.501)
	U.S.	0.0156 (0.000)***	-0.0062 (0.000)***	0.0039 (0.000)***	0.0213 (0.001)***
Firm-level controls					
Log ADR size		0.0189 (0.000)***	0.0149 (0.000)***	0.0217 (0.000)***	0.0136 (0.000)***
Idiosyncratic volatility	Home	-0.0551 (0.016)**	-0.0207 (0.256)	-0.0334 (0.067)*	-0.0374 (0.042)**
	U.S.	-0.0199 (0.313)	0.0104 (0.504)	-0.0096 (0.540)	-0.0006 (0.971)
Analyst coverage		-0.0023 (0.000)***	-0.0011 (0.000)***	-0.0010 (0.000)***	-0.0012 (0.000)***
Institutional holdings		-0.0396 (0.000)***	0.0250 (0.000)***	0.0239 (0.000)***	0.0201 (0.000)***
Country-level controls					
FX premium		0.0566 (0.000)***	0.0462 (0.000)***	0.0447 (0.000)***	0.4641 (0.000)***
ΔEquity market return		0.0055 (0.313)	0.0032 (0.500)	0.0041 (0.375)	0.0064 (0.170)
Stock market turnover		0.0059 (0.004)***	0.0159 (0.000)***	0.0175 (0.000)***	0.0172 (0.000)***
Short-selling constraint		0.0150 (0.106)	0.0320 (0.007)***	0.0287 (0.001)***	0.0304 (0.001)***
Financial crisis		-0.0095 (0.000)***	-0.0101 (0.000)***	-0.0090 (0.000)***	-0.0098 (0.000)***
Within R^2		3.82	7.99	8.11	7.58
Number of observations		22,107	31,037	30,940	31,040

one standard-deviation increase in the Amihud illiquidity measure results in an increase in the absolute ADR premium of 1.05%; one standard-deviation increase in the zero-return measure results in an increase in the absolute ADR premium of 0.32%.

Table 2 also provides some support that high home market liquidity has a negative effect on the absolute value of the ADR premium. The coefficients for home market liquidity are statistically significant only in two out of the four regression specifications. Also, the magnitude of the effect is much smaller than the effect of the U.S. market liquidity. For example, one standard-deviation increase in the home bid-ask spread results in an increase in the absolute ADR premium of 0.28%, almost ten times smaller than the increase from one standard-deviation U.S. bid-ask spread increase.

Besides the liquidity effect on the ADR premium, we also note that analyst coverage has a negative effect on the absolute value of the ADR premium. This is consistent with the studies suggesting that analyst coverage helps mitigate problems with information asymmetry (for example, Brennan and Subrahmanyam, 1995, Hong et al., 2000, Yu, 2008). In addition, the size of the ADR, forward currency premium and home market short-selling constraint have a positive effect on the absolute value of the ADR premium. Overall our results provide support for the limits to arbitrage hypothesis.

Next, we address the endogeneity between stock liquidity and the ADR premium using two quasi-natural experiments and a difference-in-difference approach. In the first experiment, we use the introduction of decimal trading in 2001 as an exogenous shock to the U.S. market liquidity. The conversion to decimalization was completed by 29$^{\text{th}}$ January, 2001 for NYSE and AMEX, and by 9$^{\text{th}}$ April, 2001 for NASDAQ. Previous studies have documented increases in trading volumes and decreases in bid-ask spreads following the decimalization event.[18] It is also possible that the reduction in minimal tick size affected the ADR premium as smaller incrementals in price quotes became available. This, however, should not be a concern for stocks, for which the deviation from price parity was relatively large, since the tick size would not have been a binding constraint that prevented trades from eliminating the deviation from parity.

We follow the approach in Fang et al. (2014), and calculate the change in ADR liquidity over the period one month before to one month after the decimalization. We sort the cross-listed firms into terciles based on the change in liquidity. The top tercile is the treatment group, representing the firms that are affected by the decimalization the most and have experienced the largest increase in liquidity. The bottom tercile is the control group, consisting of the firms that are affected by the decimalization the least and have the smallest increase in liquidity.[19] We use propensity score from a probit model to match each treatment and control firms. The probit model uses the same $Firm$ and $Country\ factors$ as in equation (1.2). We check that the mean propensity score is not different for the treatment and the control group within each block of the propensity score. We also check that the balancing property is satisfied for the covariates. Then we use the following regression to estimate the impact that a positive shock to the U.S. market liquidity has on the absolute value of the

[18] See Bacidore, Battalio, and Jennings (2002). Prior empirical work has also used decimalization as a shock to liquidity to study corporate governance, for example, Bharath (2013), and Fang (2009).

[19] We have only 103 firms in each tercile because not all firms in the sample have observations both before and after the 2001 decimalization.

As pointed out by Fang et al. (2014), the DiD approach has the advantage that it excludes omitted trends that are correlated with stock liquidity and ADR premium and helps establish identification as tests are conducted around periods of the policy changes that cause exogenous variations in stock liquidity. We also include firm fixed effects to control for unobserved differences between the treatment and the control group.

ADR premium:

$$
\begin{aligned}
|Premium_{i,t}| =& \alpha_i + \theta_1 Decimalization_t + \theta_2 Treatment_i \times Decimalization_{i,t} \\
& + \gamma_1 Liquidity_{i,t}^{Home} + \gamma_2 Firm\ factors_{i,t} + \gamma_3 Country\ factors_{i,t} \\
& + \gamma_4 Crisis_t + \epsilon_{i,t}
\end{aligned}
\tag{1.2}
$$

where $Treatment_i$ is a dummy variable equal to one if a firm is in the treatment group and zero if a firm is in the control group, and $Decimalization_t$ is a dummy variable equal to one for the post-decimalization period and zero for the pre-decimalization period of our sample. The other variables are the same as in equation (1.1).

In the second experiment, we use the U.S. dividend tax cut in 2003 as an exogenous shock to the home market liquidity. The 2003 dividend tax cut is a provision in the U.S. Jobs and Growth Tax Relief Reconciliation Act. It reduces dividend tax rate to a maximum of 15%, and applies to dividends received from U.S. companies as well as foreign companies in countries with tax treaties with the U.S., while a marginal tax rate of 35% remains for dividends received from foreign companies in countries without tax treaties with the U.S. Desai and Dharmapala (2010) and Wei (2010) show that capital flows by foreign investors (U.S. investors in our study) improve stock liquidity in the domestic market, particularly for dividend-paying stocks in countries that have tax treaties with the U.S. We identify the firms that domicile in countries with tax treaties with the U.S. and pay dividends in or after 2003 as the treatment group and firms that do not pay dividends or domicile in non-tax-treaty countries as the control group. We use the following regression specification to estimate the impact of a positive shock to home market liquidity on the absolute value of the ADR premium:

$$
\begin{aligned}
|Premium_{i,t}| =& \alpha_i + \theta_1 Tax\ cut_t + \theta_2 Treatment_i \times Tax\ cut_{i,t} \\
& + \gamma_1 Liquidity_{i,t}^{US} + \gamma_2 Firm\ factors_{i,t} + \gamma_3 Country\ factors_{i,t} \\
& + \gamma_4 Crisis_t + \epsilon_{i,t}
\end{aligned}
\tag{1.3}
$$

where $Treatment_i$ is a dummy variable equal to one if a firm is in the treatment group and zero if a firm is in the control group, and $Tax\ cut_t$ is a dummy variable equal to one for the post-tax-cut period and zero for the pre-tax-cut period of our sample. The other variables are the same as in equation (1.1).

Table 3a reports the estimation results from equations (1.2). The treatment effect, i.e. the coefficient for the interaction term between $Treatment$ and $Decimalization$, is negative and statistically significant at 1% level based on two of the four regression specifications. This suggests that even after controlling for endogeneity, the negative effect of the U.S. market liquidity on the absolute value of the ADR premium remains strong and statistically significant. For example, in Panel B when turnover is used as a proxy for liquidity, cross-listed firms in the treatment group experienced 2.12% larger reduction in the absolute

Table 1.3a: DiD Estimation with U.S. Market Liquidity Shock

This table presents the estimation results for difference-in-difference regression (1.2). The dependent variable is the absolute value of the ADR premium. The U.S. exchange decimalization is identified as an exogenous shock to the U.S. market liquidity. Firms are sorted into terciles based on the change in liquidity after the decimalization. The top tercile is the treatment group; the bottom tercile is the control group. The reported coefficients are the estimates from panel regressions with firm fixed effects. Year dummies are included in all regressions. The numbers in parentheses are p-values. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls		Spread	Turnover	Amihud	Zeros
Treatment * Decimalization		0.0118 (0.588)	-0.0220 (0.000)***	-0.0215 (0.000)***	-0.0066 (0.244)
Decimalization		-0.0922 (0.000)***	0.0122 (0.043)**	0.0112 (0.018)**	0.0144 (0.101)
Liquidity	Home	0.0077 (0.001)***	-0.0001 (0.904)	0.0054 (0.000)***	0.0264 (0.006)***
Firm-level controls					
Log ADR size		-0.0020 (0.366)	0.0071 (0.000)***	0.0054 (0.000)***	0.0011 (0.303)
Idiosyncratic volatility	Home	-0.1373 (0.006)***	-0.0574 (0.008)***	0.0076 (0.674)	-0.1473 (0.000)***
	U.S.	-0.0447 (0.279)	0.0787 (0.000)***	0.0072 (0.648)	0.0939 (0.000)***
Analyst coverage		-0.0082 (0.000)***	0.0005 (0.014)**	0.0004 (0.021)**	-0.0009 (0.003)***
Institutional holdings		-0.0070 (0.023)**	0.0309 (0.000)***	0.0340 (0.000)***	0.0310 (0.000)***
Financial crisis		-0.0124 (0.001)***	-0.0037 (0.158)	-0.0026 (0.220)	-0.0035 (0.323)
Within R^2		5.39	5.98	7.73	4.48
Number of observations		8,007	13,415	13,839	14,673

Panel B: Country-level controls		Spread	Turnover	Amihud	Zeros
Treatment * Decimalization		0.0188 (0.391)	-0.0212 (0.000)***	-0.0210 (0.000)***	-0.0081 (0.160)
Decimalization		-0.0992 (0.000)***	0.0041 (0.511)	0.0041 (0.410)	0.0087 (0.346)
Liquidity	Home	0.0069 (0.004)***	-0.0002 (0.799)	0.0048 (0.000)***	0.0146 (0.136)
Firm-level controls					
Log ADR size		-0.0038 (0.101)	0.0073 (0.000)***	0.0106 (0.000)***	0.0015 (0.173)
Idiosyncratic volatility	Home	-0.1357 (0.008)***	-0.0342 (0.112)	0.0379 (0.038)**	-0.1201 (0.000)***
	U.S.	-0.0936 (0.030)**	0.0413 (0.024)**	-0.0302 (0.062)*	0.0540 (0.034)**
Analyst coverage		-0.0082 (0.000)***	-0.0005 (0.012)**	-0.0004 (0.018)**	-0.0010 (0.001)***
Institutional holdings		-0.0058 (0.060)*	0.0303 (0.000)***	0.0353 (0.000)***	0.0311 (0.000)***
Country-level controls					
FX premium		0.0224 (0.000)***	0.0433 (0.000)***	0.0437 (0.000)***	0.0406 (0.000)***
ΔEquity market return		0.0051 (0.703)	0.0012 (0.833)	0.0015 (0.742)	0.0058 (0.443)
Stock market turnover		0.0217 (0.000)***	-0.0004 (0.865)	0.0019 (0.345)	0.0169 (0.000)***
Short-selling constraint		0.0147 (0.489)	0.0121 (0.227)	0.0092 (0.333)	0.0237 (0.199)
Financial crisis		-0.0172 (0.000)***	-0.0046 (0.092)*	-0.0036 (0.097)*	-0.0034 (0.361)
Within R^2		6.11	7.84	10.34	5.68
Number of observations		7,640	13,154	13,327	14,156

value of the ADR premium after the decimalization than similar firms in the control group. The number is 2.10% if the Amihud illiquidity measure is used as the liquidity proxy. The treatment effect is insignificant at the conventional levels when spread or the zero-return measure is used. This may be due to the small number of observations when the spread is used as the liquidity proxy.

Tables 3b reports the estimation results from equations (1.3). The coefficients of the interaction terms between $Treatment$ and $Tax\ cut$ are negative and significant at 10% level in only one specification, and are statistically insignificant in the others. When we control for endogeneity, the home market liquidity does not have a significant effect on the absolute value of the ADR premium. The results, however, show that the tax cut event itself had a negative effect on the absolute value of the ADR premium.

Table 1.3b: DiD Estimation with Home Market Liquidity Shock

The table presents the estimation results for difference-in-difference regression (1.3). The dependent variable is the absolute value of the ADR premium. The 2003 U.S. dividend tax cut is identified as an exogenous shock to the home market liquidity for countries that have tax treaties with the U.S. Dividend-paying stocks in tax-treaty countries make up the treatment group; firms paying no dividend and/or from non-tax-treaty countries make up the control group. The reported coefficients are the estimates from panel regressions with firm fixed effects. Year dummies are included in all regressions. The numbers in parentheses are p-values. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls

		Spread	Turnover	Amihud	Zeros
Treatment * Tax cut		-0.0046 (0.088)*	-0.0003 (0.911)	-0.0001 (0.993)	-0.0009 (0.713)
Tax cut		-0.0315 (0.000)***	-0.0588 (0.000)***	-0.0575 (0.000)***	-0.0591 (0.000)***
Liquidity	U.S.	0.0038 (0.000)***	-0.0061 (0.000)***	0.0054 (0.000)***	-0.0014 (0.836)
Firm-level controls					
Log ADR size		0.0071 (0.000)***	0.0143 (0.000)***	0.0199 (0.000)***	0.0134 (0.000)***
Idiosyncratic volatility	Home	-0.0792 (0.001)***	-0.0466 (0.009)***	-0.0558 (0.002)***	-0.0643 (0.000)***
	U.S.	0.0362 (0.023)**	0.0440 (0.004)***	0.0283 (0.065)*	0.0338 (0.028)**
Analyst coverage		-0.0012 (0.000)***	-0.0012 (0.000)***	-0.0012 (0.000)***	-0.0013 (0.000)***
Institutional holdings		-0.0126 (0.003)***	0.0228 (0.000)***	0.0214 (0.000)***	0.0168 (0.000)***
Financial crisis		-0.0015 (0.308)	-0.0098 (0.000)***	-0.0092 (0.000)***	-0.0097 (0.000)***
Within R^2		2.32	6.71	6.67	6.36
Number of observations		31,594	32,227	32,156	32,227

Panel B: Country-level controls

		Spread	Turnover	Amihud	Zeros
Treatment * Tax cut		-0.0034 (0.221)	-0.0008 (0.752)	-0.0010 (0.695)	-0.0002 (0.934)
Tax cut		-0.0339 (0.000)***	-0.0564 (0.000)***	-0.0553 (0.000)***	-0.0725 (0.000)***
Liquidity	U.S.	0.0030 (0.000)***	-0.0059 (0.000)***	0.0051 (0.000)***	0.0002 (0.978)
Firm-level controls					
Log ADR size		0.0076 (0.000)***	0.0145 (0.000)***	0.0197 (0.000)***	0.0135 (0.000)***
Idiosyncratic volatility	Home	-0.0704 (0.000)***	-0.0261 (0.154)	-0.0356 (0.052)*	-0.0444 (0.015)**
	U.S.	0.0046 (0.777)	0.0126 (0.422)	-0.0018 (0.910)	0.0035 (0.826)
Analyst coverage		-0.0013 (0.000)***	-0.0011 (0.000)***	-0.0011 (0.000)***	-0.0012 (0.000)***
Institutional holdings		-0.0126 (0.003)***	0.0260 (0.000)***	0.0246 (0.000)***	0.0205 (0.000)***
Country-level controls					
FX premium		0.0413 (0.000)***	0.0474 (0.000)***	0.0466 (0.000)***	0.0471 (0.000)***
ΔEquity market return		0.0075 (0.123)	0.0043 (0.363)	0.0056 (0.236)	0.0068 (0.147)
Stock market turnover		0.0150 (0.000)***	0.0158 (0.000)***	0.0163 (0.000)***	0.0172 (0.000)***
Short-selling constraint		0.0242 (0.008)***	0.0322 (0.006)***	0.0295 (0.001)***	0.0301 (0.001)***
Financial crisis		-0.0049 (0.002)***	-0.0100 (0.000)***	-0.0094 (0.000)***	-0.0099 (0.000)***
Within R^2		3.41	7.88	7.83	7.54
Number of observations		30,407	31,040	30,969	31,040

Overall, Table 3a and 3b support the results in Table 2 that the U.S. market liquidity has a strong negative effect on the absolute value of the ADR premium, while the effect of the home market liquidity is weaker and/or insignificant. The coefficients for the other variables are also consistent with those in Table 2 and are in line with previous literature. The next section investigates the effect of the U.S. and home market liquidity on price discovery and the convergence to price parity.

1.4 Price Discovery, Parity Convergence and Liquidity

In the second part of this study, we examine the price discovery process and the convergence to price parity of the cross-listed stocks. We first test the (long-run) conversion and estimate the error correction coefficients for each pair of stock prices, using a vector error correction model (VECM). We examine the role of liquidity in explaining the cross-sectional variation in the speed with which the cross-listed stock's U.S. and home market prices adjust toward the long-run parity. Then we examine the convergence to price parity from another angle by using a duration model that estimates the effect of stock liquidity accounting for the time-series and cross-sectional variations.

1.4.1 Cointegration Analysis

We begin with a cointegration analysis of the U.S. and the home market price. There should be a cointegration relations between the U.S. and the home market price of a cross-listed firm, since they represent the value of the same underlying equity and even though they may temporarily deviate from parity, such deviations should not be persistent. Standard unit root tests for the ADR price, the home market price, the U.S. equity market index, and the home equity market index suggest that for the majority of the sample firms, the null hypothesis of a unit root cannot be rejected at conventional levels.[20]

Then we estimate the short-term correction coefficients using a vector error correction model (VECM) of the cross-listed firm's U.S. market price, home market price, U.S. market index, and home market index, and examine the determinants of the price convergence to parity. The details of the VECM is included in Appendix A.4. We expect the U.S. and home market prices of a cross-listed stock to move closely together, i.e. long-run conversion to parity. To estimate the cointegrating vector, β_i, we normalize the coefficient for home market stock price to 1, and expect the coefficient for the U.S. market stock price to be insignificantly different from -1, and the coefficients for the U.S. and home market indices insignificantly different from 0.

The main parameters of interest are the short-run correction coefficients, α_i^H and α_i^{US}, which show how the U.S. and home market prices respond to a deviation between the two.

[20]Results from the unit root tests are available upon request.

Table 1.4: Cointegration and VECM

The table reports the results from the estimation of the vector error correction model for our sample of cross-listed firms. Panel A reports the number of cointegrating vectors. Panel B presents the estimated coefficients for the cointegrating vector, (β^H,β^{US},β^{Hindex},$\beta^{USindex}$). Panel C presents the estimated coefficients for the error correction coefficients, (α^H,α^{US},α^{Hindex},$\alpha^{USindex}$). The p-values from sample mean t-tests are reported in parentheses. For β^{US} in Panel B, the null hypothesis is that mean equals to -1; for the rest, the hypothesis is that mean equals to 0. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Cointegration rank test		
	Mean	Median
Rank, 95% significance	0.9905	1
Rank, 99% significance	0.8932	1

Panel B: Cointegrating vector			
	Mean	Median	T test
U.S. price, β^{US}	-0.9689	-0.9994	(0.478)
Home price, β^H	Normalize to 1		
U.S. equity market index, $\beta^{USindex}$	-0.0269	-0.0000	(0.305)
Home equity market index, β^{Hindex}	3.3156	-0.0000	(0.317)

Panel C: Error correction coefficients			
	Mean	Median	T test
U.S. price, α^{US}	0.3595	0.2085	(0.000)***
Home price, α^H	-0.4840	-0.4086	(0.000)***
U.S. equity market index, $\alpha^{USindex}$	25.0213	3.5726	(0.000)***
Home equity market index, α^{Hindex}	-21.5030	-3.1372	(0.523)

When a cross-listed firm's U.S. and home market prices differ from each other, α_i^H indicates how the home market price subsequently adjusts to this divergence, whereas α_i^{US} indicates how the U.S. market price adjusts. We expect the sign of α_i^H to be negative and the sign of α_i^{US} to be positive, given the cointegrating vector.

Panel A of Table 4 displays the mean and the median values for the number of cointegrating vectors at 95% and 99% confidence level from Johansen's cointegration tests. The majority (88.31%) of the cross-listed stocks in the sample have one cointegrating vector. In addition, when we sort stocks in portfolios based on their liquidity, the rank test results do not differ among portfolios. The median value is one for all portfolios and the means are not significantly different at conventional levels. This suggests that liquidity is not driving the results from our cointegration tests.

Panel B of Table 4 reports the estimated coefficients in the cointegrating vector. The mean (median) of β_i^{US} is -0.9689 (-0.9994). The t-test shows that the sample mean is not significantly different from -1. The estimates for β_i^{Hindex} and $\beta_i^{USindex}$ are not significantly different from zero. Overall, the results are as expected. The median of the normalized cointegrating vector estimates is (1, -1, 0, 0), i.e. the U.S. and home market prices of a median cross-listed firm converge towards parity in the long run.

Panel C of Table 4 presents the short-term correction coefficients estimated from the error correction model. α_i^H measures the contribution of the U.S. market to price discovery, because it is the extent to which the home market price responds to information provided by the U.S. market price (via a deviation from the home market price). Similarly, α_i^{US} measures the contribution of the home market to the price discovery. The estimates for α_i^H and α_i^{US} have the expected signs. The average short-term correction coefficient α_i^H is -0.4840, and α_i^{US} 0.3595. The magnitude of α_i^H is greater than that of α_i^{US}, implying a greater role played by the U.S. market in the price discovery process. When a cross-listed firm's home market price is higher than its U.S. market price by one dollar, subsequently the home market price decreases by 48 cents and the U.S. market price increases by 36 cents. Our results show that both the U.S. and home markets react to deviations from price parity, and that both markets contribute to price discovery. On average, the U.S. market dominates the price discovery process. In addition, this is not driven by the large number of Canadian firms in the sample. For Canadian firms, the average α_i^H is -0.5511, and α_i^{US} 0.4208. For non-Canadian firms, the average α_i^H is -0.4084, and α_i^{US} 0.2904. The U.S. market dominates the price discovery process for both Canadian and non-Canadian cross-listed firms.

1.4.2 Short-Term Correction Coefficients and Liquidity

We begin with a descriptive analysis of the correction coefficients and stock liquidity. Previous studies, for example, Fang et al. (2009), Khanna and Sonti (2004), and Collin-Dufresne and Fos (2015), suggest that liquidity stimulates informed traders, who buy and sell during times of high liquidity. How information is incorporated into prices, i.e. contribution to price discovery, is therefore dependent on market liquidity. Table 5 reports the estimated error correction coefficients for portfolios of cross-listed firms sorted by the liquidity proxies. P1 is the most illiquid portfolio; P4 is the most liquid portfolio. In Panel A, α_i^H measures the contribution of the U.S. market to price discovery, and is likely to relate to the U.S. market liquidity. So for α_i^H in Panel A, firms are sorted by the U.S. market liquidity. For all four liquidity proxies, the most liquid portfolio has the largest error correction coefficient in absolute value. The U.S. market liquidity positively relates to the extent to which the U.S. market contributes to price discovery. Panel B reports α_i^{US} for four portfolios of cross-listed firms sorted by the home market liquidity. The average value of the correction coefficient of P3 is greater than that of P1 based on three out of the four liquidity proxies. However, the average value of the correction coefficient of P4 is the smallest among the four portfolios.

Table 1.5: Price Convergence and Liquidity

The table reports the error correction coefficients (α^{US} and α^{H}) for the cross-listed firms sorted by liquidity. Panel A reports α^{H} for four portfolios sorted by the U.S. market liquidity; Panel B reports α^{US} for four portfolios sorted by the home market liquidity. The p-values from the t-tests for the difference in means between the least and the most liquid portfolios are reported in parentheses. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: α^{H} for portfolios sorted by U.S. market liquidity					
	Least liquid P1	P2	P3	Most liquid P4	T test P4 = P1
Spread	-0.1851	-0.4131	-0.6083	-0.7452	(0.000)***
Turnover	-0.2795	-0.5442	-0.4925	-0.6230	(0.000)***
Amihud	-0.1999	-0.3636	-0.6273	-0.7440	(0.000)***
Zeros	-0.2053	-0.3578	-0.6738	-0.6983	(0.000)***

Panel B: α^{US} for portfolios sorted by home market liquidity					
	Least liquid P1	P2	P3	Most liquid P4	T test P4 = P1
Spread	0.5827	0.3267	0.2535	0.1280	(0.020)**
Turnover	0.3644	0.3468	0.5027	0.2229	(0.155)
Amihud	0.4079	0.3811	0.4448	0.2051	(0.033)**
Zeros	0.4795	0.3593	0.4944	0.1959	(0.082)*

Overall, these results are consistent with those in Table 2 and 3. Next we turn to our formal regression analysis.

We examine the cross-sectional variation in the magnitude of the short-term correction coefficients, α_i^H and α_i^{US}, and the effect of liquidity. We use a seemingly unrelated regression model to jointly estimate the following two equations:

$$|\alpha_i^H| = a_0 + a_1 Liquidity_i^{US} + a_2 Firm\ factors_i + a_3 Country\ factors_i + \epsilon_i \tag{1.4}$$

$$|\alpha_i^{US}| = b_0 + b_1 Liquidity_i^{H} + b_2 Firm\ factors_i + b_3 Country\ factors_i + e_i \tag{1.5}$$

The $firm\ factors$ in equations (1.4) and (1.5) are the same as those discussed in section 3. For $country\ factors$, the forward currency exchange premium is replaced with the volatility of the currency exchange; the change in equity market return is replaced with the equity

Table 1.6: Cross-sectional Variation in Price Discovery

The table reports estimation results for cross-sectional regressions (1.4) and (1.5). The dependent variable is the error correction coefficient. The numbers in parentheses are the corresponding p-values for the coefficient estimates. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls	Spread		Turnover		Amihud		Zeros	
	α^H	α^{US}	α^H	α^{US}	α^H	α^{US}	α^H	α^{US}
Liquidity	-0.2327***	-0.1513***	0.1551***	0.0664**	-0.1590***	-0.1065***	-1.7658***	-1.1041**
	(0.000)	(0.007)	(0.000)	(0.049)	(0.000)	(0.000)	(0.000)	(0.013)
Firm-level controls								
Log ADR size	-0.0114	-0.0252	0.0819***	0.0210	-0.0750*	-0.0499	0.0281	-0.0028
	(0.750)	(0.441)	(0.007)	(0.500)	(0.071)	(0.165)	(0.394)	(0.930)
Idiosyncratic volatility	1.0654	3.9305***	-0.2198	2.9650**	0.8761	5.1667***	-0.1147	2.0785*
	(0.318)	(0.003)	(0.837)	(0.012)	(0.389)	(0.000)	(0.915)	(0.078)
Analyst coverage	-0.0274**	-0.0112	-0.0249**	-0.0071	-0.0238**	-0.0118	-0.0196*	-0.0035
	(0.021)	(0.362)	(0.036)	(0.566)	(0.045)	(0.323)	(0.098)	(0.769)
Institutional holdings	0.0366	0.1030	-0.2069	-0.1711	-0.2583	-0.0923	-0.1146	-0.0934
	(0.882)	(0.670)	(0.411)	(0.485)	(0.308)	(0.701)	(0.646)	(0.703)
Adjusted R^2	12.82	11.54	14.56	11.86	14.56	14.10	14.27	11.52
Number of observations	339	339	376	376	376	376	376.00	376

Panel B: Country-level controls	Spread		Turnover		Amihud		Zeros	
	α^H	α^{US}	α^H	α^{US}	α^H	α^{US}	α^H	α^{US}
Liquidity	-0.1874***	-0.0623	0.0766***	0.0404	-0.0906***	-0.0459**	-1.3969***	-0.9662**
	(0.001)	(0.204)	(0.003)	(0.190)	(0.000)	(0.034)	(0.000)	(0.024)
Firm-level controls								
Log ADR size	-0.0050	-0.0122	0.0660**	0.0119	-0.0254	-0.0220	0.0265	-0.0016
	(0.886)	(0.702)	(0.029)	(0.686)	(0.533)	(0.516)	(0.409)	(0.957)
Idiosyncratic volatility	4.1997***	4.8739***	3.6555***	4.5818***	4.1782***	5.6054***	3.2992***	4.3364***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Analyst coverage	-0.0082	0.0107	-0.0031	0.0106	-0.0022	0.0124	-0.0007	0.0124
	(0.465)	(0.335)	(0.785)	(0.345)	(0.845)	(0.262)	(0.953)	(0.259)
Institutional holdings	0.6644***	0.2981	0.5929***	0.1322	0.5618**	0.2304	0.5241**	0.1647
	(0.003)	(0.177)	(0.009)	(0.552)	(0.014)	(0.310)	(0.021)	(0.458)
Country-level controls								
FX Volatility	-0.6392**	-0.1466	-0.6648**	-0.5369*	-0.7068**	-0.5968**	-0.6593**	-0.5257*
	(0.032)	(0.629)	(0.020)	(0.076)	(0.013)	(0.049)	(0.018)	(0.076)
Equity market volatility	-0.4951	-0.2495	-0.3561	-0.2842	-0.3212	-0.2740	-0.3350	-0.2728
	(0.128)	(0.176)	(0.247)	(0.116)	(0.293)	(0.127)	(0.271)	(0.130)
Stock market turnover	-0.0041*	-0.0028	-0.0035	-0.0037	-0.0038	-0.0053**	-0.0034	-0.0036
	(0.062)	(0.176)	(0.133)	(0.118)	(0.105)	(0.038)	(0.137)	(0.113)
Short-selling constraint	-0.2206	-0.2849**	-0.1817	-0.2874**	-0.1846	-0.3072**	-0.2005	-0.2797**
	(0.104)	(0.044)	(0.192)	(0.037)	(0.182)	(0.027)	(0.145)	(0.042)
Adjusted R^2	10.76	10.95	9.53	11.79	9.76	11.44	11.09	12.62
Number of observations	339	339	376	376	376	376	376	376

market volatility.[21] Our hypothesis is that liquidity has a positive effect on the size of the short-term correction coefficients.

Table 6 presents the estimation results for equations (1.4) and (1.5). The signs of the coefficients are as expected; the coefficient is negative when spread, Amihud illiquidity, or the zero-return measure is used as the liquidity proxy, and is positive when turnover is used. Both the U.S. and home market liquidity have a positive effect on the short-term correction

[21]These two measures are scaled by 100 in the regressions for the sake of the presentation. Previous studies (Hasbrouck, 1995, Eun and Sabherwal, 2003) suggest that the U.S. market's contribution to price discovery is related to its market share of trading volume. We consider including both the U.S. and home market liquidity together in both equations to account for the effect of the relative liquidity. We find that the home market liquidity is insignificant in determining α^H and the U.S. market liquidity is insignificant in determining α^{US}. We also consider firm characteristics such as market-to-book ratio and leverage, and find that they have no significant effect on the error correction coefficients.

coefficient. In Panel B, the coefficients of the U.S. market liquidity are statistically significant in all four specifications at 1% level, while the coefficients of the home market liquidity are significant at 5% level in two of the specifications and insignificant in the other two. The effect of the U.S. market liquidity is also economically larger than that of the home market liquidity. One standard-deviation decrease in the U.S. market Amihud illiquidity measure corresponds to an increase in $|\alpha_i^H|$ by approximately 0.24; one standard-deviation decrease in the home market Amihud illiquidity measure corresponds to an increase in $|\alpha_i^{US}|$ by approximately 0.14. Overall, the results suggest that liquidity has an important effect on the cross-sectional variation in the speed with which the cross-listed stock's U.S. and home market prices adjust toward the long-run parity. The next subsection examines the liquidity effect from another angle by using a duration model.

1.4.3 Duration Analysis

In this subsection, we carry out a duration analysis and examine how liquidity affects the length of time, during which a cross-listed firm's U.S. and home market prices deviate from parity before the two prices converge. We use a standard Cox proportional hazard regression framework to estimate the coefficients and the effect of liquidity on the conditional probability that a cross-listed firm's U.S. and home market prices converge.

The first step is to construct a time-to-event dataset. The "failure event" is the convergence of a cross-listed firm's U.S. and home market prices. We calculate the differential between the two prices as below, and define the convergence of the two prices as when the price differential is smaller than the estimated roundtrip trading costs.

$$price\ diff_{i,t} = \frac{|p_{i,t}^H - p_{i,t}^{US}|}{(p_{i,t}^H + p_{i,t}^{US})/2} \tag{1.6}$$

When the price differential is small relative to the trading costs, it may not be worthwhile for investors to trade to take advantage of the deviation from price parity. For a long-short strategy, there are two times the roundtrip transaction costs, position open and close on both the long and the short side. Investors taking one-sided positions incur at least one round-trip transaction costs. Grundy and Martin (2001) calculate the raw and risk-adjusted returns of a zero investment momentum trading strategy and estimate that a 1.5% round-trip cost would make the profits insignificant. Mitchell and Pulvino (2002) assess the effect of transaction costs on the returns of risk arbitrage portfolios. By comparing the returns of value-weighted-average-return portfolio and risk-arbitrage-index-manager portfolio, they estimate an approximately 1.5% reduction in annual return by direct transaction costs (commission, surcharges, taxes) and another 1.5% reduction by indirect transaction costs (price impact). Kaul and Mehrotra (2007) estimate the median effective spread to be 1.2% on NYSE and Nasdaq and 0.8 to 1.5% on TSX for a sample of cross-listed firms. Given the results of these studies, we use a 1.5% roundtrip trading cost.[22] We assign a value of 1 to a dummy variable when $price\ diff$ in equation (1.6) is smaller than 1.5%, and a value of 0 otherwise.This defines the "failure event", i.e. the convergence of a cross-listed firm's U.S. and home market prices.

Then we estimate a Cox proportional hazard model as following:

$$h(t) = h_0(t)e^{(A_{i,t})} \tag{1.7}$$

where $h(t)$ is the hazard ratio, $h_0(t)$ is the baseline hazard, and $A_{i,t}$ is an array of explanatory variables including liquidity and control variables:

$$A_{i,t} = \gamma_1 Liquidity_{i,t} + \gamma_2 Firm\ factors_{i,t} + \gamma_3 Country\ factors_{i,t} + \gamma_4 Crisis_t \tag{1.8}$$

where the $firm$ and $country\ factors$ are the same as in equations (1.4) and (1.5).

Table 7 presents the estimation results from the duration model. The U.S. market liquidity is positively associated with the hazard ratio. The coefficients are negative when spread, Amihud illiquidity and zero-return measures are used as the liquidity proxy; it is positive when turnover is used. The liquidity effect is also economically significant. One standard-deviation decrease in the U.S. market spread is associated with an average of 8.96% increase in the conditional probability of the price convergence; one standard-deviation increase in the U.S. market turnover is associated with approximately 3.72% increase in the conditional probability of the price convergence. One standard-deviation decrease in the U.S. Amihud illiquidity measure corresponds to a 4.76% increase in the hazard ratio. On the other hand, the home market liquidity has no strong effect on the hazard ratio. The coefficient is statistically significant when turnover is used, but insignificant when the other three liquidity proxies are used. One standard-deviation increase in the home market turnover is associated with a 2.03% increase in the hazard ratio. These results are consistent with those in Table 6.

For the control variables, ADR size, analyst coverage and institutional holdings have a positive effect on the hazard ratio, whereas the currency exchange volatility and the home market short-selling constraint have a negative effect.

Finally, we explore two possible channels through which liquidity may affect the convergence of cross-listed firms' U.S. and home market prices. First, stock liquidity may increase the probability of price convergence by attracting informed trading. To test this channel, we conjecture that the effect of liquidity on price convergence is weaker for stocks with high institutional ownership. This is because institutional ownership mitigates information asymmetries, thus liquidity is less important for stocks with high institutional ownership.

[22] According to Domowitz et al. (2001), the two-way equity trading cost for countries in our sample has an average value of 1.05%.

Table 1.7: Price Convergence and Liquidity: Duration Analysis

The table presents the results from the Cox proportional hazard model specified by equations (1.7) and (1.8). The dependent variable is the hazard ratio, the conditional probability of the price convergence. The liquidity measures and the control variables are as defined in Table A.2 in the Appendix. Year dummies are included in all regressions. The numbers in parentheses are p-values with robust standard errors. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	-0.0314 (0.001)***	0.0279 (0.000)***	-0.0187 (0.000)***	-0.0291 (0.164)
	U.S	-0.0787 (0.000)***	0.0343 (0.000)***	-0.0274 (0.000)***	-0.0228 (0.314)
Firm-level controls					
Log ADR size		0.0263 (0.009)***	0.0661 (0.000)***	0.0119 (0.173)	0.0651 (0.000)***
Idiosyncratic volatility	Home	-1.2824 (0.007)***	-0.9949 (0.003)***	-0.8534 (0.012)**	-0.8581 (0.008)***
	U.S.	0.6320 (0.042)**	-0.0724 (0.747)	-0.1898 (0.396)	0.1164 (0.591)
Analyst coverage		-0.0051 (0.043)**	0.0001 (0.960)	-0.0011 (0.538)	0.0028 (0.058)*
Institutional holdings		-0.0329 (0.486)	-0.0959 (0.005)***	-0.0619 (0.033)**	0.0073 (0.822)
Financial crisis		0.1074 (0.204)	0.1022 (0.230)	0.1038 (0.254)	0.1144 (0.173)
McFadden Pseudo R^2		0.63	0.61	0.59	0.57
Number of observations		310,281	453,151	412,650	453,427

Panel B: Country-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	-0.0054 (0.614)	0.0137 (0.002)***	-0.0010 (0.806)	-0.0368 (0.106)
	U.S.	-0.0705 (0.000)***	0.0226 (0.000)***	-0.0179 (0.000)***	-0.0241 (0.305)
Firm-level controls					
Log ADR size		0.0314 (0.001)***	0.0607 (0.000)***	0.0294 (0.000)***	0.0619 (0.000)***
Idiosyncratic volatility	Home	-1.1382 (0.020)**	-0.6536 (0.045)**	-0.6607 (0.066)*	-0.6613 (0.038)**
	U.S.	0.7009 (0.040)**	0.1396 (0.568)	-0.0553 (0.830)	0.2343 (0.321)
Analyst coverage		0.0018 (0.508)	0.0064 (0.000)***	0.0064 (0.000)***	0.0066 (0.000)***
Institutional holdings		0.1153 (0.006)***	0.1172 (0.001)***	0.1533 (0.000)***	0.1197 (0.000)***
Country-level controls					
FX Volatility		-0.1201 (0.097)*	-0.1601 (0.007)***	-0.1898 (0.005)***	-0.1473 (0.013)**
Equity market volatility	Home	0.0065 (0.801)	-0.0349 (0.128)	-0.0119 (0.600)	-0.0292 (0.173)
	U.S.	-0.0511 (0.148)	-0.0145 (0.631)	-0.0243 (0.460)	-0.0227 (0.450)
Stock market turnover		-0.0495 (0.306)	-0.0564 (0.235)	-0.0707 (0.168)	-0.0251 (0.579)
Short-selling constraint		-0.2601 (0.000)***	-0.2938 (0.000)***	-0.3123 (0.000)***	-0.2889 (0.000)***
Financial crisis		0.0494 (0.519)	0.0301 (0.691)	0.0353 (0.666)	0.0350 (0.639)
McFadden Pseudo R^2		0.51	0.51	0.48	0.49
Number of observations		310,279	453,149	412,648	453,425

Table 1.8a: Institutional Ownership and the Liquidity Effect

The table presents the results from the Cox proportional hazard model augmented with the interaction terms between liquidity and institutional ownership. The dependent variable is the hazard ratio, the conditional probability of the price convergence. The liquidity measures and the control variables are as defined in Table A.2 in the Appendix. Year dummies are included in all regressions. The numbers in parentheses are p-values with robust standard errors. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	-0.0375 (0.000)***	0.0270 (0.000)***	-0.0250 (0.000)***	-0.0288 (0.168)
	U.S	-0.1321 (0.000)***	0.0534 (0.000)***	-0.0578 (0.000)***	-0.0581 (0.026)**
Firm-level controls					
Log ADR size		0.0202 (0.047)**	0.0662 (0.000)***	0.0022 (0.804)	0.0651 (0.000)***
Idiosyncratic volatility	Home	-1.3147 (0.005)***	-0.9539 (0.005)***	-0.7997 (0.014)**	-0.8580 (0.008)***
	U.S.	0.6076 (0.046)**	-0.0448 (0.842)	-0.1027 (0.639)	0.1174 (0.588)
Analyst coverage		-0.0005 (0.863)	0.0003 (0.871)	0.0018 (0.310)	0.0028 (0.056)*
Institutional holdings		1.5021 (0.000)***	-0.5165 (0.000)***	2.4524 (0.000)***	0.0038 (0.904)
Liquidity *Institutional holdings	U.S.	0.2399 (0.000)***	-0.0737 (0.000)***	0.1278 (0.000)***	0.1529 (0.357)
Financial crisis		0.1072 (0.183)	0.1004 (0.239)	0.1034 (0.248)	0.1145 (0.173)
McFadden Pseudo R^2		0.68	0.62	0.65	0.57
Number of observations		310,281	453,151	412,650	453,427

Panel B: Country-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	-0.0070 (0.510)	0.0124 (0.005)***	-0.0045 (0.247)	-0.0364 (0.110)
	U.S	-0.1201 (0.000)***	0.0446 (0.000)***	-0.0437 (0.000)***	-0.0653 (0.022)**
Firm-level controls					
Log ADR size		0.0249 (0.010)***	0.0610 (0.000)***	0.0213 (0.010)***	0.0618 (0.000)***
Idiosyncratic volatility	Home	-1.1678 (0.016)**	-0.5953 (0.074)*	-0.6161 (0.076)*	-0.6609 (0.038)**
	U.S.	0.6993 (0.038)**	0.1839 (0.453)	0.0398 (0.874)	0.2361 (0.318)
Analyst coverage		0.0071 (0.012)**	0.0066 (0.000)***	0.0097 (0.000)***	0.0066 (0.000)***
Institutional holdings		1.6432 (0.000)***	-0.3832 (0.001)***	2.4618 (0.000)***	0.1162 (0.000)***
Liquidity *Institutional holdings	U.S.	0.2334 (0.000)***	-0.0886 (0.000)***	0.1159 (0.000)***	0.1789 (0.281)
Country-level controls					
FX Volatility		-0.1233 (0.090)*	-0.1531 (0.009)***	-0.1862 (0.005)***	-0.1472 (0.013)**
Equity market volatility	Home	-0.0021 (0.936)	-0.0391 (0.084)*	-0.0142 (0.532)	-0.0294 (0.170)
	U.S.	-0.0425 (0.221)	-0.0146 (0.627)	-0.0253 (0.441)	-0.0227 (0.451)
Stock market turnover		-0.0614 (0.197)	-0.0595 (0.212)	-0.0957 (0.060)*	-0.0254 (0.573)
Short-selling constraint		-0.2494 (0.000)***	-0.2851 (0.000)***	-0.2874 (0.000)***	-0.2888 (0.000)***
Financial crisis		0.0497 (0.496)	0.0275 (0.720)	0.0366 (0.648)	0.0350 (0.640)
McFadden Pseudo R^2		0.56	0.52	0.52	0.49
Number of observations		310,279	453,149	412,648	453,425

We test this hypothesis by augmenting equation (1.8) with the interaction term between the U.S. market liquidity and the institutional ownership.

Secondly, liquidity may increase the probability of price convergence by attracting arbitrage trading. With this channel, the effect of liquidity should be stronger for stocks with high holding costs, because liquidity allows traders to trade at lower transaction costs, and is particularly important for these stocks. Using idiosyncratic volatility as a proxy for holding cost, we test this channel by augmenting equation (1.8) with the interaction terms between the liquidity and the idiosyncratic volatility for both the U.S. and the home markets.

Table 8a and 8b report the results for the tests of these two mechanisms. In Table 8a, the U.S. market liquidity is positively associated with the conditional probability of the price convergence. The coefficient estimates for the U.S. market liquidity proxies and the interaction terms between liquidity and institutional ownership have the opposite signs, suggesting that institutional ownership weakens the liquidity effect on the conditional probability of the convergence of a cross-listed firm's U.S. and home market prices.[23] The coefficient for the interaction term is statistically significant in three out of the four specifications. In Panel B, one standard-deviation decrease in the U.S. market spread corresponds to an 8.25% increase in the hazard ratio for a firm with the mean institutional ownership, compared to a 0.35% increase in the hazard ratio for a firm with an institutional ownership that is one standard-deviation above the mean. Similarly, one standard-deviation increase in the U.S. market turnover corresponds to a 4.75% increase in the hazard ratio for a firm with the mean institutional ownership, and a 1.61% increase for a firm with an institutional ownership that is one standard-deviation above the mean. With the Amihud illiquidity measure, one standard-deviation increase in the institutional ownership above the mean completely reverses the liquidity effect from an 11.52% increase in the hazard ratio to a 2.39% decrease. These results suggest that the liquidity effect on the price convergence is weaker for stocks with high institutional ownership, and is stronger for stocks with low institutional ownership.

In Table 8b, the coefficients for the interaction terms between the U.S. market liquidity and idiosyncratic volatility have the same sign as the coefficients for the liquidity proxies. It suggests that the liquidity effect on the price convergence is stronger for stocks with higher idiosyncratic volatility. In Panel B, one standard-deviation decrease in the U.S. market spread corresponds to a 10% increase in the hazard ratio for a firm with the mean idiosyncratic volatility, and a 13.08% increase in the hazard ratio for a firm with an idiosyncratic volatility that is one standard-deviation above the mean. Similarly, one standard-deviation increase in the U.S. market turnover corresponds to a 3.62% increase in the hazard ratio for a firm with the mean idiosyncratic volatility, and a 4.16% increase in the hazard ratio for a firm with an idiosyncratic volatility that is one standard-deviation above the mean. Interestingly, the coefficients for the home market liquidity are statistically insignificant, while the interaction terms between the home market liquidity and idiosyncratic volatility are significant. Overall, these results are in support of the mechanism that liquidity increases the conditional probability of the price convergence by easing transactional frictions and stimulating arbitrage trading.

1.5 Robustness Tests and Discussions

1.5.1 Alternative Specifications

In this subsection, we re-estimate regression equations (1.1), (1.2) and (1.3), using the natural logarithm of the absolute value of the ADR premium as the dependent variable.

[23] As a robustness check, we include the interaction between institutional ownership and the home market liquidity. We find that institutional ownership does not impact the effect of the home market liquidity, possibly because the ownership data covers the holdings of the U.S. institutional investors.

Table 1.8b: Holding Costs and the Liquidity Effect

The table presents the results from the Cox proportional hazard model augmented with the interaction terms between liquidity and idiosyncratic volatility. The dependent variable is the hazard ratio, the conditional probability of the price convergence. The liquidity measures and the control variables are as defined in Table A.2 in the Appendix. Year dummies are included in all regressions. The numbers in parentheses are p-values with robust standard errors. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	0.0005 (0.974)	0.0119 (0.165)	-0.0066 (0.472)	0.1002 (0.713)
	U.S	-0.0559 (0.006)***	0.0321 (0.000)***	-0.0095 (0.096)*	-0.0154 (0.006)***
Firm-level controls					
Log ADR size		0.0296 (0.003)***	0.0654 (0.000)***	0.0191 (0.073)*	0.0674 (0.000)***
Idiosyncratic volatility	Home	-2.9948 (0.026)**	0.1412 (0.852)	-1.5204 (0.098)*	-0.3446 (0.378)
	U.S.	-0.9268 (0.371)	0.0017 (0.997)	-4.3208 (0.000)***	-0.0161 (0.951)
Liquidity *Idiosyncratic volatility	Home	-0.3707 (0.110)	0.1750 (0.016)**	-0.0451 (0.412)	-0.2561 (0.509)
	U.S.	-0.2727 (0.074)*	0.0165 (0.743)	-0.2108 (0.000)***	-1.0082 (0.000)***
Analyst coverage		-0.0051 (0.046)**	0.0002 (0.908)	0.0024 (0.136)	0.0064 (0.000)***
Institutional holdings		-0.0757 (0.124)	-0.0965 (0.004)***	0.0028 (0.275)	0.1861 (0.000)***
Financial crisis		0.0914 (0.274)	0.1061 (0.209)	-0.2298 (0.125)	0.1260 (0.176)
McFadden Pseudo R^2		0.65	0.61	0.59	0.41
Number of observations		310,281	453,151	412,650	453,427

Panel B: Country-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	-0.0053 (0.680)	0.0081 (0.268)	-0.0061 (0.483)	0.0794 (0.937)
	U.S.	-0.0442 (0.017)**	0.0176 (0.039)**	-0.0094 (0.064)*	-0.0030 (0.021)**
Firm-level controls					
Log ADR size		0.0334 (0.001)***	0.0598 (0.000)***	0.0257(0.010)**	0.0618 (0.000)***
Idiosyncratic volatility	Home	-2.0633 (0.001)***	0.9792 (0.152)	-2.5244 (0.004)***	-0.3360 (0.048)**
	U.S.	-1.5105 (0.024)**	0.3605 (0.422)	-3.5612 (0.000)***	0.0530 (0.647)
Liquidity *Idiosyncratic volatility	Home	-0.2409 (0.093)*	0.2514 (0.000)***	-0.1065 (0.036)**	-0.5682 (0.083)*
	U.S.	-0.3684 (0.000)***	0.0424 (0.450)	-0.1802 (0.000)***	-0.9105 (0.000)***
Analyst coverage		-0.0041 (0.089)*	0.0065 (0.000)***	0.0032 (0.032)**	0.0093 (0.000)***
Institutional holdings		-0.0704 (0.164)	0.1147 (0.001)***	0.0015 (0.597)	0.0068 (0.021)**
Country-level controls					
FX Volatility		-0.1138 (0.061)*	-0.1574 (0.009)***	-0.1784 (0.012)**	-0.1996 (0.006)***
Equity market volatility	Home	0.0570 (0.028)**	-0.0353 (0.122)	0.0146 (0.457)	-0.0190 (0.333)
	U.S.	-0.0816 (0.002)***	-0.0166 (0.584)	-0.0530 (0.052)*	-1.6994 (0.602)
Stock market turnover		-0.0423 (0.588)	-0.0483 (0.306)	-0.0307 (0.512)	-0.0380 (0.396)
Short-selling contraint		-0.9684 (0.051)*	-0.2974 (0.000)***	-0.2686 (0.000)***	-0.2966 (0.000)***
Financial crisis		0.0162 (0.817)	0.0342 (0.652)	-0.0460 (0.474)	0.0088 (0.899)
McFadden Pseudo R^2		0.69	0.52	0.64	0.50
Number of observations		310,279	453,149	412,648	453,425

Table 1.9: log(ADR Premium) and Liquidity

This table presents the estimation results for regression specification (1.1), using the natural logarithm of the absolute value of the ADR (ordinaries) premium as the dependent variable. The liquidity measures and the control variables are as defined in Table A.2. The reported coefficients are the estimates from panel regressions with firm fixed effects. Year dummies are included in all regressions. The numbers in parentheses are p-values with robust standard errors. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Firm-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	0.1917 (0.000)***	-0.0324 (0.334)	0.0980 (0.000)***	0.7490 (0.000)***
	U.S.	0.0985 (0.048)**	-0.0065 (0.009)***	0.0963 (0.002)***	0.3179 (0.036)**
Firm-level controls					
Log ADR size		0.0829 (0.299)	-0.0354 (0.503)	0.1363 (0.037)**	-0.0421 (0.423)
Idiosyncratic volatility	Home	0.1553 (0.764)	0.4443 (0.262)	0.2357 (0.539)	0.2938 (0.462)
	U.S.	1.3861 (0.001)***	1.9786 (0.000)***	1.5236 (0.000)***	1.7790 (0.000)***
Analyst coverage		-0.0044 (0.753)	-0.0076 (0.370)	-0.0031 (0.714)	-0.0088 (0.318)
Institutional holdings		-0.3283 (0.115)	0.2935 (0.057)*	0.3026 (0.057)*	0.1845 (0.225)
Financial crisis		-0.1450 (0.000)***	-0.1534 (0.000)***	-0.1236 (0.000)***	-0.1479 (0.000)***
Within R^2		24.65	22.80	24.59	22.38
Number of observations		23,218	32,224	32,127	32,227

Panel B: Country-level controls					
		Spread	Turnover	Amihud	Zeros
Liquidity	Home	0.1901 (0.000)***	-0.0446 (0.184)	0.1056 (0.000)***	0.6688 (0.000)***
	U.S.	0.0742 (0.153)	-0.0799 (0.013)**	0.0871 (0.003)***	0.3581 (0.017)**
Firm-level controls					
Log ADR size		0.0674 (0.402)	-0.0429 (0.408)	0.1257 (0.046)**	-0.0498 (0.332)
Idiosyncratic volatility	Home	0.2716 (0.602)	0.6503 (0.109)	0.4228 (0.290*	0.4597 (0.263)
	U.S.	1.3161 (0.001)***	1.7060 (0.000)***	1.2861 (0.000)***	1.5427 (0.000)***
Analyst coverage		-0.0023 (0.869)	-0.0062 (0.439)	-0.0018 (0.818)	-0.0074 (0.377)
Institutional holdings		-0.2799 (0.172)	0.3237 (0.037)**	0.3283 (0.041)**	0.2144 (0.165)
Country-level controls					
FX premium		0.4829 (0.005)***	0.5016 (0.001)***	0.4665 (0.002)***	0.4850 (0.001)***
ΔEquity market return		-0.0751 (0.008)***	-0.1209 (0.000)***	-0.1139 (0.000)***	-0.0743 (0.003)***
Stock market turnover		0.3613 (0.003)***	0.2623 (0.014)**	0.2743 (0.009)***	0.2639 (0.019)**
Short-selling constraint		0.4793 (0.000)***	0.5264 (0.000)***	0.4557 (0.000)***	0.4962 (0.000)***
Financial crisis		-0.1304 (0.000)***	-0.1409 (0.000)***	-0.1123 (0.000)***	-0.1351 (0.000)***
Within R^2		27.28	24.88	26.72	24.44
Number of observations		22,107	31,037	30,940	31,040

The results are consitent with those in Table 2 and 3. In Table 9, both U.S. and home market liquidity are negatively associated with the logarithm of the absolute value of the ADR premium. For example, in Panel B, one standard-deviation increase in the U.S. market Amihud illiquidity measure results in an increase in the abosulte ADR premium of 1.34% from its average level. The effect is comparable to the 1.05% in Table 2.

Table 10 presents the estimation results for the DiD regressions. Panel A uses the 2001 U.S. exchange decimalization as a positive shock to the U.S. market liquidity. The coefficients for the interaction term between $Treatment$ and $Decimalization$ are negative and significant in three of the four specifications. Panel B uses the 2003 U.S. dividend tax cut as a positive shock to the home market liquidity. The coefficients for the interaction term between $Treatment$ and $Tax\ cut$ are statistically insignificant in all four specifications. The results are consistent with those in Table 3. They suggest that the positive shock to the

Table 1.10: log(ADR Premium) and Liquidity: DiD Estimations

This table presents the estimation results for difference-in-difference regressions (1.2) and (1.3), using the natural logarithm of the absolute value of the ADR (ordinaries) premium as the dependent variable. The reported coefficients are the estimates from panel regressions with firm fixed effects and year dummies. The numbers in parentheses are p-values with robust standard errors. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: U.S. market liquidity shock					
		Spread	Turnover	Amihud	Zeros
Treatment * Tax cut		0.0419 (0.759)	-0.0242 (0.312)	-0.0347 (0.145)	-0.0344 (0.154)
Tax cut		-06182 (0.000)***	-0.7537 (0.000)***	-0.6937 (0.000)***	-0.7978 (0.000)***
Liquidity	U.S.	0.1475 (0.000)***	-0.0908 (0.001)***	0.1282 (0.000)***	0.5114 (0.000)***
Firm-level controls					
Log ADR size		-0.0067 (0.897)	0.0439 (0.409)	0.0956 (0.133)	-0.0506 (0.339)
Idiosyncratic volatility	Home	0.2891 (0.514)	0.5581 (0.178)	0.5125 (0.220)	0.2434 (0.568)
	U.S.	1.2788 (0.000)***	1.7194 (0.000)***	1.4270 (0.000)***	1.6775 (0.000)***
Analyst coverage		-0.0035 (0.660)	-0.0062 (0.440)	-0.0046 (0.558)	-0.0075 (0.370)
Institutional holdings		0.2060 (0.167)	0.2970 (0.063)*	0.3182 (0.047)**	0.2223 (0.156)
Country-level controls					
FX premium		0.5004 (0.001)***	0.5084 (0.001)***	0.4902 (0.001)***	0.5088 (0.001)***
ΔEquity market return		-0.0742 (0.003)***	-0.1062 (0.000)***	-0.1022 (0.000)***	-0.0626 (0.012)**
Stock market turnover		0.2783 (0.014)**	0.2476 (0.020)**	0.2472 (0.020)**	0.2671 (0.016)**
Short-selling constraint		0.4363 (0.000)***	0.5211 (0.000)***	0.4718 (0.000)***	0.4871 (0.001)***
Financial crisis		-0.1234 (0.000)***	-0.1396 (0.000)***	-0.1264 (0.000)***	-0.1369 (0.000)***
Within R^2		24.25	24.72	25.69	24.12
Number of observations		30,407	31,040	30,969	31,040

Panel B: Home market liquidity shock					
		Spread	Turnover	Amihud	Zeros
Treatment * Decimalization		1.1162 (0.000)***	-0.2678 (0.000)***	-0.3939 (0.042)**	-0.2431 (0.000)***
Decimalization		-0.4325 (0.015)**	-0.0424 (0.580)	0.0455 (0.707)	0.0124 (0.875)
Liquidity	Home	0.1290 (0.166)	-0.0702 (0.094)*	0.1390 (0.000)***	0.6661 (0.000)***
Firm-level controls					
Log ADR size		-0.0203 (0.846)	-0.0591 (0.480)	0.0526 (0.560)	-0.1752 (0.001)***
Idiosyncratic volatility	Home	0.4109 (0.535)	0.1856 (0.803)	0.5412 (0.454)	-0.6044 (0.344)
	U.S.	0.5776 (0.309)	1.8500 (0.008)***	1.1503 (0.091)*	1.9606 (0.001)***
Analyst coverage		-0.0252 (0.321)	0.0059 (0.588)	0.0026 (0.791)	-0.0018 (0.863)
Institutional holdings		-0.0447 (0.194)	0.4044 (0.098)*	0.3419 (0.146)	0.0024 (0.994)
Country-level controls					
FX premium		0.1533 (0.004)***	0.5962 (0.002)***	0.6575 (0.001)***	0.4916 (0.002)***
ÎTEquity market return		-0.0753 (0.095)*	-0.0918 (0.024)**	-0.0915 (0.019)**	-0.0776 (0.031)**
Stock market turnover		0.4676 (0.007)***	0.1423 (0.405)	0.2487 (0.103)	0.2687 (0.039)**
Short-selling constraint		0.5445 (0.000)***	0.6449 (0.000)***	0.7179 (0.000)***	0.7243 (0.006)***
Financial crisis		-0.1159 (0.012)**	-0.1109 (0.004)***	-0.0858 (0.008)***	-0.0559 (0.059)*
Within R^2		33.94	26.09	29.38	26.46
Number of observations		7,640	13,154	13,327	14,156

U.S. stock liquidity leads to a decrease in the size of the ADR premium, whereas the home market liquidity does not have a causal effect on the size of the ADR premium.

1.5.2 DiD Placebo and Falsification Tests

In this subsection, we use placebo and falsification DiD tests to confirm the validity of the treatment effect in the quasi-natural experiments. First we redefine *Decimalization* and *Tax cut* with randomly selected dates and keep the *Treatment* variables unchanged. Then we randomly assign firms to the treatment and control groups, while keeping the *Decimalization* and *Tax cut* variables unchanged. We re-estimate equations (1.2) and (1.3) to examine whether the fake treatments will have a significant effect on the absolute value of the ADR premium. The results from the placebo and falsification tests show that the fake treatments do not have a significant effect. The coefficients of the interaction terms between *Treatment* and *Decimalization*, as well as between *Treatment* and *Tax cut*, are not significant.

1.5.3 Additional Robustness Tests

In this subsection, we conduct four additional robustness tests. First, we estimate equation (1.2) for a subsample of firms that have large U.S. and home market price differentials (above the median level) before the decimalization. In the quasi-natural experiment using the 2001 U.S. exchange decimalization event, it is possible that the reduction in minimal tick size affected the ADR premium as smaller incrementals in price quotes became available. This, however, should not be a concern for stocks, for which the deviation from price parity was relatively large, since the tick size would not have been a binding constraint that prevented trades from eliminating the deviation from parity. When we estimate the DiD regression for this subsample with large U.S. and home market price differentials, the results are similar to those in Table 3a. In three of the four specifications, the treatment effect is larger for the subsample than the full sample. For example, when the Amihud illiquidity measure is used as the liquidity proxy, the coefficient of the interaction term between *Treatment* and *Decimalization* is -0.0523, compared to -0.0210 in Panel B of Table 3a.

Secondly, we exclude non-dividend firms and estimate equation (1.3) for the subsample of dividend-paying firms. In the experiment using the 2003 U.S. dividend tax cut, non-dividend firms are unlikely to be subject to the same effect as dividend-paying firms. Although our treatment group does not include non-dividend firms from countries with tax treaties with the U.S., we exclude these firms as a robustness test, i.e. the treatment groups consists of dividend-paying firms from tax-treaty countries, and the control group includes dividend-paying firms from countries without tax treaties with the U.S.[24] We find that the treatment effect is negative and significant; the coefficients for the interaction terms between *Treatment* and *Tax cut* are negative and statistically significant at the conventional levels in all four specifications. For the subsample of dividend-paying firms, the positive shock to the home market liquidity led to a decrease in the absolute value of the ADR premium.

In the third test, we exclude countries with non-overlapping trading hours with the U.S. In this study, we match the home market closing price to the intraday U.S. price with time ticker closest to and within 30 minutes after the home market closes. The match is imperfect as trading hours of stock markets in the Asian-Pacific countries in our sample do not overlap with the trading hours in the U.S. Our main results are based on the full sample including these countries. In this part of the robustness analysis, we exclude countries with non-overlapping trading hours with the U.S., and obtain similar results to those presented in the paper.

[24] We consider a firm as non-dividend firm if it did not pay dividend in all years before the 2003 tax cut.

Finally, we test the robustness of our results for the subsample of ADR's, excluding firms that are cross-listed as ordinary shares. The results are overall consistent with those for the full sample. In addition, the home market liquidity has a significantly negative causal effect on the absolute value of the ADR premium, based on two of the four liquidity proxies, when the 2003 U.S. tax cut is used as a positive shock to the home market liquidity. However, the U.S. market liquidity has a weaker effect on the short-term correction coefficients for the ADR subsample, compared to the results for the full sample.

1.5.4 Pairs-Trading Strategy

In this subsection, we carry out a long-short pairs trading strategy for the cross-listed firms in our sample. We use the timing definition from our duration analysis where we open long-short positions in a stock when the price difference between the share prices in the U.S. and home market is greater than the trading costs for a roundtrip trade. We create zero investment cost positions where each dollar in the long leg (the lower-priced market) is financed by a dollar from the short leg (in the higher-priced market). We close the positions when the two prices converge, i.e. their difference is smaller than the trading costs.

We construct this pairs trading strategy for each cross-listed stock over the entire sample period and calculate the buy-and-hold return. Positions in each stock can be opened and closed multiple times over the sample period. If prices do not converge before the end of the sample period, then this last position is excluded from the total return calculations.[25]

To control for the riskiness of this pairs trading strategy, we regress the buy-and-hold return on Fama-French, momentum, and liquidity risk factors. The FF and momentum factors are the differences between the U.S. and the home market, corresponding to the long or short position in the strategy. The liquidity factor is available only for the U.S. market.[26] We also control for the effect of the short-sell ban during 2008 and for the fact that apart from Canadian stocks, most other foreign companies' shares are traded in the U.S. as ADRs.

Panel A of Table A.3 in the Appendix reports the returns and trading statistics of the trading strategy. For our sample, the average (median) number of round-trip trades per cross-listed firm is 222 (174). The average (median) time a position is open is 9.76 (3.02) days. The annualized return per round-trip trade is on average (median) 0.35% (0.13%), with standard error 0.0004. Although statistically significant, the annualized return from the strategy is small. Panel A also shows that the trades in Canadian cross-listed stocks

[25]We assume zero return for holding cash and zero cost of loaning stocks. We follow Gatev et al. (2006) to form the strategy and calculate returns.

[26]The Fama-French and momentum factors are from Kenneth R. French Data Library, and the liquidity factors from WRDS. For the home market, one of the following factors is used: global excluding U.S., European, Japanese, Asia Pacific excluding Japan, and North American.

generate slightly higher return, on average (median) 0.51% (0.21%), with positions open for shorter time duration. As expected, for the period before the 2008 financial crisis, the strategy returns were smaller with positions remaining open for shorter time periods.

We then regress the buy-and-hold returns from the trading strategy on the Fama-French, momentum, and Pastor-Stambaugh liquidity risk factors. Panel B of Table A.3 presents the regression results. There are significant risk-adjusted returns for the cross-listed firms. The excess return is larger from Canadian firms, but is smaller before the 2008 financial crisis. This is consistent with results in Panel A.

1.6 Summary and Conclusions

Our paper examines the relationship between price deviations for cross listed stocks and market liquidity. Using a sample of international firms that trade on U.S. stlock exchanges, we examine the determinants of the cross-sectional variation in the size of the deviation from price parity, the respective market's contribution to price discovery, and the price convergence. We use the introduction of decimal trading in 2001 as an exogenous shock to liquidity in the U.S. market and the U.S. dividend tax cut in 2003 as an exogenous shock to liquidity in the home market to address the potential endogeneity between liquidity and the ADR premium. Our results show that lower ADR liquidity leads to a larger price difference between the U.S. and the home market. The effect remains significant after we control for information asymmetries, holding costs and other firm- and country-level characteristics. Our results suggest that the U.S. market liquidity has a stronger effect than the home market liquidity does, both statistically and economically.

We also examine the extent to which the U.S. and home markets contribute to the price discovery process. We estimate a vector error correction model and analyze the factors that affect the short-term correction coefficients. We find that on average the U.S. market plays a greater role in the price discovery of cross-listed non-U.S. shares. We use the correction coefficients in a regression analysis, and find that there is a positive effect of liquidity on price discovery. In line with our baseline results, the liquidity effect is stronger for the U.S. market than for the home market.

Finally, we estimate a duration model on the length of time during which the difference between a cross-listed firm's U.S. and home market prices exceeds the trading costs. Our results show that there is a positive relationship between stock liquidity and the conditional probability of the price convergence. In addition, we find that institutional ownership weakens the liquidity effect on the price convergence, whereas idiosyncratic volatility strengthens the liquidity effect. Overall our results show that liquidity is an important determinant of the size of the ADR premium, the price discovery process and the way deviations from price parity are eliminated.

Chapter 2

Do All Diversified Firms Hold Less Cash? Evidence Around the World

2.1 Introduction

Previous research has documented the large and growing cash holdings of U.S. publicly traded firms. For example, Bates, Kahle, and Stulz (2009) document that the average cash to assets ratio of U.S. listed industrial firms has increased from 10.5% in 1980 to 23.2% in 2006. The Federal Reserve Flow of Funds Accounts reports that U.S. corporate cash crossed the $2 trillion mark in the second quarter of 2011. This spectacular increase in U.S. corporate cash holdings has attracted the attention of both academics and Finance practitioners who have tried to understand what has been the driving force behind this change.

The increase in cash holdings, however, has not been the same for all firms. Duchin (2010), for example, points out that the average cash holdings of standalone firms are almost double the cash holdings of diversified firms. In this paper, we use a large sample of 17,557 international firms from 12 countries for the period from 1998 to 2013 to study the relationship between corporate diversification and cash holdings. Using Duchin's (2010) measures of diversification that account for the cross-divisional correlation in investment opportunities and cash flow, we document a much smaller diversification effect on cash than the effect previously documented for U.S. firms. In our baseline model, one standard-deviation increase in the cross-segment correlation in investment opportunities (decrease in diversification) corresponds to an increase of 1.45% (2.34%) in the average (median) cash holdings. In contrast, Duchin (2010) reports a much larger effect for the U.S. publicly traded firms. In his sample, an increase of one standard deviation in the cross-divisional correlation in investment opportunities leads to an increase of 4.4% (9.1%) in the cash holdings of the average (median) firm. We find that our weak result is not completely driven by the inclusion of non-U.S. firms in our sample or the cross-country differences in the degree of precautionary motives for cash. In this paper, we search for an explanation for this weak result.

First, we examine how agency problems affect the relationship between diversification and cash holdings. Agency problems can help explain why some firms choose to forego the opportunity to lower cash reserves even when the diversification effect is strong. Managers who maximize their private benefits of control may distort the allocation of the firm's resources and as a result hoard more cash within divisions, even though diversification reduces the firm's overall need for precautionary liquid reserves. We use four proxies for agency costs and test the hypothesis that there is a stronger diversification effect for multi-segment firms with low agency costs. Our results suggest that weak country-level shareholder protection weakens the diversification effect of investment opportunities. This helps explain the weak diversification effect for our sample.

Next, we examine whether financial constraints affect the extent to which firms benefit from the diversification effect on cash holdings. A firm's precautionary motives for cash matter only when the firm faces binding financial constraints. If the firm can raise low-cost external financing when needed, then the precautionary motive for cash will be weak and the effect of diversification on cash insignificant. We use three proxies for financial constraints and test the hypothesis that there is a stronger diversification effect for firms facing financial constraints. In line with previous research, we find that financial constraints do not explain the weak diversification effect but in fact suggest a stronger negative relationship between cash and diversification.

Finally, we consider the role of product market competition in determining corporate cash holdings. Firms may use cash as a competitive tool in the product markets (Fresard, 2010, Hoberg et al., 2014). When competition is strong enough, it may become the dominant factor in determining corporate financial policies, and therefore weaken the diversification effect on cash. However, it is also possible that competition improves efficiency, including the inter-segment allocation of financial resources. Firms facing strong product market competition may be more susceptible to the opportunities for cash savings arising from diversification and thus have a stronger diversification effect. Our results suggest that product market competition strengthens the diversification effect on cash. Diversified firms may not always hold less cash than otherwise similar standalone firms do, when the product market competition is less severe. The product market competition can explain a wide variation in the diversification effect, a 4.80% difference between firms with the strongest and the weakest level of product market competition. Weak competition can lessen or even reverse the diversification effect, which helps explain the weak diversification effect for our sample.

We examine two possible channels via which competition may affect diversification and cash holdings. First, product market competition affects cash and the diversification effect on cash because competition drives innovation and firms use internally generated funds and cash reserves to finance R&D investment (Brown et al., 2009, and He, 2014). Secondly, product market competition affects cash and the diversification effect on cash because competition increases the uncertainty in firm-level activities (Aghion et al., 2005, Sharpe and Currie, 2008, and Aghion et al., 2014). Firms need resources in order to be able to react to both positive and negative productivity shocks. Our results support both channels. The competition effect on the interaction between cash and Q diversification is statistically and economically larger for high R&D intensity firms and for firms with high uncertainty in sales and productivity growth.

Our paper broadens the cash holdings and corporate diversification literature along several dimensions. Previous studies have argued that diversified firms naturally have less cash as they have used up their reserves in previous acquisitions. Other studies have suggested that diversified firms are larger, and economies of scales allow them to hold less liquid assets. Duchin (2010), on the other hand, shows that diversified firms have lower cash balances, relative to their standalone counterparts, because they enjoy the benefit of coinsurance. Firms hold precautionary cash so that they will not forego future profitable investment opportunities. The imperfect correlation in investment opportunities and cash flows between divisions reduces the diversified firm's exposure to the risk of mismatch between investment opportunities and sources of funds available and thus decreases the amount of precautionary cash balances the firm has to hold.

Among the diversified firms in our sample, there is still a wide variation in corporate cash across countries and industries. Not all diversified firms hold less cash than the similar standalone firms do, as not all multi-segment firms are able to exploit the potential benefits of diversification in terms of lower cash holdings. Previous literature has identified several channels that might weaken these benefits. The first possible explanation is based on the inefficient internal capital markets hypothesis (Shin and Stulz, 1998). In Rajan et al. (2000), for example, divisional managers with strong bargaining power expropriate resources from high productivity divisions and overinvest in low productivity divisions. Such capital misallocation has been associated with the so-called diversification discount, where multi-segment firms trade at a discount relative to a theoretical portfolio of standalone firms. In addition, the need for holding more cash may arise for reasons other than funding potential division-level projects, e.g. empire building and investing in projects that maximize managers' private benefits of control.[1]

On the other hand, Fresard (2010) identifies a different- strategic- role of cash holdings and shows that large cash reserves can allow firms to gain market share at the expense of

[1]Previous studies also examine the relationship between governance and corporate cash. Dittmar et al. (2003) find that firms in countries with poor shareholder protection hold much more cash than firms in countries with good shareholder protection do. Kalcheva and Lins (2007) also suggest that entrenched managers hold more cash, especially in countries where shareholder protection is weak. Harford et al. (2008) suggest that country level governance enforcement is more important than firm level determinants. In countries with poor legal shareholder protection managers can hoard cash easier than those in countries with strong legal shareholder protection can.

their rivals. This means that cash rich firms can finance competitive choices in the product markets, and firms' competitive outcomes depend not only on their own cash reserves but also on their rivals' cash holdings. In turn, Hoberg et al. (2014) show that product market competitions influence firms' financial policies. Possible threats from rivals (measured by product market "fluidity") decrease firms' payouts and increase their cash holdings. Firms may build up cash reserves to fend off predatory behavior and potential threats from product market rivals. When competition, or perceived competition, is strong enough, it may become the dominant factor in determining corporate financial policies, and weaken or reverse the diversification effect on cash. Previous studies have not considered the effect that product market competition may have on the interaction between diversification and cash holdings. Our results provide support for such interaction.

Foley et al. (2007) suggest that the tax costs from repatriating foreign income can partly explain the large cash holdings of U.S. multinational companies. We define firms as multinational if they report foreign incomes during the sample period (Pinkowitz et al, 2012), and find that our results hold for these firms as well.

Finally, we contribute to the literature on innovation and cash holdings. He (2014) shows that the documented trend of increase in the cash balances held by U.S. firms is driven by the R&D intensive firms. Lyandres and Palazzo (2014) also show that the strategic consideration for holding cash is particularly important for innovative firms. Sanchez and Yurdagul (2003) identify idiosyncratic uncertainty as an important factor in accounting for the cross-sectional variations in cash holdings. Consistent with these studies, we find that product market competition plays an important role in determining the way diversification affects cash holdings for firms with higher R&D stock and higher productivity volatility.

The remainder of this paper is organized as follows. Section 2 describes the sample data and presents some summary statistics. Section 3 presents the methodology we use in this paper. Section 4 discusses the empirical results and their interpretation, and examines the possible channels through which product market competition affects the relationship between diversification and cash holdings. Section 5 considers some robustness tests and Section 6 concludes.

2.2 Data and Summary Statistics

2.2.1 Sample Data

We begin by searching the universe of publicly traded firms in the Worldscope database for the list of the 39 countries that constitute the Capital Market Development Index by McLean and Zhao (2014). For each country, we collect annual firm-level accounting data for our sample firms from Datastream and annual financial data by business segment from Worldscope for each 4-digit SIC code business segment. We apply the commonly used criteria to filter the sample. We exclude financial (primary SIC between 6000 and 6999) and utility (primary SIC between 4900 and 4999) companies.[2] We eliminate observations where cash holdings (cash and short-term investment) is missing or cash holding exceeds total assets. We also remove observations with missing segment SIC codes. For the purposes of our analysis, we identify business segments at the 2-digit SIC code level.[3] Diversified firms are those with two or more distinct 2-digit SIC code business segments. Focused firms are those with only one such segment. Then we remove all firms in countries for which there are less than 200 firms, or the number of focused firms is below 10% of all firms in that country.[4] We remove countries where both the equity and debt market development indexes are below the median level. If access to capital market is restricted, then firms are likely to hold liquid assets because the transaction costs to raise funds are high. We also remove countries that have low corruption or political stability scores. To avoid potential problems with outliers, we check the distribution of each variable. We trim the 1st and 99th percentiles of each variable by country. Our final sample consists of 17,557 companies from 12 countries for the period from 1998 to 2013.

Table 1 Panel A presents the distribution of sample firms by country together with some country-level characteristics. In total, 31.33% of the firms in our sample are diversified but the percentage varies by country. The majority of firms in Canada and the U.S. are focused, with 5.71% and 17.73% diversified, respectively, while diversified firms make up larger percentages in the Asian countries in our sample. A significant proportion of the sample consists of multinationals.[5] The table also reports a country's legal origin, shareholder rights index (La Porta et al., 1998 and Spamann, 2010), and financial market development (McLean and Zhao, 2015). Import penetration is the value of import over the sum of import and domestic production.[6] Appendix B.1 includes definitions of variables used in the paper.

Panel B of Table 1 ranks the countries in order of the average difference in cash holdings between diversified and focused firms. On average, diversified firms hold less cash than focused firms do in all the sample countries except for South Korea. The differences in medians between diversified and focused firms are much smaller than the differences in

[2] Multi-segment companies with financial divisions are not excluded, if the financial division is not the primary business segment.

[3] A more refined identification of business segment will significantly reduce the number of firms when calculating industry averages. Also we define a segment as non-operating if the segment SIC code is 9999 (see Glaser and Muller, 2010). A non-operating segment is not counted as a business segment.

[4] In calculating the diversification measures, we use the average Q of focused firms in a particular industry to proxy for segment Q of diversified firms. If the number of focused firms or the number of firms per country-industry is too small, we cannot construct the diversification measure.

[5] A firm is multinational if it has reported foreign sales during the sample period. This definition is used by Pinkowitz et al. (2012). Similarly, Foley et al. (2007) use foreign income and foreign income tax to measure a multinational firm's involvement in foreign operations.

[6] Import and domestic production data are from Datastream and the World Bank.

Table 2.1: Country Characteristics

This table presents the distribution of sample firms by country and country-level characteristics. Variable definitions are in Appendix B.1.

Panel A: Country characteristics

Country	Number of firms	Diversified firms	Multinational firms	Legal origin	Shareholder rights	Financial market development	Import penetration
Australia	1010	237	431	English	4	0.887	13.27%
Canada	2489	142	482	English	4	1.016	22.73%
France	490	197	360	French	5	0.799	19.89%
Germany	596	222	420	German	4	0.860	23.50%
Hong Kong	955	568	741	English	4	2.435	65.69%
Japan	3022	1615	1158	German	5	1.278	10.96%
Korea, South	1435	435	637	German	6	1.140	28.25%
Malaysia	842	519	513	English	4	0.882	44.48%
Singapore	528	309	424	English	4	1.070	61.16%
Sweden	284	94	194	Scandinavian	4	0.900	25.79%
United Kingdom	1344	354	896	English	5	1.334	22.87%
United States	4562	809	1834	English	2	1.551	12.24%

Panel B: Country ranked by the average difference in cash holdings between diversified and focus firms

Country	Mean			Median		
	Diversified	Focus	Difference	Diversified	Focus	Difference
Canada	11.25%	24.17%	-12.92%***	5.20%	10.88%	-5.68%***
United States	17.62%	28.77%	-11.15%***	11.26%	18.67%	-7.41%***
Australia	16.05%	26.96%	-10.91%***	7.65%	16.31%	-8.65%***
Sweden	10.75%	18.54%	-7.78%***	6.65%	10.23%	-3.58%***
United Kingdom	14.58%	21.47%	-6.90%***	8.78%	12.48%	-3.70%***
Germany	13.89%	18.55%	-4.66%***	8.71%	11.15%	-2.44%***
Japan	15.82%	19.61%	-3.79%***	12.71%	15.82%	-3.11%***
Hong Kong	21.06%	23.93%	-2.87%***	15.58%	18.55%	-2.97%***
France	14.36%	16.67%	-2.31%***	10.59%	10.59%	0.00%
Malaysia	12.51%	14.79%	-2.27%***	8.23%	9.83%	-1.60%***
Singapore	17.40%	19.21%	-1.81%***	13.47%	13.67%	-0.20%**
Korea, South	13.35%	13.27%	0.08%	9.38%	9.21%	0.17%**

means. There is, however, a wide variation in the differences in means (medians) across countries.

Table 2 Panel A summarizes the financial characteristics of our sample firms. It shows wide variations in firm characteristics and significant differences between diversified and focused firms. The mean (median) level of cash holdings is 20.11% (12.48%) of total assets and the standard deviation is 21.77%. Comparing diversified and focused firms, the average (median) diversified firm has a 15.85% (11.19%) cash to total assets ratio whereas the ratio for focused firms is 22.81% (13.79%). The differences in means and in medians between the two groups are significant at conventional levels. The mean (median) Tobin's Q is 1.624 (1.380) for all sample firms. Diversified firms have smaller Tobin's Q than focused firms; the difference is statistically significant. Diversified firms acquire less new financing than focused firms do. They have less net debt and equity issuances, distribute larger payouts in the form of dividends and share repurchase, and have lower capital expenditures. The profitability of the average (median) firm (EBITDA to assets) is 6.28% (8.26%) for diversified firms, and -5.20% (7.19%) for focused firms, whereas the mean (median) operating cash flow is 3.24% (5.80%) of total assets for diversified firms, and -8.68% (4.80%) for focused firms. The negative EBITDA and operating cash flows for focused firms are driven by a few countries including Australia, Canada, U.K. and the U.S. The extreme negative earnings and cash flows are concentrated in mining (SIC 10-14), manufacturing (SIC 20-39), and services (SIC 70-89) industry.[7]

Table 2.2: Firm Characteristics

The table presents the summary statistics for three samples: all firms, diversified firms, and focus firms. The sample consists of non-finanical and non-utility firms from 12 countries for the period from 1998 to 2013. Diversified firms are those with two or more operating segments by the 2-digit SIC. The last two columns are p-values from difference in mean t-test and difference in median rank test. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	All firms			Diversified firms		Focused firms		Difference in	
	Mean	Median	Std Dev	Mean	Median	Mean	Median	Mean	Median
Panel A: Firm descriptive measures									
Size, in millions USD	1,831	121	11,559	3,032	245	1,106	73	1,927***	172***
Cash holdings	20.11%	12.48%	21.77%	15.85%	11.19%	22.81%	13.79%	-6.96%***	-2.60%***
EBITDA	-0.62%	7.74%	37.23%	6.28%	8.26%	-5.20%	7.19%	11.48%***	1.07%***
Operating cash flow	-4.00%	5.32%	37.92%	3.24%	5.80%	-8.68%	4.80%	11.92%***	1.01%***
Tobin's Q	1.624	1.380	0.966	1.474	1.296	1.737	1.468	-0.263***	-0.173***
Long-term debt	10.74%	4.13%	14.61%	12.04%	7.73%	9.93%	1.80%	2.10%***	5.93%***
Total debt	20.58%	15.15%	22.67%	22.97%	20.04%	19.11%	11.01%	3.85%***	9.03%***
Net debt issuance	0.24%	0.00%	10.11%	-0.07%	-0.09%	0.44%	0.00%	-0.51%***	-0.09%***
Net equity issuance	3.20%	0.00%	44.93%	0.87%	-0.02%	4.70%	0.00%	-3.84%***	-0.02%***
Payout	1.76%	0.39%	3.40%	1.82%	0.70%	1.72%	0.00%	0.09%***	0.69%***
R&D expense	5.58%	1.25%	12.39%	2.56%	0.95%	7.33%	1.55%	-4.77%***	-0.59%***
CAPEX	5.29%	2.90%	7.05%	4.33%	2.80%	5.89%	2.97%	-1.57%***	-0.18%***
Net working capital	-2.22%	0.31%	32.64%	1.30%	1.98%	-4.47%	-0.29%	5.77%***	2.26%***
Price-cost margin	0.090	0.058	3.261	0.226	0.047	-0.006	0.072	0.232***	-0.025***
HHI	0.188	0.119	0.178	0.200	0.137	0.180	0.107	0.019***	0.030***
Panel B: Cross-segment diversification									
Number of segments	1.433	1.000	0.755	2.405	2.000	1.000	1.000	1.405***	1.000***
Tobin's Q correlation	-0.005	0.000	0.016	-0.021	-0.010	0.000	0.000	-0.021***	-0.010***
Cash flow correlation	-0.001	0.000	0.005	-0.006	-0.003	0.000	0.000	-0.006***	-0.003***
Q-Cash flow correlation	0.171	0.185	0.377	0.103	0.105	0.196	0.274	-0.093***	-0.168***
Tobin's Q volatility	0.308	0.258	0.206	0.238	0.201	0.329	0.281	-0.091***	-0.080***
Cash flow volatility	0.069	0.052	0.062	0.050	0.030	0.074	0.056	-0.024***	-0.026***
Relative value added	0.00%	0.00%	1.27%	-0.02%	-0.01%	0.00%	0.00%	-0.02%***	-0.01%***
Absolute value added	-0.05%	0.00%	6.06%	-0.25%	-0.11%	0.00%	0.00%	-0.25%***	-0.11%***

2.2.2 Measuring Corporate Diversification and the Efficiency of Cross-segment Transfers

The average number of segments (at 2-digit SIC level) for the diversified firms in our sample is less than three. Previous studies have used the number of segments or a dummy variable indicating whether a firm has more than one segment as a proxy for diversification (see, for example, Opler et al., 1999 and Subramaniam et al., 2011). There are, however, several problems with this measure. First, even though we use a 2-digid SIC classification, the degree of correlation between the investment opportunities and cash flows varies across

[7] Our results are robust when excluding these observations in our sample.

industries and countries. Therefore, larger number of segments, by itself, does not necessarily mean lower diversification. Second, as shown by Duchin (2010), the effect of the number of segments does not remain significant when alternative diversification measures are used in cash holdings regressions. Finally, diversification measures based on the number of reported segments are subject to measurement errors (Erdorf et al., 2012).

In this study, we follow Duchin (2010) and use measures of diversification based on the correlation between the cross-segment investment opportunities and cash flows. If we treat a diversified firm as a portfolio of focused firms (its segments), then the volatility of the firm (portfolio) is less than the weighted-sum of the volatility of its segments (components) due to imperfect inter-segment correlations. The volatility of a focused firm's investment opportunities is calculated as the 10-year standard deviation of the annual Tobin's Q. We use the average Q of all focused firms in each 2-digit SIC industry and country as a proxy for the investment opportunities of a diversified firm's segment that is from the same industry and country.[8] The diversification in investment opportunities for a diversified firm is then the difference between the firm's Q volatility based on the actual inter-segment correlations in Q and the volatility assuming perfect inter-segment correlation of one. The measure captures the inter-segment correlation effect and the degree of diversification in investment opportunities. The measure is zero for focused firms, negative for multi-segment firms and the lower the level of inter-segment correlation, the smaller (more negative) the diversification measure. Similarly, we calculate the measure of inter-segment diversification in cash flows as the difference between the firm's cash flow volatility using the actual inter-segment correlations in cash flows and the volatility assuming perfect inter-segment correlation of one.

Table 2 Panel B summarizes the diversification measures. For diversified firms in our sample the mean (median) Tobin's Q correlation is -0.0210 (-0.0097). The mean (median) cash flow correlation is -0.0059 (-0.0025). Panel B also reports a firm's Q and cash flow volatilities without considering the inter-segment correlations. The mean (median) of Q volatility is 0.2380 (0.2006) for diversified firms, and 0.3288 (0.2806) for focused firms. The mean (median) of cash flow volatility is 0.0502 (0.0301) for diversified firms, and 0.0744 (0.0558) for focused firms.

Panel B of Table 2 also reports Q-cash flow correlation for the sample firms. This is the "financing gap" in Acharya et al. (2007). They argue that there are hedging benefits to hold cash, i.e. firms can transfer resources across time to low cash flow states and fund future investment opportunities. Firms with high "hedging needs" or low correlation be-

[8]To calculate the standard deviations of Q and cash flow, there should be at least 5 non-missing values in the 10-year window. We collect data for the focused firms in our sample for the period 1988 and 1997 (10-year window before the beginning of our sample period). This way we have the diversification measures starting from 1998. We use the similar method when calculating sales growth, productivity and firm cash flow volatilities.

tween investment opportunities and cash flows prefer saving cash, whereas firms with low "hedging needs" benefit more from debt reduction. For our sample, the mean (median) of the correlation between Tobin's Q and cash flow is 0.1709 (0.1848) and the standard deviation is 0.3768. On average, diversified firms have smaller Q-cash flow correlations or larger financing gaps than focused firms do.

Finally, the table reports relative and absolute value added by inter-segment capital allocation. These two measures are developed by Rajan et al. (2000) to measure the efficiency of capital transfers across a firm's multiple divisions. The absolute value added measures the market value consequences of inter-segment transfers by comparing the capital expenditures at each segment of a diversified firm with the average focused firm from the matching industry. The relative value added measures the value consequences of inter-segment transfers by comparing the capital expenditures at each segment of a diversified firm with other segments of the same firm, as well as the average focused firm from the matching industry. Both the absolute and relative values added are zero for focused firms by definition. As they become larger, the inter-segment transfer becomes more efficient. The mean (median) of the relative value added is -0.02% (-0.01%) of total assets for diversified firms, while the mean (median) of the absolute value added is -0.25% (-0.11%). This suggests that on average inter-segment transfers of resources destroy value and are inefficient.[9] The next section discusses the methodology we use in this study.

2.3 Methodology

First, we examine the result documented by previous studies that diversified firms hold less cash than their focused counterparts do in an international context.

Hypothesis 1: diversified firms hold less cash than similar standalone firms do.

Our first empirical specification is as follows:

$$\begin{aligned} cash\ holding_{i,t} =& \alpha_i + \beta_1 Qdiv_{i,t} + \beta_2 CFdiv_{i,t} + \gamma_1 firm\ controls_{i,t} \\ & + \gamma_2 year\ dummies_t + \epsilon_{i,t} \end{aligned} \tag{2.1}$$

where $Qdiv_{i,t}$ measures the inter-segment diversification in investment opportunities for firm i in year t and $CFdiv_{i,t}$ measures the inter-segment diversification in cash flows as discussed in the previous section. *Firm controls* is a vector of other firm-level characteristics that may influence corporate cash holdings. Financing gap is the correlation between a firm's cash flows and investment opportunities, and is a measure of the firm's hedging needs (Acharya et

[9]The 99 and 1 percentiles are 4.58% and -3.86% for the relative value added, and are 12.50% and -8.79% for the absolute value added.

al., 2007).[10] Following the regression specification in Duchin (2010), we include the number of operating segments, firm size (the natural logarithm of total assets), the level of operating cash, Tobin's Q, non-cash net working capital, as well as Q and cash flow volatilities. The variable definitions are in Appendix B.1. We also control for firm and year fixed effects.

We compare the difference in diversification effect between firms with high and low precautionary motives of holding cash. To do that, we construct a precautionary motives index similar to the measure in McLean and Zhao (2015). We calculate the average R&D expenses and cash flow volatilities for each industry from the focused firms in that industry. Then we rank industries based on these two values, respectively, and calculate the average of the two ranks. We use this average rank as a measure of the precautionary motives for firms in each industry.[11] A larger value of this variable represents a stronger precautionary motive for cash holdings. We use U.S. firms and industries only in the calculation and assume that an industry would have high/low precautionary motives for cash regardless if it is in the U.S. or not. As McLean and Zhao (2015) point out, the advantage of using U.S. industries is that it utilizes more firms in more different industries and offers less noisy estimates.[12] Then we divide firms into two subsamples, with high and low precautionary motives, respectively. We estimate equation (3.1) for the two subsamples and expect the diversification effect to be stronger for the high precautionary motive subsample.

Next, we examine how agency problems may affect the diversification effect on cash holdings. Agency problems may hamper a firm's opportunity to benefit from the diversification effect, because managers who maximize their private interest may distort the allocation of the firm's resources. Shin and Stulz (1998) show that capital is not always allocated to the segments with the best investment opportunities. Divisional managers who have bargaining power and play "power-seeking" games may hoard divisional resources which leads to inefficient cash flow allocation, i.e. underinvestment in divisions with better investment opportunities and overinvestment in divisions with worse opportunities. Rajan et al. (2000) use multi-segment firm data and show that there is capital misallocation and the greater the diversity (differences in resources and investment opportunities across segments) the more inefficient the capital allocation is. With inefficient capital allocation, the imperfect correlations in investment opportunities and cash flows across segments still reduce the firm-level

[10] Acharya et al. (2007) suggest that cash should not be considered as negative debt when there are financial constraints. The access to credit lines may also affect firms' motives to hold cash as credit lines provide liquidity when needed. However, previous studies (Sufi, 2009, Lins et al., 2010) have shown that firms do not always use cash and credit lines interchangeably. In addition, firms with high cash flows can obtain credit lines, while firms with low cash flows may not be able to obtain credit lines. We control for firm-level cash flows, which partly account for the accessibility of credit lines.

[11] For a diversified firm, it is the firm's primary industry.

[12] For robustness, we also calculate this measure by country, and find qualitatively similar results for the subsamples based on the precautionary motives.

risk of the demand and supply of cash; however, it may not lead to an outcome of lower cash holdings, because the ability of divisions with good investment opportunities to obtain resources is hindered by the allocation inefficiency. We examine the following hypothesis.

Hypothesis 2: there is a stronger diversification effect for multi-segment firms with low agency costs.

Our second empirical specification is as follows:

$$\begin{aligned} cash\ holding_{i,t} =&\alpha_i + \beta_1 Qdiv_{i,t} + \beta_2 CFdiv_{i,t} + \beta_3 AC_{i,t} + \beta_4 Qdiv \times AC_{i,t} \\ &+ \beta_5 CFdiv \times AC_{i,t} + \gamma_1 firm\ controls_{i,t} + \gamma_2 year\ dummies_t + \epsilon_{i,t} \end{aligned} \tag{2.2}$$

where the agency costs, AC, is measured by the absolute and relative value added by transfer (Rajan et al., 2000). They measure the efficiency of a firm's internal capital market. A higher efficiency is interpreted as lower agency costs. Other variables are the same as in equation (3.1).

Alternatively, we use two corporate governance measures for the agency costs, as corporate governance mechanisms may mitigate agency problems and reduce agency costs. Bebchuk et al. (2009) show that six governance provisions[13] play a key role in determining firm values. We construct the entrenchment index similar to Bebchuk et al. (2009), with one additional item - whether a firm's CEO is also a board member. A larger value of the index indicates management entrenchment and higher agency costs. The other measure is the country-level minority investor protection index from the World Bank Doing Business Reports, and is constructed based on the ease of shareholder suits, director liability and disclosure regulations.

Next, we test how financial constraints affect the extent to which firms enjoy the diversification effect on cash holdings. A firm's precautionary motives for cash matter only when the firm faces binding financial constraints. If the firm can raise low-cost financing when needed, then the precautionary motive for holding cash reserves would be weak and the effect of diversification on cash insignificant. We test this hypothesis.

Hypothesis 3: there is a stronger diversification effect for firms facing more financial constraints.

Our third empirical specification is as follows:

$$\begin{aligned} cash\ holding_{i,t} =&\alpha_i + \beta_1 Qdiv_{i,t} + \beta_2 CFdiv_{i,t} + \beta_3 FC_{i,t} + \beta_4 Qdiv \times FC_{i,t} \\ &+ \beta_5 CFdiv \times FC_{i,t} + \gamma_1 firm\ controls_{i,t} + \gamma_2 year\ dummies_t + \epsilon_{i,t} \end{aligned} \tag{2.3}$$

[13] These provisions are staggered boards, limits to shareholder bylaw amendments, poison pills, golden parachutes, and supermajority requirements for mergers and charter amendments. They provide incumbents protection from the consequences of removal.

where FC is the financial constraints variable. We use firm size and payout ratio (Almeida et al., 2004, Denis and Sibilkon, 2009) to categorize firm-years into a constrained group (FC takes a value of 1) and an unconstrained group (FC takes a value of 2). Firms with size or payout ratio below (above) the median make up the constrained (unconstrained) group. We also use a financial market development index (McLean and Zhao, 2015) as a third proxy to measure how easy firms in a country can obtain external financing through the country's equity and debt markets. Other variables are the same as in equation (3.1).

Next, we examine how product market competition may affect the diversification effect on cash. Previous studies (Fresard, 2010, Morrellec et al., 2013, Hoberg et al., 2014) have shown that product market competition increases corporate cash holdings. Firms may use cash to gain market share or fend off rivals in their product markets. Competition may further affect diversified firms via the diversification effect on cash. When competition, or perceived competition, is strong enough, it may become the dominant factor in determining corporate financial policies, and weaken the diversification effect on cash. However, it is also possible that competition improves efficiency. Facing strong competition firms have to use resources more efficiently, e.g. the efficiency of cross-divisional cash flow allocation. Thus, for firms facing strong product market competition the diversification effect on cash holdings will be stronger. We test the following hypothesis:

Hypothesis 4: there is a weaker diversification effect for firms facing stronger product market competition.

Our fourth empirical specification is as follows:

$$\begin{aligned} cash\ holding_{i,t} =& \alpha_i + \beta_1 Qdiv_{i,t} + \beta_2 CFdiv_{i,t} + \beta_3 PC_{i,t} + \beta_4 Qdiv \times PC_{i,t} \\ &+ \beta_5 CFdiv \times PC_{i,t} + \gamma_1 firm\ controls_{i,t} + \gamma_2 year\ dummies_t + \epsilon_{i,t} \end{aligned} \tag{2.4}$$

where product market competition, PC, is measured in three different ways. One measure is the price-cost margin (PCM) - operating income before depreciation and amortization over sales. The PCM of an industry is the average of the focused firms in that industry and country. For focused firm, we use the industry PCM, whereas for diversified firm, we use the segment sales-weighted average value. The second measure is an industry's Herfindahl-Hirschman Index (HHI), which is the sum of squared market shares of focused firms and segments in that industry and country. For focused firm, we use the industry HHI directly, whereas for diversified firm, we use the segment sales-weighted average value. The third measure is the degree of import penetration, which is a proxy for the country-level import competition. Other variables are the same as in equation (3.1). The next section discusses our estimation results.

2.4 Results

In this section, we discuss the estimation results and their implications for our hypotheses. First, we focus on the effect of correlation in investment opportunities and cash flow on cash holdings as specified in regression equation (3.1). Table 3 reports the estimation results: columns (1) and (2) include all firms, column (3) U.S. firms only, and column (4) non-U.S. firms. All specifications control for firm and year fixed effects and are estimated with robust standard errors clustered at firm level. From column (2), one standard-deviation increase in the correlation in investment opportunities corresponds to an increase of 1.45% (2.34%) in cash holdings for the average (median) firm. This suggests a much weaker diversification effect than that documented in Duchin (2010).[14] For his sample of U.S. firms, an increase of one standard deviation in the cross-divisional correlation in investment opportunities leads to an increase of 4.4% (9.1%) in the cash holdings of the average (median) firm. Columns (3) and (4) suggest that the difference is not fully driven by the non-U.S. firms in our sample. In column (3), one standard-deviation increase in the correlation in investment opportunities corresponds to an increase of 2.41% (3.91%) in cash holdings for the average (median) U.S. firm. For non-U.S. firms in column (4), one standard-deviation increase in the correlation in investment opportunities corresponds to an increase of 1.16% (1.81%) in cash holdings for the average (median) firm.

Table 3 also suggests that the inter-segment diversification in cash flows, the correlation between Q and cash flows, and the number of segments do not have significant effects on cash. This is consistent with results found by Duchin (2010). The effects of the other control variables are as expected. Larger firms have smaller cash-to-asset ratios whereas firms with better growth opportunity (higher Tobin's Q) and higher level of cash flows hold more cash. Firms facing higher level of operational risk (higher Q and cash flow volatilities) also hold more cash.

Table 3 documents a negative relationship between the inter-segment diversification in investment opportunities and corporate cash holdings. The diversification effect on cash is much weaker than found by previous studies and is not fully explained by the inclusion of international firms in our sample. It is possible that the weaker diversification effect is a result of firms' weak precautionary motives for cash. We compare firms with low and high precautionary motives, and find that although the coefficients on the diversifications in investment opportunities are statistically and economically larger for the subsample of high precautionary motives, the precautionary motives alone do not explain the weaker diversification effect for our sample. We also estimate equation (3.1) for a subsample that only includes diversified firms, in order to address the concern that the negative relation

[14] Similar to Duchin (2010), we do not find a significant effect for the inter-segment diversification in cash flows.

Table 2.3: Cash Holding and Firm Diversification

The table presents estimates from regressions explaining firm-level cash holdings. The sample consists of non-finanical and non-utility firms from 12 countries for the period from 1998 to 2013. Variable definitions are in Appendix B.1. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	All (1)	All (2)	U.S. (3)	Non-U.S. (4)
Q correlation	0.2446***	0.1824***	0.4191***	0.1274***
	(0.000)	(0.000)	(0.006)	(0.007)
CF correlation	0.3401*	0.3153	-0.2626	0.4775**
	(0.086)	(0.108)	(0.535)	(0.023)
Q-CF correlation		0.0005	0.0011	-0.0032
		(0.844)	(0.851)	(0.266)
Number of segments		-0.0030	-0.0044041	-0.0035
		(0.224)	(0.642)	(0.161)
ln (assets)		-0.0244***	-0.015***	-0.0283***
		(0.000)	(0.000)	(0.000)
Q volatility		0.0271***	0.0505155	0.0332***
		(0.000)	(0.103)	(0.000)
CF volatility		0.1129***	0.0951997	0.093**
		(0.000)	(0.101)	(0.011)
Firm CF		0.0294***	0.0402***	0.0211***
		(0.000)	(0.000)	(0.002)
Tobin's Q		0.0287***	0.0267***	0.0302***
		(0.000)	(0.000)	(0.000)
Net working capital		-0.0489***	-0.0455***	-0.0522***
		(0.000)	(0.000)	(0.000)
Year F.E.	Yes	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes	Yes
Adjusted R^2	0.597	0.712	0.772	0.663
No. of Observations	120,735	78,479	18,820	59,659

between diversification and cash is driven by self-selection. Diversified and focused firms may not face similar investment opportunities or have similar abilities to deal with investment opportunities. In addition, diversified firms may naturally hold less cash than focused firms do because they have used it to expand operations by acquiring new divisions. We find that even among diversified firms, higher inter-segment correlation in investment opportunities and cash flows (lower level of diversification) is associated with higher cash-to-asset ratios on average.[15]

Next, we explore possible explanations for the weaker diversification effect in international context, in particular, the effect of agency costs, financial constraints, and product market competition.

Table 4 reports the estimation results from regression specification (2.2), using four proxies for agency costs: absolute value added, relative value added, managerial entrenchment index, and minority shareholder protection. The coefficients of the diversification measures and the control variables are consistent with those in Table 3. Based on column (1), firms with more efficient internal capital markets on average hold less cash. In columns (1) to (3), the firm-level measures of agency costs do not have a significant influence on the relationship between the diversification in investment opportunities and cash holdings. Based on column (4), firms in countries with stronger shareholder protections hold less cash. The coefficient of the interaction term between shareholder protection and diversification in Q is positive and significant, suggesting that the diversification effect on cash is stronger in countries with better shareholder protection. This means that a weaker country-level shareholder protection helps to explain the weak diversification effect. For the U.S. the shareholder protection index is 8.30, with which one standard-deviation increase in Q diversification corresponds to an average 3.61% decrease in the cash-to-asset ratio. For non-U.S. countries in our sample, the average of the shareholder protection index[16] is 6.99, with which the effect of one standard-deviation increase in Q diversification on cash is 3.04%. The smallest (largest) value of the shareholder protection index is 4.7(9.3) for our sample, which gives a Q diversification effect of 2.05% (4.05%).

Next, we examine the role of financial constraints. Table 5 reports the estimation results from equation (2.3), with three proxies for financial constraints: firm size, payout ratio, and financial market development index. The magnitude of the coefficients of the inter-segment diversification in investment opportunities are larger than those reported in Table 3, while the coefficients of the control variables are comparable. Unconstrained firms hold more cash, as suggested by the positive and significant coefficients of financial constraints in columns (2) and (3). Further, there is moderate evidence to support our hypothesis that financial constraints strengthen the relation between diversification in Q and cash holdings. In column

[15]The tables containing these results are not appended in the paper, and are available upon request.

[16]The index may take a value between 0 and 10.

Table 2.4: Agency Costs and The Diversification Effect on Cash

The table presents estimates from regressions explaining the relation between agency costs and the diversification effect on cash holdings. The sample consists of non-finanical and non-utility firms from 12 countries for the period from 1998 to 2013. Variable definitions are in Appendix B.1. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	absolute value added (1)	*relative value added* (2)	*entrenchment index* (3)	*minority shareholder protection* (4)
Q correlation	0.1430***	0.1605***	0.1896***	-0.2211
	(0.005)	(0.003)	(0.000)	(0.318)
CF correlation	0.2417	0.1620	0.4673**	1.6404*
	(0.248)	(0.439)	(0.031)	(0.097)
Agency costs	-0.0647**	-0.0212	0.0012	-0.0091**
	(0.028)	(0.522)	(0.301)	(0.022)
AC * Q correlation	-0.4132	-1.2650	-0.0328	0.0547*
	(0.271)	(0.194)	(0.244)	(0.078)
AC * CF correlation	-2.5271	0.1653	-0.2055**	-0.1701
	(0.278)	(0.968)	(0.017)	(0.193)
Q-CF correlation	0.0003	0.0005	0.0005	0.0005
	(0.911)	(0.845)	(0.839)	(0.847)
Number of segments	-0.0032	-0.0023	-0.0029	-0.0024
	(0.289)	(0.466)	(0.252)	(0.348)
ln (assets)	-0.0250***	-0.0248***	-0.0246***	-0.0247***
	(0.000)	(0.000)	(0.000)	(0.000)
Q volatility	0.0275***	0.0275***	0.0267***	0.0269***
	(0.001)	(0.001)	(0.001)	(0.000)
CF volatility	0.1068***	0.1071***	0.1137***	0.1242***
	(0.001)	(0.001)	(0.000)	(0.000)
Firm CF	0.0279***	0.0280***	0.0295***	0.0293***
	(0.000)	(0.000)	(0.000)	(0.000)
Tobin's Q	0.0288***	0.0287***	0.0286***	0.0287***
	(0.000)	(0.000)	(0.000)	(0.000)
Net working capital	-0.0441***	-0.0439***	-0.0487***	-0.0487***
	(0.000)	(0.000)	(0.000)	(0.000)
Year F.E.	Yes	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes	Yes
Adjusted R^2	0.712	0.713	0.712	0.712
No. of Observations	72,789	72,269	78,479	78,479

(1), one standard-deviation increase in Q diversification corresponds to an average of 2.89% decrease in cash for financially constrained firms, while the effect is only 1.03% for firms in the less constrained group. Although less financial constraints may explain the weak diversification effect, there is no evidence suggesting that firms become less constrained in recent years or that non-U.S. firms are less constrained than U.S. firms. Therefore, financial constraints do not explain the weak diversification effect for our sample.

Table 2.5: Financial Contraints and The Diversification Effect on Cash

The table presents estimates from regressions explaining the relation between financial constraints and the diversification effect on cash holdings. The sample consists of non-finanical and non-utility firms from 12 countries for the period from 1998 to 2013. Variable definitions are in Appendix B.1. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	size (1)	*payout* (2)	*financial market development* (3)
Q correlation	0.5793***	0.3181**	0.2059*
	(0.007)	(0.036)	(0.054)
CF correlation	1.1957	0.3143	0.8115**
	(0.119)	(0.571)	(0.027)
Financial constraints	-0.0057	0.0036*	0.0120***
	(0.148)	(0.052)	(0.001)
FC * Q correlation	-0.2266**	-0.0773	-0.0176
	(0.038)	(0.339)	(0.815)
FC * CF correlation	-0.5430	0.0132	-0.3089
	(0.186)	(0.963)	(0.157)
Q-CF correlation	0.0006	-0.0019	0.0000
	(0.824)	(0.464)	(0.991)
Number of segments	-0.0031	-0.0034	-0.0033
	(0.219)	(0.205)	(0.181)
ln (assets)	-0.0237***	-0.0258***	-0.0246***
	(0.000)	(0.000)	(0.000)
Q volatility	0.0270***	0.0250***	0.0280***
	(0.000)	(0.003)	(0.000)
CF volatility	0.1123***	0.1050***	0.1107***
	(0.000)	(0.001)	(0.000)
Firm CF	0.0293***	0.0302***	0.0297***
	(0.000)	(0.000)	(0.000)
Tobin's Q	0.0287***	0.0284***	0.0287***
	(0.000)	(0.000)	(0.000)
Net working capital	-0.0490***	-0.0427***	-0.0486***
	(0.000)	(0.000)	(0.000)
Year F.E.	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes
Adjusted R^2	0.712	0.715	0.712
No. of Observations	78,479	70,891	78,479

Table 6 reports the estimation results from equation (2.4). We consider the role of product market competition in determining corporate cash holdings. The coefficients of the diversification measures and control variables are consistent with those reported in tables 3 to 5. In columns (1) and (2), higher values of PCM and HHI indicate less intense product market competitions faced by firms. Consistent with previous studies, firms facing stronger product market competition hold more cash. The coefficients of the interaction terms between competition and Q correlation are negative, indicating a stronger diversification effect where the product market competition is more intense. This lends support to the hypothesis that competition improves efficiency. To evaluate the magnitude of the impact of product market competition on the interaction between Q diversification and cash, we compare the diversification effects at different levels of product market competition. For example, with the mean HHI one standard-deviation increase in the diversification in investment opportunities corresponds to 1.92% (3.09%) decrease in cash for the average (median) firm. When the HHI is one standard deviation above the mean (weaker competition), the diversification effect becomes 0.93% (1.50%) for the average (median) firm. These results suggest that weak product market competition may help explain the weak diversification effect for our sample. The average HHI for U.S. firms in our sample is 0.11, with which one standard-deviation increase in Q diversification corresponds to an average 2.36% decrease in the cash-to-asset ratio. Non-U.S. firms in our sample face less product market competition. The average HHI for non-U.S. firms is 0.21, with which the effect of one standard-deviation increase in Q diversification on cash is 1.78% on average. The 1 percentile of the HHI sample distribution is 0.03, indicating strong product market competition; at this HHI level, the effect of one standard-deviation increase in Q diversification is 2.82%. The 99 percentile of HHI is 0.89; at this weak level of competition, the effect of one standard-deviation increase in Q diversification is -1.98%.[17]

In column (3) of Table 6, higher values of import penetration indicate stronger import competition firms face at the country level. Firms hold more cash in countries where the values of imports amount to greater fractions of the domestic productions. However, import penetration does not have a significant effect on the interaction between Q diversification and cash.

Taken together, our empirical results suggest that both the weak country-level shareholder protection and low product market competition help explain the weak effect of the diversification in investment opportunities on cash holdings. The product market competition can explain a wider variation in the diversification effect, a 4.80% difference between firms with the strongest (lowest) and the weakest (highest) level of product market competition (HHI). Further, weak competition can even reverse the diversification effect. Diversified firms may not always hold less cash than otherwise similar standalone firms do when the product market competition is less severe. Weak country-level shareholder protection also explains the weak diversification effect to a smaller degree. The difference in the diversification effect between countries with the strongest and the weakest shareholder protection is 2.00%.

[17]We conduct similar calculations using PCM as the proxy for product market competition.

Table 2.6: Product Market Competition and Firm Cash Holdings

The table presents estimates from regressions explaining the relation between product market competition and firm-level cash holdings. The sample consists of non-finanical and non-utility firms from 12 countries for the period from 1998 to 2013. Variable definitions are in Appendix B.1. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	price-cost margin (1)	*Herfindahl-Hirschman Index* (2)	*import penetration* (3)
Q correlation	0.2338***	0.3618***	0.2304***
	(0.000)	(0.000)	(0.005)
CF correlation	-0.0323	-0.3473	0.6059*
	(0.879)	(0.335)	(0.096)
Product market competition	-0.0038***	-0.0388***	0.1493**
	(0.000)	(0.003)	(0.040)
PC * Q correlation	-0.1833*	-0.6772**	-0.1596
	(0.068)	(0.038)	(0.538)
PC * CF correlation	-0.0057	2.8946**	-1.1470
	(0.822)	(0.012)	(0.281)
Q-CF correlation	0.0041*	0.0050**	0.0013
	(0.098)	(0.042)	(0.593)
Number of segments	-0.0001	0.0006	-0.0035
	(0.965)	(0.816)	(0.169)
ln (assets)	-0.0202***	-0.0163***	-0.0247***
	(0.000)	(0.000)	(0.000)
Q volatility	0.0164**	0.0108	0.0287***
	(0.026)	(0.138)	(0.000)
CF volatility	0.0902***	0.0880***	0.1116***
	(0.003)	(0.002)	(0.000)
Firm CF	0.0285***	0.0307***	0.0295***
	(0.000)	(0.000)	(0.000)
Tobin's Q	0.0285***	0.0286***	0.0284***
	(0.000)	(0.000)	(0.000)
Net working capital	-0.0491***	-0.0602***	-0.0495***
	(0.000)	(0.000)	(0.000)
Year F.E.	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes
Adjusted R^2	0.711	0.725	0.712
No. of Observations	78,456	73,581	77,801

2.5 Discussions and Robustness Tests

2.5.1 Endogeneity of Product Market Competition

Firms' cash holdings and product market competition may be endogenous. Facing strong competition firms respond by increasing cash balances. On the other hand, larger cash balances enable firms to take competitive actions against product market rivalries (Fresard, 2010), and further intensify competition. To mitigate this issue, we use a 2SLS approach with instrumental variables. We include the lagged competition and the change in the number of peers in the set of instruments for product market competition. The lagged competition captures the systematic differences in the level of competition in different industries. The change in the number of peers is the number of firms in an industry and country during the current year minus the number in the previous year, and is a proxy for the entry and exit in that industry. It is reasonable to argue that an increase in the number of firms intensifies competition but does not have a direct influence on existing firms' cash policies other than through its association with the level of competition.

Table 7 reports the IV estimates for the effect of our measures of product market competition on firms' cash holdings. The results are consistent with the previous tables. Better diversification in investment opportunities decreases firms' cash holdings. Firms hold more cash when facing stronger product market competition. In column (2), the interaction term between HHI and Q correlation is negative and significant at 5% level. The diversification effect is weaker when the HHI is higher and the product market competition is less intense. Overall, Table 7 suggests that our results are robust to the endogeneity between cash and product market competition.

2.5.2 Channels of The Competition Effect

In this section, we examine two possible channels via which competition affects cash holdings and diversification. We consider the effect of innovation and the uncertainty of firm activities. First, competition drives innovation, and firms use internally generated funds and cash reserves to finance investment in R&D. We expect that the competition effect on cash will be stronger for innovative firms. Secondly, competition increases the uncertainty of firm's growth opportunity and business activities. Either a positive or a negative shock to firm activities will require additional resources. Sanchez and Yurdagul (2013) show that firm's idiosyncratic uncertainty is important in explaining the cross-sectional variations in cash holdings. Therefore, we expect the competition effect on cash to be stronger for firms with higher levels of uncertainty.

First, we examine innovation as a channel of the competition effect on cash. To define innovative firms, we calculate their R&D stock. Assuming a 15% annual depreciation rate (Griliches, 1981), the current year's R&D stock is the current year's R&D expenses plus 85% of previous year's R&D stock. For the first year in sample, the R&D stock is equal

Table 2.7: Product Market Competition and Cash Holdings, Instrumental Variables

The table presents the second stage estimates from 2SLS regressions explaining the relation between product market competition and firm-level cash holdings. The lagged competition and the change in the number of peers are used as instruments. IV estimations include J-statistics (p-values) for overidentification restrictions. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	price-cost margin (1)	*Herfindahl-Hirschman Index* (2)	*import penetration* (3)
Q correlation	0.1469**	0.3961***	0.2450***
	(0.011)	(0.000)	(0.003)
CF correlation	0.1323	-0.0913	0.5952*
	(0.552)	(0.816)	(0.100)
Product market competition	-0.0208***	-0.0423*	0.2435***
	(0.000)	(0.077)	(0.008)
Competition * Q correlation	-0.0394	-0.8100**	-0.1958
	(0.389)	(0.045)	(0.454)
Competition * CF correlation	-0.1385	1.5808	-1.1452
	(0.419)	(0.219)	(0.267)
Q-CF correlation	0.0020	0.0050**	0.0023
	(0.433)	(0.041)	(0.372)
Number of segments	-0.0020	0.0021	-0.0029
	(0.446)	(0.396)	(0.274)
ln (assets)	-0.0250***	-0.0159***	-0.0241***
	(0.000)	(0.000)	(0.000)
Q volatility	0.0215***	0.0074	0.0301***
	(0.006)	(0.307)	(0.000)
CF volatility	0.0790**	0.0730**	0.0971***
	(0.016)	(0.016)	(0.002)
Firm CF	0.0324***	0.0297***	0.0288***
	(0.000)	(0.000)	(0.000)
Tobin's Q	0.0288***	0.0288***	0.0291***
	(0.000)	(0.000)	(0.000)
Net working capital	-0.0572***	-0.0661***	-0.0577***
	(0.000)	(0.000)	(0.000)
Year F.E.	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes
Centered R^2	0.758	0.774	0.763
No. of Observations	74,474	69,249	73,604
J-Statistic (p-value)	0.552	0.469	0.168

to the R&D expense for that year. Firms with R&D stock above the country-industry-year median are considered as innovative.[18] We divide the firms into two subsamples - high R&D firms and low R&D firms - and run the regression specified in equation (2.4) for the two subsamples.

Table 2.8: Effect of Product Market Competition, Subsamples by R&D Stock

The table presents estimates from regressions explaining the relation between product market competition and firm-level cash holdings. High R&D firms are those with R&D stock above the country-industry-year median; low R&D firms are those with R&D stock below the median. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	price-cost margin		*Herfindahl-Hirschman Index*		*import penetration*	
	(1): High R&D	(2): Low R&D	(3): High R&D	(4): Low R&D	(5): High R&D	(6): Low R&D
Q correlation	0.2650***	0.0510	0.4288***	0.0636	0.4302***	0.0790
	(0.000)	(0.421)	(0.001)	(0.539)	(0.001)	(0.442)
CF correlation	0.5545	0.0534	-0.0125	-0.0780	0.5526	0.7538
	(0.106)	(0.847)	(0.984)	(0.874)	(0.376)	(0.104)
Product market competition	-0.0038**	-0.0038***	-0.0085	-0.0168	0.0878	0.1372
	(0.030)	(0.002)	(0.691)	(0.284)	(0.468)	(0.158)
Competition * Q correlation	-0.0016	-0.0329	-0.7910*	-0.0390	-0.6439	0.0519
	(0.974)	(0.302)	(0.053)	(0.923)	(0.135)	(0.865)
Competition * CF correlation	-0.0909	-0.1288	3.4348*	1.4765	0.4541	-2.1267*
	(0.586)	(0.300)	(0.077)	(0.321)	(0.808)	(0.098)
Q-CF correlation	0.0038	0.0001	0.0043	0.0021	0.0041	0.0005
	(0.320)	(0.971)	(0.249)	(0.508)	(0.280)	(0.874)
Number of segments	0.0021	-0.0038	0.0025	-0.0030	0.0021	-0.0042
	(0.547)	(0.231)	(0.484)	(0.318)	(0.543)	(0.201)
ln (assets)	-0.0173***	-0.0308***	-0.0164***	-0.0252***	-0.0172***	-0.0308***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Q volatility	0.0317***	0.0168*	0.0259**	0.0088	0.0324***	0.0190*
	(0.010)	(0.079)	(0.037)	(0.343)	(0.009)	(0.061)
CF volatility	0.2204***	0.0279	0.2094***	0.0347	0.2247***	0.0321
	(0.000)	(0.418)	(0.000)	(0.284)	(0.000)	(0.343)
Firm CF	0.0458***	0.0168**	0.0533***	0.0129*	0.0450***	0.0162**
	(0.000)	(0.011)	(0.000)	(0.095)	(0.000)	(0.015)
Tobin's Q	0.0238***	0.0328***	0.0226***	0.0351***	0.0239***	0.0328***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Net working capital	-0.1039***	-0.0281***	-0.1090***	-0.0432***	-0.1034***	-0.0289***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.781	0.657	0.777	0.683	0.781	0.657
No. of Observations	30,730	47,336	29,687	43,565	30,649	46,762

Tables 8 reports the estimation results. In columns (3) and (4) the coefficient of the interaction term between HHI and Q diversification is negative. It is significant for the high R&D subsample, but insignificant for the low R&D subsample. Product market competition strengthens the effect of the diversification in investment opportunities on cash for the high R&D firms, but does not have a significant impact for the low R&D firms.

[18]For the purpose of dividing subsamples, we group diversified firms by their primary SIC.

Then we examine growth uncertainty as another channel of the competition effect. We use sales growth volatility to measure the uncertainty in firm activities and divide firms into two subsamples: high volatility firms and low volatility firms. We run the regression specified in equation (2.4) for the two subsamples. Table 9 reports the results. Product market competition strengthens the effect of Q correlation for high volatility firms, but not for low volatility firms. In columns (3) and (4), the coefficient of the interaction term between HHI and Q diversification is negative and significant for the high volatility firms, and insignificant the low volatility firms.

Table 2.9: Effect of Product Market Competition, Subsamples by Sales Growth Volatility

The table presents estimates from regressions explaining the relation between product market competition and firm-level cash holdings. High-vol firms are those with sales growth volatility above the country-industry-year median; low-vol firms are those below the median. Standard errors are robust and clustered by firm; p-values are included in brackets. Significance at the 1%, 5%, and 10% levels is represented by ***, **, and *, respectively.

	price-cost margin		*Herfindahl-Hirschman Index*		*import penetration*	
	(1): High vol	(2): Low vol	(3): High vol	(4): Low vol	(5): High vol	(6): Low vol
Q correlation	0.1200	-0.0231	0.3550**	0.0736	0.2444*	0.0752
	(0.230)	(0.651)	(0.041)	(0.448)	(0.077)	(0.469)
CF correlation	0.1751	0.3487	1.1094*	-0.2115	0.7576*	-0.2238
	(0.547)	(0.197)	(0.054)	(0.689)	(0.070)	(0.691)
Product market competition	-0.0018	-0.0012	-0.0721***	-0.0296	0.1816*	0.1020
	(0.247)	(0.428)	(0.000)	(0.141)	(0.082)	(0.517)
Competition * Q correlation	-0.0034	0.0555	-1.2847**	-0.6529	-0.3668	-0.6039
	(0.925)	(0.213)	(0.043)	(0.130)	(0.462)	(0.198)
Competition * CF correlation	-0.2308	-0.0007	-2.6073	2.9620	-1.6798	2.7769
	(0.152)	(0.997)	(0.286)	(0.116)	(0.227)	(0.203)
Q-CF correlation	-0.0027	0.0175***	0.0225***	0.0180***	-0.0012	0.0177***
	(0.591)	(0.000)	(0.000)	(0.000)	(0.722)	(0.000)
Number of segments	0.0035	-0.0068**	-0.0021	-0.0066**	0.0030	-0.0066**
	(0.404)	(0.014)	(0.400)	(0.016)	(0.329)	(0.018)
ln (assets)	-0.0277***	-0.0063	-0.0208***	-0.0067	-0.0283***	-0.0064
	(0.000)	(0.149)	(0.000)	(0.124)	(0.000)	(0.146)
Q volatility	-0.0091	0.0335***	0.0636***	0.0322***	-0.0005	0.0325***
	(0.549)	(0.007)	(0.000)	(0.009)	(0.960)	(0.008)
CF volatility	0.0949*	0.0758*	-0.0976**	0.0791**	0.0841**	0.0781*
	(0.076)	(0.061)	(0.024)	(0.050)	(0.020)	(0.052)
Firm CF	0.0333***	0.0678***	-0.0918***	0.0673***	0.0322***	0.0670***
	(0.002)	(0.003)	(0.000)	(0.004)	(0.001)	(0.004)
Tobin's Q	0.0281***	0.0214***	0.0865***	0.0217***	0.0278***	0.0213***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Net working capital	-0.1160***	-0.2108***	-0.0935***	-0.2117***	-0.1249***	-0.2106***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Firm F.E	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.796	0.797	0.800	0.798	0.796	0.797
No. of Observations	18,072	19,645	18,018	19,644	17,962	19,619

2.5.3 Alternative Variable Specifications

For robustness checks, we use alternative variables specifications to measure innovation and firm-level uncertainty. We use R&D expenses and R&D dummy instead of R&D stock. R&D dummy is 1 for firms with non-zero R&D expenses during the sample period, and 0 for firms with zero or missing R&D expenses. For the uncertainty in firm activities, we use firm-level cash flow volatility and productivity growth volatility (Sanchez and Yurdagul, 2013) instead of sales growth volatility. The firm-level cash flow volatility is the standard deviation of cash flows (over total assets) over the past 10 years, with at least 5 non missing values in the 10-year period. The productivity growth volatility for a given year is the standard deviation of the productivity growth over the past 10 years. To estimate productivity growth we first calculate a firm's capital stock from capital expenditures, assuming an 8% annual depreciation rate. For the first year in sample, the capital stock is equal to the capital expenditure for that year. Then we regress the firm's operating income on capital stock and calculate the fitted errors. This is a rolling regression with one additional observation added each year. The productivity growth in year t is then the year t error minus the year $t-1$ error.

We also consider alternative methods to split the sample firms. Instead of comparing firms above and below the medians, we divide subsamples by terciles and compare firms in the top and the bottom terciles. The results from these tests are not included in the tables. Overall, the results are qualitatively consistent with those presented in the paper.

2.6 Conclusions

This paper provides international evidence on the interaction between corporate liquidity, diversification and product market competition. Previous studies have documented a negative diversification effect on corporate cash holdings. Our results show that this negative effect continues to hold for international firms, albeit to a much smaller extent. This difference is not driven by the inclusion of international firms in our sample or by the degree of precautionary motives for holding cash. We search for an explanation for the weaker diversification effect.

We examine the impact of agency costs, financial constraints and product market competition on the diversification effect on cash. Our results suggest that product market competition is the most important driver of this result. Weak product market competition (high HHI) can weaken or even reverse the diversification effect on cash. In addition, weak country-level shareholder protection also helps explain the weak diversification effect. Financial constraints strengthen the impact of diversification on cash holdings. This is consistent with Duchin (2010), but does not explain the weak diversification effect in our sample.

Finally, we provide evidence supporting two channels via which product market competition affects the diversification effect on cash. The competition effect is statistically and economically larger for high R&D intensity firms and for high uncertainty firms. Product market competition plays a key role in determining corporate cash policies because competition drives innovation and R&D investment that is financed by internal funds, and increases the uncertainty in firms' activities.

Chapter 3

Deposit Insurance Design and Credit Union Risk

3.1 Introduction

The popularity of deposit insurance among regulators and policy makers around the world is based on the widely held view that it increases the stability of the financial system. As of October 31, 2014, 113 countries had an explicit deposit insurance program in place, while 40 other countries were either in the process of its implementation or had some form of implicit guarantees.[1] In addition, as a response to the financial crisis of 2007-08, many countries such as Germany, Italy, and the U.S. added government guarantees to certain types of deposits in order to ensure depositors' confidence in the face of unstable market conditions. Even for countries without explicit deposit insurance, governments are likely to face extreme political pressure to act as guarantors when a widespread crisis occurs and the financial system is destabilized. Demirguc-Kunt, Kane, and Laeven (2008) argue that every country offers implicit deposit insurance, no matter how strongly its top officials may deny it.[2]

In this paper, we examine the impact of deposit insurance design on the risk of financial institutions in the context of Canadian credit unions. Credit unions in Canada are provincially regulated cooperatives with deposit guarantee varying by province and type of deposit. We use a sample of 107 credit unions incorporated in British Columbia for the period April 1992 to December 2014. In particular, we analyze the effect of a policy amendment introduced in November 2008 to offer protection to depositors in response to

[1] International Association of Deposit Insurers (IADI) `http://www.iadi.org/di.aspx?id=67`.

[2] Any private insurance fund faces the risk of a run on its liquid assets. In times of financial instability, depositors may lose their trust in the credibility of the insurance fund's promise to cover deposits. Government guarantees can help restore depositors' confidence and prevent panic-based deposit runs. Government guarantees introduced after the financial crises are still in effect in Germany, Italy and the U.S. In many other G10 countries, they were used only as a temporary measure and were left to expire by the end of 2013. Examples include Australia, Denmark, and Singapore.

Table 3.1: Deposit Insurance Coverage in G10 Countries

The table outlines explicit deposit insurance programs in G10 countries for banks or deposit-taking institutions in general. The information is extracted from Demirguc-Kunt et al. (2014), and is up to date as of 2013. D (ND) indicates that the deposit insurance program for cooperatives is (not) different from that for the rest of the financial system.

Country	Statutory coverage	Change since 2008: Increased coverage	Change since 2008: Government guarantee	Cooperatives
Belgium	EUR 100,000	y		ND
Canada	CAD 100,000			D
France	EUR 100,000	y		ND
Germany	EUR 100,000	y	y	D
Italy	EUR 100,000		y	D
Japan	JPY 10,000,000			D
Netherlands	EUR 100,000	y		ND
Sweden	EUR 100,000	y		ND
Switzerland	CHF 100,000	y		ND
United Kingdom	GBP 85,000	y		ND
United States	USD 250,000	y	y	D

the financial crisis.[3] The amendment introduced two changes. First, the maximum deposit coverage was increased from \$100,000 to unlimited for all eligible deposits.[4] Second, the insurance premium levied was changed from a flat rate to a charge based on the institution's risk ratings.[5]

The main argument for deposit insurance is depositor protection, i.e. minimizing the probability of bank runs and financial contagion. In addition, an explicit deposit insurance regulation can reduce the political pressure to bail out failed financial institutions (see Mortlock and Widdowson, 2005). Deposit insurance, however, is criticized because it can reduce depositors' monitoring and disciplining incentives, potentially allowing banks to engage in excessive risk-taking. Whether deposit insurance reduces the probability of bank runs is theoretically ambiguous. In a seminal paper, Diamond and Dybvig (1983) present a model where banks make long term loans funded with demand deposits. In a "good" equilibrium, only depositors who experienced a liquidity shock withdraw funds. In a "bad" equilibrium, however, there is a run on the bank. The authors show that deposit insurance

[3] There is evidence that credit unions were facing funding constraints during the 2007-2008 financial crisis. In 2007, net borrowing from the Central 1 (the enitity acting as a clearing house and depositor/lender of excess/insufficient liquidity), increased 1.21 times compared to 2006 and 3.14 times compared to 2005.

[4] This put B.C. on par with Alberta. Deposit insurance limits to a maximum of \$100,000 in Ontario, and \$250,000 in Quebec.

[5] The credit union ratings are assigned by the regulator based on site visits and supervisory examination.

rules out the bad equilibrium, because depositors no longer fear losing their money. Deposit insurance, however, can decrease the incentives for depositors to monitor and discipline banks. Previous studies (for example, Demirguc-Kunt and Detragiache, 2002, Wagster, 2007, and Anginer et al., 2014) provide evidence for an increase in the risk-taking activities of financial institutions after the introduction of deposit insurance. Acharya and Mora (2012) examine deposit flows for banks prior to their failure. Even though overall deposits declined, the failing banks were able to increase insured deposits. The authors conclude that such an increase in insured deposit flows provides evidence that deposit guarantees weaken depositor incentive to monitor.

The empirical evidence on the impact of deposit insurance is mixed and varies across jurisdictions, over time, and with the specific design of the insurance scheme. Demirguc-Kunt and Detragiache (2002), for example, examine the effect of deposit insurance in 60 countries and conclude that explicit deposit insurance decreases bank stability, and that the effects are stronger in countries with a weak institutional environment. Other papers have argued that deposit insurance does not necessarily lead to an increase in risk-taking behavior. Anginer et al. (2014) provide evidence that introducing deposit insurance leads to an increase in risk-taking activities during "normal" times but it had a strong "stabilization" effect during the recent financial crisis. Allen et al. (2011) provides several solutions to mitigate the distortions introduced by deposit insurance, such as risk-based insurance pricing, strong regulatory environment, and co-insurance mechanisms.

There are several different channels through which changes in deposit insurance scheme could affect the earnings uncertainty of financial institutions such as credit unions. First, the unlimited deposit coverage may strengthen depositors' confidence and reduce the probability of panic-based withdrawals. Second, the change from a flat to a risk-based insurance premium may provide incentives for credit unions to adjust their risk management practices and optimize the level of risk-taking. In contrast, fully insured depositors may lack the incentives to monitor and discipline credit unions so that these institutions end up taking greater risks and/or investing less resources in improving operational efficiency. Finally, the increase in coverage to unlimited may attract new flow of funds predominantly from the wholesale market. These wholesale deposits may create addition liquidity risk for credit unions if there are large withdrawals in the future. In addition, the new deposit inflows can be used to fund income-earning loan assets but excessive loan asset growth may lead to deteriorating asset quality, and therefore to higher losses in the long run (see Hess et al., 2009, Foos et al., 2010, and Amador et al., 2013).

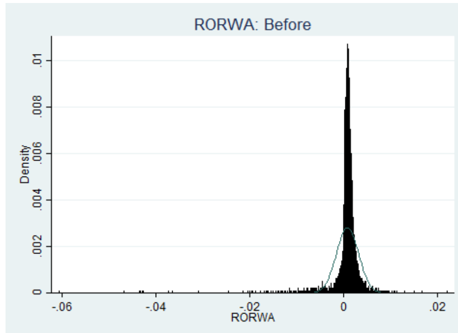
We follow Kuritzkes and Schuermann (2008) and convert credit union earnings into a return-based measure by dividing (pre-tax) net income by risk-weighted assets.[6] We call

[6]Credit unions calcucate the risk-weighted assets according to the regulator's Capital Adequacy Return Completion Guide using Basel I risk weights.

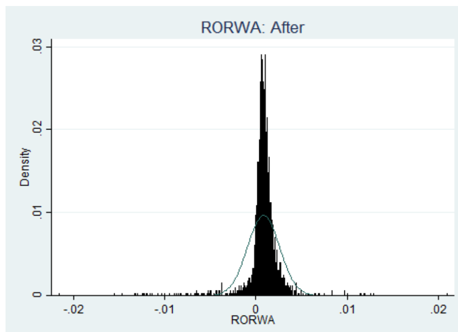
this the return on risk-weighted assets or $RORWA$. Figure 1 represents the empirical distribution of $RORWA$ at the 99% confidence level before (Panel A) and after the policy change (Panel B), and Figure 2 shows the conditional volatility of $RORWA$ before and after the change. The figures illustrate the main point of our paper in a simple way. Following the sharp increase in volatility during the 2007-08 financial crisis, there was a general trend of a decrease in credit union portfolio risk after the policy change to levels lower than the pre-policy and pre-crisis time period. Our formal analysis shows that the extreme loss (the left tail of the empirical distribution of $RORWA$) after the policy change was smaller than pre-policy period at conventional significance levels. Similarly, our regression results show that, following the change in the deposit insurance scheme, there was a decrease in credit unions' earnings uncertainty for all our measures of risk-taking. The effect of the policy change on earnings uncertainty of the credit unions in our sample is economically large and statistically significant, e.g. there was a 0.06% decrease in the annualized conditional volatility of $RORWA$ after the introduction of the policy amendment which is large relative to the average volatility of 2.99%. Ideally, we would like to carry out a DID estimation, matching credit unions in the province of British Columbia to similar credit unions headquartered in a province such as Ontario where the deposit insurance remained unchanged. Unfortunately Canadian credit union data are not publicly available. Instead, we use publicly available data on Canadian commercial banks. Our regression results show that Canadian banks did not experience a decrease in their earnings risk during the time period from the policy change to the end of our sample. Consistent with the hypothesis that stronger deposit insurance provisions increase depositors confidence, we find that following the policy change, there was a stronger deposit and loan growth as well as an increase in capital-to-asset ratio for credit unions relative to Canadian banks. We show that the effect of the policy change was stronger for smaller, less levered credit unions as well as for those with fewer members and smaller market share.

Financial cooperatives differ from commercial banks in several important ways. First, commercial banks are owned by shareholders, who have voting rights based on the class and fraction of shares they hold. Cooperatives, on the other hand, are owned by their members, depositors and borrowers, who have equal voting rights with one-member-one-vote priciple. Financial cooperatives, unlike commercial banks, often focus on different objectives and scope of operations and are motivated by solidarity ideals. They are non-profit, operate in localized areas and provide services mostly to individuals and small businesses. They distribute earnings to their members in the forms of higher interest on deposits, lower interest on loans, as well as directly through cash dividends. In contrast, commercial banks are for-profit entities. They are larger in size, have wider geographic reach and provide

Figure 3.1: Distribution of Return on Risk-Weighted Assets



(a) $RORWA$ distribution before the policy change



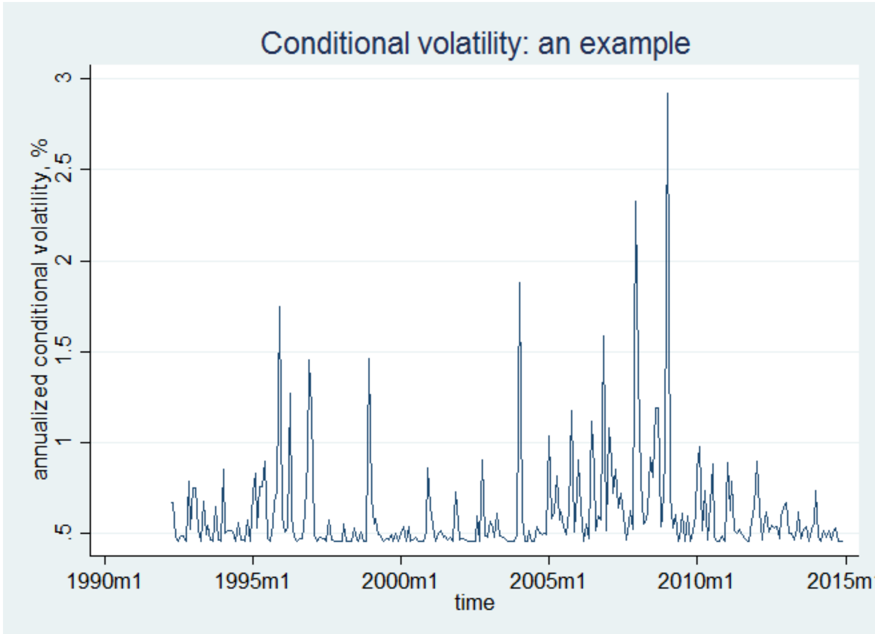
(b) $RORWA$ distribution after the policy change

services to large corporations as well as individuals and small businesses.[7] However, credit unions have specific characteristics that make them highly complementary to the banking sector. For example, credit unions are more efficient than banks in assessing borrowers' creditworthiness, because the members know each other fairly well due to "a common bond" (usually occupational, community or other associational bond) and can impose sanctions on delinquent payers. Unfortunately, evidence suggests that in general members are unable to control and discipline credit unions. The one-member-one-vote rule means that the incentive and ability of members to generate sufficient voting power is limited. As a result, members' attendance to vote in board elections or other key decisions is low (Hillier et al., 2008). This lack of supervisory power and depositors discipline exacerbate the moral hazrd problem and increases the probability of credit union run in the event of members' loss of confidence (Hessou and Lai, 2016).

Canadian commercial banks are federally regulated by the Office of the Superintendent of Financial Institutions (OSFI) with the Canada Deposit Insurance Corporation (CDIC) providing deposit insurance for eligible bank deposits up to a maximum of $100,000 per

[7] The assets of Royal Bank of Canada, the largest Canadian bank, are almost five times the assets of Desjardins, the largest federation of credit unions in Canada.

Figure 3.2: Conditional Volatility of Return on Risk-Weighted Assets



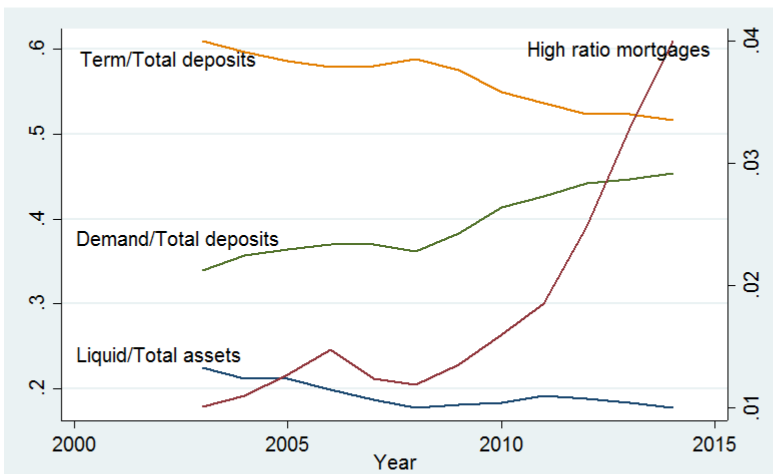
depositor per insured category. Canadian credit unions, on the other hand, are subject to provincial regulations where each province implements its own deposit insurance program. In BC, the Financial Institutions Act and the Credit Union Incorporation Act govern how these institutions are formed and operate. The Acts require a credit union to maintain adequate liquid assets and an adequate capital base in relation to its business. The Financial Institutions Commission (FICOM) regulates BC credit unions. A credit union needs to have deposits, including accrued interest, in the Credit Union Central of BC that are at least equal to 8% of its deposit and other debt liabilities. This reserve ratio remains unchanged since the beginning of 2006. A credit union is also required to have a capital base that is at least 8% of its risk-weighted assets before any prescribed operational restrictions. In addition, FICOM set a supervisory capital target of 10%, which became effective in March 2013.[8]

Cooperative financial institutions are an important part of the financial system. They are the main alternative to commercial banks in providing financial services to consumers and small businesses. Credit unions fund 12.5% of the residential mortgages in Canada (see Crawford et al., 2013). Moore (2014) reports that the market shares of credit unions vary across provinces, from 4% in Ontario to over 30% in Quebec. The traditional business model

[8]For Liquidity Requirement Regulation, see `http://www.bclaws.ca/civix/document/id/loo93/loo93/332_90#section5`. For Capital Requirements Regulation, see `http://www.bclaws.ca/civix/document/id/loo88/loo88/315_90#section2`. For FICOM's supervisory target, see `http://www.fic.gov.bc.ca/index.aspx?p=fid/guidelines#cu`.

of credit unions is based on the net interest margin between loan assets and deposit fundings. The decrease in the interest margin over the last ten years has resulted in credit unions adjusting their balance sheet structure to increase interest earnings and reduce funding costs. Figure 3 shows that over the last ten years, BC credit unions have reduced their holdings of liquid assets, and have increased the proportion of high-ratio mortgages in their portfolios. In terms of funding sources, the credit unions increased the use of demand deposits while decreased their reliance on term deposits. The credit unions have also sought economy of scale through mergers and acquisitions. There were over 60 consolidations among the credit unions between 1992 and 2014, of which over 40 took place between 1999 and 2005. 10% of the mergers were between credit unions of similar sizes, i.e. the target's total assets were over 60% of the assets of the acquirer. In 85% of the mergers, a smaller credit union was aquired by another much larger credit union, i.e. a credit union that had more than twice its level of total assets.

Figure 3.3: Assets and Liabilities



The literature on risk-taking of financial institutions focuses primarily on commercial banks and devotes little attention to financial cooperatives. According to Hesse and Cihak (2007), only 0.1% of published research on financial institutions relates to cooperative banking. The paper closest to ours is Karels and McClatchey (1999) who show that U.S. credit unions do not increase risk-taking behavior after the adoption of deposit insurance.Our paper complements the existing literature by examining the impact of deposit insurance on the earnings uncertainty of credit unions. Currently, there are discussions on regulatory reform to break provincial borders and bring Canadian credit unions under the federal charter. The implementation of such policies may lead to drastic shifts in the regulatory environment of credit unions. Our paper contributes to these discussions and sheds light on how a change in deposit insurance may affect these institutions.

The remainder of this paper is organized as follows. Section 2 describes the sample data and presents some summary statistics. Section 3 discusses the methodology we use in the study. The results are discussed in Section 4. Finally, Section 5 concludes the paper and suggests possible opportunities for future research.

3.2 Data and Summary Statistics

Our sample contains proprietary financial information for 107 Canadian credit unions, incorporated in the province of British Columbia, for the period April 1992 to December 2014. The data include information from the monthly financial reports, including balance sheets and income statements as well as other statistics such as the amount of loans in arrears, unfunded loans and the number of depositor-members. Several data items are reported quarterly, e.g. variable- and fixed-rate assets and liabilities. The final sample consists of 18,682 credit union-month observations. We also collect similar financial reporting data for Canadian banks, as well as the daily stock returns.[9] There is no variable representing the membership for banks. To measure bank's corporate governance, we use a corporate governance index produced by The Globe and Mail.

Table 2 presents summary statistics for the credit unions in our sample.[10] The table shows that the credit unions in our sample are both small and have fairly low level of risk. The average (median) credit union has CAD$477.50 ($95.97) million in total assets. However, there is a wide variation in size with the bottom decile of credit union size of only CAD$12.29 million and the top decile of CAD$990.16 million. The average (median) credit union holds 20.30% (17.39%) of its total assets in cash or other liquid assets (*Liquid assets*), and 76.80% (79.48%) in loan assets (*Net loans*). Residential mortgages are the main category of loan assets for credit unions, representing 70.5% of all loan assets. A loan with a loan-to-value ratio above 75% is considered a high ratio loan. Most of the high ratio mortgages are insured. The uninsured high-ratio loans are on average 2.34% of total residential mortgages, or 1.32% of total assets. For the average (median) credit union, nonperforming loans, i.e. loans that are at least 30 days past due and are not yet written off as assets, are 0.98% (0.73%) of total assets. On the liability side, the average credit union holds CAD$425.37 million in deposits, 33.93% of which are demand deposits (*Demand deposits*). *Gap ratio* measures the balance sheet mismatch. For variable-rate assets and liabilities, the mean (median) gap ratio is 48.27% (46.08%). For fixed-rate assets and liabilities with 4-6 months to maturity, the mean (median) gap ratio is 40.57% (40.04%). The average (median) capital-to-asset ratio is 5.71% (5.55%).

In Panel C of Table 2, the average monthly net income is $0.188 million. Non-interest income is 12.22% of total net income. The annualized mean (median) monthly return on risk-weighted assets is 0.88% (1.09%) and the annualized volatility of the return on risk-

[9]The data for banks is quarterly from 1997 to 2014.

[10]The variable definitions are in Appendix C.1.

Table 3.2: Summary Statistics

The table presents summary statistics for our sample, an unbalanced panel of 107 credit unions from 1992 to 2014. Panel A and B include balance sheet characteristics of the credit unions. Panel C presents measures of income and the return on risk-weighted assets. Panel D presents the proxies for credit union's importance and governance scores. The variable definitions are in Appendix C.1.

	Mean	Median	Std Dev	1 pctl	99 pctl
Panel A: Assets					
Total assets ($millions)	477.50	95.97	1,547.00	0.36	9,485.34
Liquid assets	20.30%	17.39%	10.39%	8.32%	57.38%
Net loans	76.80%	79.48%	10.24%	40.89%	89.73%
High-ratio mortgages	1.32%	0.13%	2.85%	0.00%	14.94%
Nonperforming loans	0.98%	0.73%	0.95%	0.00%	4.46%
Panel B: Liabilities and capital ratio					
Total deposits ($millions)	425.37	89.48	1,349.48	0.34	8,371.78
Demand deposits	33.93%	33.35%	13.32%	0.00%	69.15%
Gap ratio: variable rate	48.27%	46.08%	29.91%	0.94%	100.00%
Gap ratio: fixed rate 4 - 6 months	40.57%	40.04%	23.28%	0.83%	90.25%
Capital-to-asset ratio	5.71%	5.55%	1.57%	2.68%	11.36%
Panel C: Incomes and returns					
Net income, monthly ($millions)	0.188	0.032	0.969	-0.420	3.936
Non-interest income	12.22%	12.63%	37.46%	-0.01%	34.52%
Return on risk-weighted assets	0.88%	1.09%	8.93%	-10.94%	6.96%
Volatility of RORWA, annualized	2.99%	0.64%	20.28%	0.18%	13.01%
Panel D: Governance indicators					
Membership	22,329	7,381	56,356	246	372,613
Market share	1.46%	0.38%	3.78%	0.00%	23.35%
Score on senior management	3.058	3.000	0.589	2.000	4.000
Score on board oversight	2.785	3.000	0.502	1.000	4.000

weighted assets over the sample period has an average of 2.99%. In Panel D, the average credit union has 22,329 members, and 1.46% of the market share in terms of deposits. The scores on senior management and board oversight are ratings assigned to the credit unions by the regulators based on site visits and supervisory examinations. The highest score is 4; the lowest is 1. The average score is 3.058 for senior management, and 2.785 for board oversight.

3.3 Research Design

As discussed in the previous section, we use the return on risk-weighted assets $RORWA_{i,t} = \frac{NI_{i,t}}{RWA_{i,t}}$ as a measure of credit union i's earnings during time period t. NI is net income and RWA is the dollar value of the risk-weighted assets. We begin with a Value-at-Risk analysis and compare the left tail of the empirical distribution of $RORWA$ before and after the policy change. Then, we estimate linear regression models of measure of ex-post earnings uncertainty to examine the effect of the change in deposit insurance on credit union risk-taking. We estimate the following model:

$$Risk_{i,t} = \alpha_i + \beta \times DI_t + \gamma \times Control\ variables_{i,t} + \theta \times Year_t + \epsilon_{i,t} \tag{3.1}$$

We use two measures for $Risk$. The first measure is the conditional volatility of $RORWA$ derived from a GARCH(1,1) model. The second measure is the realized volatility of $RORWA$ estimated using a 3-year rolling window.[11] DI is a dummy variable that equals one for time periods after the change in the deposit insurance program and 0 otherwise. A positive β indicates that on average the change is associated with higher earnings uncertainty whereas a negative β indicates that the change is associated with lower uncertainty. $Control\ variables$ include credit union size (measured as the logarithm of total assets), liquid assets as a fraction of total assets, and net loans-to-asset ratio as a measure of credit unions' asset-liability structure (see Efing et al., 2015 for details). Additional control variables that capture size and governance are membership measured as the logarithm of the number of depositor-members, market share of total deposits, and the governance scores on senior management and board oversight. Equation (3.1) also controls for credit union and year fixed effects.

Next, we examine the possible channels through which the change in deposit insurance may have affected credit unions' earnings uncertainty. We hypothesize four channels: (1) depositor confidence: the increase in insurance coverage increases depositors' confidence and therefore prevents panic-driven deposit withdrawals; (2) risk-based premium: the risk-based insurance premiums may discourage excessive risk-taking; (3) moral hazard: in the

[11] We scale both the conditional and the realized volatility so that we can compare coefficients across regression specifications. Both the conditional and the realized volatility are estimated from monthly returns. In the regressions, they are annualized and are scaled by 100.

absence of incentives, depositor-shareholders may be unwilling to monitor and discipline credit unions, and as a result increase risk-taking and/or decrease operating efficiency; (4) new deposit influx: a surge of new funds into the credit union system may create additional liquidity risk.

To examine the effect of these channels, we first compare the deposit and loan growth as well as the loan quality for the sample of credit unions versus a sample of Canadian commercial banks for the period before and after the deposit insurance policy change. Note that the deposit insurance policy change did not affect Canadian commercial banks. Then, we examine the effect of the policy change on alternative measures of ex-ante risk-taking as the dependent variable in equation (3.1). In particular, we use the proportion of non-interest to total income, the proportion of high-ratio to total mortgages, and the capital-to-asset ratio.

We also examine how the effect of the change in deposit insurance program varies across different financial cooperatives. First, we test whether the policy change had a different effect on large versus small credit unions. Previous studies have shown that, in the context of banks, size matters in terms of the effect of financial regulations on these institutions. We argue that large institutions have better access to resources and are more resilient to changes in the economic and regulatory environment. Also, the deposit insurance is more likely to improve depositors' confidence for smaller credit unions. As a result, the change would have a stronger effect for smaller institutions. However, from a market discipline point of view, larger institutions are monitored closely by the regulators, whose monitoring efforts would not change after the policy is implemented. This, to some degree, mitigates the moral hazard issues associated with deposit insurance. We estimate the following model:

$$Risk_{i,t} = \alpha_i + \beta \times DI_t + \delta \times DI_t \times SMALL_{i,t} + \gamma \times Control\ variables_{i,t} + \theta \times Year_t + \epsilon_{i,t} \quad (3.2)$$

where $SMALL$ equals to 1 if the size (logarithm of total assets) of a credit union is below the sample median during a 3-year period before the policy change, and 0 otherwise. The rest of the variables are the same as in equation (3.1).

We examine whether credit unions with higher leverage reacted differently to the changes in the deposit insurance program. Le (2013) shows that after the introduction of deposit insurance, an increase in leverage drives an increase in risk-taking for banks. However, the banks that were highly levered before the deposit insurance adoption did not respond to the policy change. Highly levered institutions may not be able to further increase leverage (risk-taking), because regulators often monitor these financial institutions' capitalization very closely. However, new depositors/investors may still prefer well-capitalized credit unions even though their deposits are fully covered by the deposit insurance program. We estimate the following model:

$$Risk_{i,t} = \alpha_i + \beta \times DI_t + \delta \times DI_t \times LOWLEV_{i,t} + \gamma \times Control\ variables_{i,t} + \theta \times Year_t + \epsilon_{i,t} \tag{3.3}$$

where $LOWLEV$ equals to 1 if the leverage ratio of a credit union is below the sample median during a 3-year period before the policy change, and 0 otherwise.[12] The rest of the variables are the same as in equation (3.1).

Finally, we examine whether credit unions' response to the policy change depends on their relative importance. Governments are often under pressure to bail out large financial institutions. The explicit deposit insurance should have a smaller effect for these credit unions. We use membership and market share in terms of deposits as two proxies of the importance of credit unions. The failure of a credit union will affect more people if it has a large member base. Similarly, a larger dollar amount deposits will be affected if a credit union with a larger share of the deposit market fails. To examine the impact of such importance on credit unions' response to the policy change, we augment equation (3.1) to include the interaction term between DI and membership or market share.

$$Risk_{i,t} = \alpha_i + \beta \times DI_t + \delta \times DI_t \times IMPORTANCE_{i,t} + \gamma \times Control\ variables_{i,t} + \theta \times Year_t + \epsilon_{i,t} \tag{3.4}$$

where $IMPORTANCE$ is either the (logarithm of) number of depositor-members or the market share of the credit union. The rest of the variables are the same as in equation (3.1).

3.4 Estimation Results

3.4.1 Baseline Model: The Overall Effect of The Policy Change

Table 3 presents the left tail of the empirical distribution of the mean-adjusted return on risk-weighted assets, $RORWA$. Panel A includes all credit unions whereas Panel B only includes the credit unions remaining active after the change in the deposit insurance program.[13]

In Panel A, the 99 percentile of $RORWA$ for the full sample is -0.98%, i.e. 99% of the time, the monthly earnings did not fall below 0.98% of the average earning. The value is -1.02% for the time period before the change, and -0.69% after the change. The table shows that (for conventional confidence levels) $RORWA$ quantiles for the time period after the change are much larger than the values for the time period before the policy change. In

[12] The leverage ratio is calculated as $1 - \frac{capital}{assets}$. For robustness check, we use risk-weighted assets in place of total assets and exclude other liabilities in the calculation. The results remain the same.

[13] Due to a sharp decline in the number of credit unions in recent years, we re-estimate all models with a balanced sample to control for possible attrition bias. The results remain the same.

Table 3.3: Left Tail of the Mean-Adjusted Return On Risk-Weighted Assets

The table presents the quantiles representing extreme losses from the empirical distribution of the mean-adjusted return on risk-weighted assets. The values are drawn for three time periods. The *full* period is from April 1992 to December 2014. The period *before* the change in deposit insurance is from April 1992 to October 2008. The period *after* the change is from November 2008 to December 2014. In Panel A, returns from all credit unions are included to construct the distribution. Panel B uses a subsample of credit unions that remain active after October 2008.

	Full	Before	After
Panel A: All credit unions			
Number of observations	18,575	15,271	3,304
Confidence level			
99%	-0.98%	-1.02%	-0.69%
99.5%	-1.40%	-1.56%	-1.06%
99.9%	-4.33%	-4.41%	-1.49%
Panel B: Subsample of credit unions			
Number of observations	12,808	9,504	3,304
Confidence level			
99%	-0.82%	-0.84%	-0.69%
99.5%	-1.18%	-1.21%	-1.06%
99.9%	-2.23%	-2.53%	-1.49%

Panel B, the extreme loss after the change at each confidence level is again smaller than that before the change, although the difference between the two periods is smaller.

Table 4 presents the results from the estimation of equation (3.1). All specifications are estimated with credit union and year fixed effects and robust standard errors. In Panel A, the dependent variable is the annualized conditional volatility of $RORWA$ derived from a GARCH(1,1). The coefficients for DI are negative and significant for all regression specifications. In column (5) (the complete specification) the policy change is associated with 0.0583% decrease in the annualized conditional volatility of $RORWA$. The coefficients are consistent across different specifications. In Panel B, the dependent variable is the realized volatility of $RORWA$ calculated as the annualized standard deviation of monthly returns using a three-year rolling window. The results are consistent with those in Panel A.

Table 3.4: Deposit Insurance and Credit Union Risk

The table presents the results from the estimation of regression equation (1). In Panel A, the dependent variable is the conditional volatility of the return on risk-weighted assets ($RORWA$) estimated from a GARCH(1,1) model. In Panel B, the dependent variable is the realized volatility of $RORWA$ calculated using a 3-year rolling window. DI is a dummy variable that equals to 1 for time periods after the change in deposit insurance and 0 otherwise. The rest of the variables are defined in Appendix C.1. P-values are reported in brackets. All regressions are estimated with credit union fixed effects, year fixed effects and robust standard errors. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

Panel A: Conditional volatility of $RORWA$					
	(1)	(2)	(3)	(4)	(5)
DI	-0.0553***	-0.0539***	-0.0553***	-0.0564***	-0.0583***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size		0.0450	0.0986*	0.1025***	0.1563**
		(0.185)	(0.096)	(0.005)	(0.037)
Liquid assets		1.8435*	1.6209	2.7429**	2.5431**
		(0.081)	(0.116)	(0.026)	(0.035)
Net loans		1.9464*	1.7340*	3.0952**	2.8907**
		(0.069)	(0.097)	(0.012)	(0.015)
Membership			-0.0850		-0.0424
			(0.218)		(0.653)
Market share			-1.1874		-3.0256***
			(0.103)		(0.001)
Governance score: management				-0.0570***	-0.0476**
				(0.001)	(0.036)
Governance score: board				-0.0230	-0.0278
				(0.299)	(0.255)
Credit union F.E.	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes
Number of observations	12,091	12,091	12,091	8,691	8,691
Adjusted R^2	0.450	0.450	0.450	0.362	0.362

Panel B: Realized volatility of $RORWA$					
	(1)	(2)	(3)	(4)	(5)
DI	-0.0016***	-0.0078***	-0.0084**	-0.0040*	-0.0024
	(0.000)	(0.003)	(0.012)	(0.054)	(0.380)
Size		0.0461	0.0700	-0.0545*	-0.1217
		(0.163)	(0.425)	(0.068)	(0.153)
Liquid assets		-0.8228	-0.8265	-0.5179	-0.4919
		(0.354)	(0.360)	(0.449)	(0.484)
Net loans/assets		-1.4837	-1.4844	-1.0587	-1.0387
		(0.131)	(0.135)	(0.168)	(0.182)
Membership			-0.0275		0.0861
			(0.822)		(0.495)
Market share			-0.2275		0.2182
			(0.733)		(0.769)
Governance score: management				-0.1139**	-0.1214**
				(0.024)	(0.013)
Governance score: board				0.0791***	0.0829***
				(0.007)	(0.003)
Credit union F.E.	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes
Number of observations	14,947	14,947	14,947	11,344	11,344
Adjusted R^2	0.680	0.683	0.683	0.563	0.563

Next, we run the regression in equation (3.1) for the sample of Canadian banks instead of the credit unions. All the variables are the same as defined for the credit unions, except that there is no variable representing the membership for banks and a corporate governance index produced by The Globe and Mail is used as the governance measure. The dependent variable is the conditional volatility of daily stock returns estimated from a GARCH(1,1).[14] Table 5 presents the estimation results. The coefficient of the DI dummy is statistically insignificant. This is as expected. It suggests that the change in deposit insurance design has an effect on credit unions above the existing policy, and does not affect the banks that are under a different federal deposit insurance regime.

3.4.2 Deposit Insurance Effect: Channels and Credit Union Characteristics

Table 6 compares the deposit and loan asset growth and loan quality of the credit unions versus those of commercial banks. In Panel A, the total deposit growth rate for credit unions is on average 7.72% lower than the deposit growth rate for banks during the full sample period. In the time period after the policy change, both credit unions and banks exhibited slower deposit growth. This of course is due to the 2007-08 financial crisis. However, deposit growth at credit unions was stronger when compared to the growth rate for banks. After

[14]We use daily stock return to estimate daily conditional volatility, and take the average during a given quarter. Then we scale it to a monthly measure in order to assimilate the variable for credit unions.

Table 3.5: Deposit Insurance Regression for Canadian Banks

The table presents the results from the estimation of regression equation (1) for the sample of Canadian banks. The data is quarterly from 1997 to 2014. The dependent variable is the conditional volatility of stock returns estimated from a GARCH(1,1) model. All variables are the same as defined for the credit unions. There is no variable for the number of members. The governance score is a corporate governance index by The Globe and Mail. P-values are reported in brackets. All regressions are estimated with bank fixed effects and robust standard errors. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

	(1)	(2)
DI	-0.0278	0.0236
	(0.588)	(0.840)
Size		-0.0046
		(0.971)
Liquid assets		-0.0515
		(0.667)
Net loans		-0.5573
		(0.137)
Market share		0.3997
		(0.662)
Governance score		-0.6090**
		(0.038)
Bank F.E.	Yes	Yes
Number of observations	584	424
Adjusted R^2	0.020	0.107

controlling for the change in deposits growth rate at banks, the deposits growth rate at credit unions after the policy change is 14.81% higher than the rate before the policy change. The pattern is similar for demand deposit growth. After controlling for the growth rate at banks, the credit unions' demand deposit growth rate after the policy change is 7.45% higher than the rate before the change.

Table 3.6: Deposits and Loans, Before and After the Policy Change

The table compares the deposit growth, loan growth, and loan quality at credit unions and commercial banks. *, **, and *** denote 10%, 5%, and 1% significance level, respectively, from sample mean and group mean comparison t tests.

Panel A: Deposit growth						
	Deposits			Demand deposits		
	cu	bank	cu - bank	cu	bank	cu - bank
All years	8.01%***	15.74%***	-7.72%***	8.82%***	17.66%	-8.84%***
Before the change	8.69%***	18.64%***	-11.54***	8.59%***	17.53%***	-8.94%***
After the change	5.02%***	7.11%***	-2.09%	9.85%***	18.17%***	-8.33%***
After - Before	-3.67%***	-11.53%***	14.81%***	1.26%	0.64%	7.45%***
Panel B: Loan growth						
	Loans			Loan commitments		
	cu	bank	cu - bank	cu	bank	cu - bank
All years	8.54%***	9.55%***	-1.02%	14.62%***	8.36%***	6.26%***
Before the change	9.37%***	10.74%***	-1.36%	16.82%***	7.32%***	9.50%***
After the change	4.83%***	5.82%***	-0.99%	5.27%***	10.39%**	-5.11%*
After - Before	-4.55%***	-4.92%**	4.49%*	-11.55%***	3.07%	-13.14%**

Panel C: Loan quality			
	Nonperforming loans		
	cu	bank	cu - bank
All years	0.98%***	1.75%***	-0.76%***
Before the change	1.01%***	2.08%***	-1.07%***
After the change	0.85%***	0.92%***	-0.08%
After - Before	-0.08%	-3.30%	3.22%

In Panel B of Table 6, credit union loan growth rate after the policy change was 4.49% higher than the rate before the change relative to the changes in loan growth for banks. Together with the deposit growth results, this is consistent with the hypothesis that the increase in deposit insurance coverage enhances depositors' confidence and attracts fund influx to credit unions, which then use the funds to enlarge their loan portfolios. Also in Panel B, the credit unions have stronger growth in loan commitments than the banks do only in the time periods before the policy change. After the policy change, the controlled growth rate is 13.14% lower than the rate before the change, suggesting that credit unions slowed down in extending new credit lines. Loan commitment is a form of liquidity provision. It imposes liquidity risk to the credit unions that provide cash on demand to customers.

The slowed expansion of loan commitments can be an indication that credit unions are reluctant and more prudent to take on this type of risk.

Panel C of Table 6 shows that on average credit unions have lower proportion of nonperforming loans when compared to banks. The ratio of nonperforming loans to total loans is 0.76% lower for credit unions. There is no significant shift in the ratio for both credit unions and banks after the policy change. Overall, our results suggest that credit unions experienced deposit influx as a result of the policy change. They transform the funds into loan assets. In addition, credit unions were exposed to lower liquidity risk in the form of loan commitments and they maintained the quality of their loan assets.

Table 7 reports the effect of the change in deposit insurance program on alternative measures of ex-ante risk-taking. In column (1), the DI dummy is associated with more income diversification at the credit unions. $Size$ has a negative effect on non-interest income, which is the opposite of the expectation. Credit unions with more liquid assets and net loans have less non-interest income, whereas the credit unions with more members have more non-interest income. In column (2), the policy change is associated with more high-ratio mortgages. The effect of DI is statistically significant at the conventional level, but is not economically large. The change in deposit insurance program is associated with a 0.01% increase in the high-ratio mortgages, but this effect is very small with only 0.003 standard-deviation increase. Finally in column (3), the policy change has a significantly positive effect on the capital-to-asset ratio. Taken together, the results suggest that the change in the deposit insurance program increased credit unions' income diversification and capital ratio, both of which contributed to the lower overall risk at these financial institutions.

Next, we examine how the effect of deposit insurance varies with credit union characteristics. Column (1) of Table 8 presents the estimation results from regression equation (3.2). The coefficients of DI and the interaction term between DI and $SMALL$ are both significantly negative. The policy change had a greater effect on smaller credit unions; the effect of DI on the annualized conditional volatility of $RORWA$ for the small group is 0.0047% higher than the effect for the large group. This is consistent with our hypothesis that larger credit unions are more resilient to changing economic conditions, and that depositors already have more confidence in these credit unions. As expected, the effect of the policy change for larger credit unions was smaller than for smaller credit unions. The coefficients of the control variables are consistent with those in Table 4.

Column (2) of Table 8 includes the estimation results from equation (3.3). The coefficient of DI is significantly negative, while the coefficient of the interaction term between DI and $LOWLEV$ is significantly positive. For credit unions with higher ex-ante leverage, the policy change decreased the annualized conditional volatility by 0.125%. However, for credit unions with lower ex-ante leverage, the policy change increased the conditional volatility by 0.0117%. This is consistent with Le (2013) that following the introduction of deposit insurance, an increase in leverage is a main source of increase in banks' risk-taking. Credit

Table 3.7: Alternative Risk Measures

The table presents the results from the estimation of regression equation (1). Alternative risk measures are used as the dependent variable in each column. DI is a dummy variable that equals to 1 for time periods after the change in deposit insurance and 0 otherwise. The rest of the variables are defined in Appendix C.1. P-values are reported in brackets. All regressions are estimated with credit union fixed effects, year fixed effects and robust standard errors. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

	(1) Non-interest income	(2) High-ratio mortgage	(3) Captal-to-asset
DI	0.0135***	0.0001**	0.0006***
	(0.000)	(0.035)	(0.000)
Size	-0.0530***	0.0040	-0.0211***
	(0.000)	(0.173)	(0.000)
Liquid assets	-0.6455***	-0.0437	0.0820***
	(0.000)	(0.144)	(0.000)
Net loans	-0.7355***	-0.0345	0.0961***
	(0.000)	(0.248)	(0.000)
Membership	0.0546***	0.0074**	0.0190***
	(0.000)	(0.033)	(0.000)
Market share	-0.0661	0.1614***	-0.1217***
	(0.485)	(0.001)	(0.000)
Governance score: management	-0.0010	-0.0040**	-0.0040***
	(0.830)	(0.019)	(0.000)
Governance score: board	0.0039	0.0027**	-0.0033***
	(0.382)	(0.024)	(0.000)
Credit union F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
Number of observations	13,094	13,144	13,144
Adjusted R^2	0.273	0.648	0.769

Table 3.8: Impact of Credit Union Characteristics

The table examines the impact of credit union characteristics. $SMALL$ is 1 for credit unions with average assets below the sample median during the 3-year period before the change in deposit insurance design, and 0 otherwise. $LOWLEV$ is 1 for credit unions with average leverage ratio below the sample median. P-values are reported in brackets. All regressions are estimated with credit union fixed effects, year fixed effects and robust standard errors. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

Panel A: Conditional volatility of $RORWA$		
	(1)	(2)
DI	-0.0609***	-0.1250***
	(0.000)	(0.000)
DI * SMALL	-0.0047*	
	(0.068)	
DI * LOWLEV		0.1367***
		(0.000)
Size	0.1557**	0.1583**
	(0.039)	(0.034)
Liquid assets	2.6226**	2.8483**
	(0.034)	(0.023)
Net loans	2.9527**	3.2018***
	(0.016)	(0.010)
Membership	-0.0357	-0.0433
	(0.709)	(0.652)
Market share	-3.0547***	-1.8276**
	(0.001)	(0.026)
Governance score: management	-0.0483**	-0.0625***
	(0.038)	(0.010)
Governance score: board	-0.0283	-0.0287
	(0.282)	(0.215)
Credit union F.E.	Yes	Yes
Year F.E.	Yes	Yes
Number of observations	8,520	8,520
Adjusted R^2	0.361	0.362

Panel B: Realized volatility of $RORWA$		
	(1)	(2)
DI	-0.0229	-0.0034
	(0.554)	(0.900)
DI * SMALL	-0.0131	
	(0.605)	
DI * LOWLEV		0.0006
		(0.992)
Size	-0.1115	-0.1067
	(0.204)	(0.231)
Liquid assets	-0.4068	-0.3931
	(0.547)	(0.564)
Net loans/assets	-0.9969	-0.9813
	(0.186)	(0.190)
Membership	0.1010	0.1025
	(0.412)	(0.405)
Market share	-0.0003	-0.0073
	(1.000)	(0.992)
Governance score: management	-0.1252***	-0.1232**
	(0.009)	(0.011)
Governance score: board	0.0857***	0.0840***
	(0.003)	(0.004)
Credit union F.E.	Yes	Yes
Year F.E.	Yes	Yes
Number of observations	11,086	11,086
Adjusted R^2	0.573	0.573

unions with lower ex-ante leverage may be encouraged by the protection given by the unlimited deposit insurance and increase their risk-taking activities. Also, when we consider credit unions with larger membership base and larger deposit market share, the coefficient of DI in Table 9 is negative, while the coefficients of the interaction terms between DI and the proxies for importance are positive. It suggests that the policy change had a greater effect on credit unions with few members and smaller market share. This is consistent with the notion of implicit government guarantee on financial institutions. Larger credit unions are more likely to receive bail-out from the government, with or without an existing financial safety net or legislative mandate. If such implicit guarantee is perceived as possible, then an explicit insurance program would not have a significant impact on these credit unions. Our results support this conjecture.

3.4.3 Robustness Test

In this section, we carry out several robustness tests on our main results. First, we filter the sample to include only credit unions that are active in the time period both before and after the policy change. Over the last two decades, the number of credit unions has been decreasing due to mergers and acquisitions. Most of these mergers happened during the early 2000's, and, based on anecdotal evidences, involved a poorly operated credit union being acquired. To address the attrition bias caused by the exit of poorly performing credit unions, we re-estimate equation (3.1) for the subsample of credit unions that remain active

Table 3.9: Credit Union Importance

The table examines the impact of credit union importance on the effect of deposit insurance. In equation (3.4), $IMPORTANCE$ is proxied by either the membership or market share of the credit union. P-values are reported in brackets. All regressions are estimated with credit union fixed effects, year fixed effects and robust standard errors. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

Panel A: Conditional volatility of $RORWA$		
	(1)	(2)
DI	-0.2258*	-0.0516***
	(0.056)	(0.000)
DI * membership	0.0186*	
	(0.052)	
DI * market share		0.7542**
		(0.045)
Size	0.1455*	0.1554**
	(0.065)	(0.037)
Liquid assets	2.6417**	2.5308**
	(0.033)	(0.035)
Net loans	2.9871**	2.8781**
	(0.015)	(0.016)
Membership	-0.0404	-0.0448
	(0.669)	(0.639)
Market share	-3.7456***	-1.9038
	(0.002)	(0.174)
Governance score: management	-0.0449**	-0.0476**
	(0.037)	(0.037)
Governance score: board	-0.0325	-0.0280
	(0.180)	(0.251)
Credit union F.E.	Yes	Yes
Year F.E.	Yes	Yes
Number of observations	8,691	8,691
Adjusted R^2	0.362	0.362

Panel B: Realized volatility of *RORWA*		
	(1)	(2)
DI	-0.2383***	-0.0003
	(0.008)	(0.959)
DI * membership	0.0250***	
	(0.007)	
DI * market share		-0.0972
		(0.645)
Size	-0.1388	-0.1231
	(0.106)	(0.148)
Liquid assets	-0.5423	-0.4729
	(0.441)	(0.504)
Net loans/assets	-1.0968	-1.0208
	(0.160)	(0.192)
Membership	0.0760	0.0879
	(0.539)	(0.487)
Market share	-0.0836	0.3251
	(0.920)	(0.667)
Governance score: management	-0.1231**	-0.1215**
	(0.012)	(0.014)
Governance score: board	0.0786***	0.0823***
	(0.005)	(0.003)
Credit union F.E.	Yes	Yes
Year F.E.	Yes	Yes
Number of observations	11,344	11,344
Adjusted R^2	0.564	0.563

after the policy change. Table 10 column (1) presents the results. The results remain the same as those in Table 4 column (5).

Next, we test whether our results hold in a time window balanced around the policy change. Instead of all available years, we use a subsample ranging from January 2003 to December 2014. Column (2) of Table 10 includes all credit unions, while column (3) uses the subsample of active credit unions. We again obtain results that are consistent with Table 4. In addition, we find a negative relationship between credit union size and the conditional variance. Column (4) to (6) in Table 10 estimate the effect of the policy change on alternative risk measures for the filtered subsample as in column (3). Similar to Table 7, there is a positive relationship between the policy change and non-interest income as well as the capital ratio, while the policy change does not have a significant effect on the holding of high-ratio mortgages.

3.5 Conclusions and Discussions

In this paper, we examine the effect of an amendment in the deposit insurance program on the earnings uncertainty of credit unions. The amendment consists of two changes: an increase in the insurance coverage to unlimited and the adoption of risk-based insurance premium. We find that overall these changes in the deposit insurance program decreased

Table 3.10: Robustness Tests

The table reports results from the robustness checks. In column (1) to (3), the dependent variable is the conditional volatility of the return on risk-weighted assets. Column (1) excludes the credit unions that are inactive after the policy change. Column (2) excludes the time period before 2003 to have a balanced time window around the policy change. Column (3) applies both of these two criteria. Column (4) to (6) uses the filtered sample as in column (3), and non-interest income, high-ratio mortgages, and capital ratio as the dependent variable, repectively. P-values are reported in brackets. All regressions are estimated with credit union fixed effects, year fixed effects and robust standard errors. *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
DI	-0.0550***	-0.0552***	-0.0525***	0.0150***	0.0000	0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.967)	(0.000)
Size	0.1671*	-0.1698***	-0.1940***	-0.0596***	0.0145*	-0.0261***
	(0.054)	(0.006)	(0.008)	(0.000)	(0.090)	(0.000)
Liquid assets	3.1657**	2.1336***	2.0950***	-0.3693**	0.0040	0.0615**
	(0.028)	(0.000)	(0.001)	(0.020)	(0.943)	(0.030)
Net loans	3.5913**	1.5050***	1.4080***	-0.3453*	0.0555	0.0694**
	(0.014)	(0.002)	(0.007)	(0.052)	(0.369)	(0.024)
Membership	-0.0425	0.2774***	0.2846***	0.0283**	0.0206***	0.0177***
	(0.684)	(0.000)	(0.000)	(0.043)	(0.009)	(0.000)
Market share	-3.3871***	-3.8126***	-3.5302***	-0.4936**	0.1482	-0.0079
	(0.000)	(0.003)	(0.006)	(0.018)	(0.159)	(0.843)
Governance score: management	-0.0487**	-0.0820***	-0.0855***	0.0046	-0.0044**	-0.0021***
	(0.038)	(0.000)	(0.000)	(0.417)	(0.029)	(0.000)
Governance score: board	-0.0292	0.0317	0.0347	-0.0038	-0.0007	-0.0014*
	(0.233)	(0.163)	(0.138)	(0.406)	(0.648)	(0.070)
Credit union F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	8,152	4,293	4,131	6,502	6,502	6,502
Adjusted R^2	0.351	0.426	0.417	0.165	0.758	0.892

the conditional volatility of the returns on risk-weighted assets of the credit unions. The increase in insurance coverage is likely to enhance depositors' confidence, represented by stronger deposit growth at the credit unions after the policy change. Our results also show that the policy change increases credit unions' non-interest income and capital-to-asset ratio. These can be devices utilized by the credit unions to reduce risk in response to the implementation of the risk-based insurance premium. In addition, we find that the effect of the policy change is larger for smaller credit unions, as well as those with few members and smaller market share. In contrast, the policy change increases the conditional volatility of less levered credit unions.

Overall, our results support the hypotheses that an increase in deposit insurance coverage strengthens investor's confidence and has a stabilizing effect, while the adoption of risk-based insurance premium help alleviate moral hazard problem and reduce excessive risk taking. However, such a policy change should not be evaluated as having a one-sided impact. It may also have unintended consequences, for example, the policy change attracted deposit influx from the wholesale clients. This intensified the credit unions' dependence on concentrated funding sources. The wholesale depositors can be quick to take large withdrawals, and tend to be less reliable and more volatile when the market conditions change. The increased reliance on this type of funding can expose credit unions to greater liquidity risk. In addition, the cost of complying to new regulations is frequently the subject of complaint that it imposes limits to credit union's profitability.

Canadian credit union legislation is unique, because these financial institutions are regulated at the provincial level. Several regulatory bodies and deposit insurance programs exist across provinces. It segments the credit union system that is relatively small in size compared to the rest of the financial system. This may hinder the efficiency of operating a deposit insurance program that assumes geographically and industrially concentrated risks. Future research may consider the viability of a deposit insurance program in a small and highly concentrated financial system.

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Appendix A

Appendix for Chapter 1

A.1 Cross-listed Firms and Country-level Characteristics

This table presents the distribution of the sample firms by country. Legal origin and shareholder rights are from La Porta et al. (1998). Stock market development is an index from McLean and Zhao (2014). Foreign exchange (FX) volatility is the annualized volatility of daily exchange rates. Stock market turnover is an index published by the World Bank in World Development Index 2012.

Country	Number of firms	Legal origin	Shareholder rights	Stock market development	FX volatility	Stock market turnover
Argentina	14	French	4	0.064	0.1709	3.76
Australia	20	English	4	0.744	0.1333	84.65
Brazil	14	French	3	0.235	0.1624	67.88
Canada	334	English	5	0.778	0.0896	61.58
Chile	18	French	5	0.308	0.0950	16.01
France	14	French	3	0.581	0.1042	66.43
Germany	8	German	1	0.474	0.1027	91.77
Hong Kong	7	English	5	0.788	0.0047	123.08
Israel	37	English	3	0.632	0.0769	45.90
Japan	23	German	4	0.509	0.1124	99.85
Mexico	28	French	1	0.150	0.1040	25.31
Netherlands	13	French	2	0.769	0.1045	70.85
Norway	10	Scandinavian	4	0.598	0.1228	56.28
South Africa	14	English	5	0.598	0.1749	54.93
Spain	8	French	4	0.607	0.1041	106.32
Sweden	9	Scandinavian	3	0.692	0.1243	73.00
Switzerland	8	German	2	0.821	0.1143	63.74
United Kingdom	71	English	5	0.829	0.0891	84.04

A.2 Variable Definitions

Variable	Definition
Panel A: Security characteristics	
ADR (ordinaries) premium	A cross-listed firm's U.S. market price over its home market price, adjusted by the ADR ratio, and minus one. A number greater (less) than zero represents ADR premium (discount).
SO(ADR)/SO(Home)	The ratio of ADR (ordinaries) outstanding to shares outstanding of the underlying stock in the home market.
NYSE	A dummy variable equal to one if an ADR (ordinary) is traded on NYSE.
AMEX	A dummy variable equal to one if an ADR (ordinary) is traded on AMEX.
NASDAQ	A dummy variable equal to one if an ADR (ordinary) is traded on NASDAQ.
Idiosyncratic volatility	The standard deviation of the residuals of stock returns regressed on market index returns.
Analyst coverage	The number of price estimates by analysts.
Institutional holdings	The shares held by U.S. institutional investors as a fraction of shares outstanding.
Panel B: Liquidity measures	
Spread	The natural logarithm of bid-ask spread over the midpoint of bid-ask spread.
Turnover	The natural logarithm of daily volume over shares outstanding.
Amihud	The natural logarithm of absolute daily return over dollar volume.
Zeros	The number of zero-return days in a period of time over the number of trading days in the same time period.
Panel C: Firm-level variables	
Assets	The natural logarithm of total assets.
Sales	Net sales.
Debt to Asset	The book value of long-term debt over the book value of total assets.
Market to Book	The market value of shares over the book value of common equity.
Panel D: Country-level variables	
English	A dummy variable equal to one if a country has English legal origin.
French	A dummy variable equal to one if a country has French legal origin.
German	A dummy variable equal to one if a country has German legal origin.
Shareholder rights	An index measuring a country's legal protections for minority shareholders.
Stock market turnover	An index measuring a country's overall stock market turnover and transaction costs.
Stock market development	An index measuring a country's stock market development.
Equity market index	Broad-based equity market index by country.
FX premium	1-month forward exchange rate over spot exchange rate and minus one.
FX volatility	The annualized volatility of daily exchange rates.
Panel E: Time events	
Financial crisis	A dummy variable equal to one for the time period between 1 September 2007 and 30 September 2008, and zero otherwise.
Decimalization	A dummy variable equal to one for the time period after the U.S. exchange decimalization, and zero otherwise. For ADRs (ordinaries) listed on NYSE and Amex, the value is one from 29 January 2001 until the end of the sample period; for ADRs (ordinaries) listed on Nasdaq, the value is one from 9 April 2001 until the end of the sample period.
Tax cut	A dummy variable equal to one for the time period after the 2003 U.S. tax cut, and zero otherwise.

A.3 Long/Short Trading Strategy

This table presents the results from a long/short trading strategy. Trades are open when the price differential between a cross-listed firm's U.S. and home market price is larger than the estimated trading costs. Panel A summarizes the returns and trading statistics. Panel B includes the results from regressing the returns against Fama-French, momentum, and Pastor-Stambaugh liquidity risk factors. The numbers in parentheses are p-values with robust standard errors. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

Panel A: Returns and trading statistics				
	Mean	Median	Std Dev	Std Error
All firms				
Annualized return	0.0035	0.0013	0.0102	0.0004
Number of round-trip trades per firm	222	174	186	7.4668
Time postions are open in days	9.7586	3.0186	39.4746	1.5802
Canadian firms				
Annualized return	0.0051	0.0021	0.0109	0.0006
Number of round-trip trades per firm	206	179	161	8.8042
Time postions are open in days	4.2721	2.5551	9.6896	0.5296
Before 2008				
Annualized return	0.0018	0.0010	0.0076	0.0004
Number of round-trip trades per firm	124	98	82	4.0991
Time postions are open in days	6.3049	2.5632	20.0833	1.0017

Panel B: Systemic risk			
	All firms	Canadian firms	Before 2008
Intercept	0.4443***	0.5491***	0.1998***
	(0.000)	(0.000)	(0.000)
Market	-0.0032	-0.0032	0.0044*
	(0.278)	(0.606)	(0.088)
SMB	-0.0013	0.0113	-0.0084
	(0.882)	(0.431)	(0.344)
HML	0.0001	0.0064	-0.0054
	(0.987)	(0.543)	(0.699)
Momentum	0.0046	0.0133**	0.0068
	(0.232)	(0.015)	(0.210)
Level of Aggregate Liquidity	0.0390***	0.0682***	-0.0150
	(0.000)	(0.000)	(0.418)
Innovations in Aggregate Liquidity	-0.0537***	-0.1141***	0.0302
	(0.005)	(0.001)	(0.453)
R^2	5.59	9.43	2.34

A.4 VECM of Stock Prices and Market Indices

We estimate the following vector error correction model for each firm i. We use Bayesian information criteria to choose the optimal lag order. For most firms, a lag order of one is optimal so we estimate the model with one lag. Eun and Sabherwal (2003) use a similar method to study Canadian cross-listed stocks.

$$\begin{aligned}\Delta p_{i,t}^{H} =& \alpha_i^{H}(\beta_i^{H} p_{i,t-1}^{H} + \beta_i^{US} p_{i,t-1}^{US} + \beta_i^{Hindex} p_{i,t-1}^{Hindex} + \beta_i^{USindex} p_{i,t-1}^{USindex}) \\ &+ \gamma_i \Delta p_{i,t-1}^{H} + \delta_i \Delta p_{i,t-1}^{US} + \theta_i \Delta p_{i,t-1}^{Hindex} + \nu_i \Delta p_{i,t-1}^{USindex} + a_i^{H}\end{aligned} \tag{A.4.1}$$

$$\begin{aligned}\Delta p_{i,t}^{US} =& \alpha_i^{US}(\beta_i^{H} p_{i,t-1}^{H} + \beta_i^{US} p_{i,t-1}^{US} + \beta_i^{Hindex} p_{i,t-1}^{Hindex} + \beta_i^{USindex} p_{i,t-1}^{USindex}) \\ &+ \gamma_i \Delta p_{i,t-1}^{H} + \delta_i \Delta p_{i,t-1}^{US} + \theta_i \Delta p_{i,t-1}^{Hindex} + \nu_i \Delta p_{i,t-1}^{USindex} + a_i^{US}\end{aligned} \tag{A.4.2}$$

$$\begin{aligned}\Delta p_{i,t}^{Hindex} =& \alpha_i^{Hindex}(\beta_i^{H} p_{i,t-1}^{H} + \beta_i^{US} p_{i,t-1}^{US} + \beta_i^{Hindex} p_{i,t-1}^{Hindex} + \beta_i^{USindex} p_{i,t-1}^{USindex}) \\ &+ \gamma_i \Delta p_{i,t-1}^{H} + \delta_i \Delta p_{i,t-1}^{US} + \theta_i \Delta p_{i,t-1}^{Hindex} + \nu_i \Delta p_{i,t-1}^{USindex} + a_i^{Hindex}\end{aligned} \tag{A.4.3}$$

$$\begin{aligned}\Delta p_{i,t}^{USindex} =& \alpha_i^{USindex}(\beta_i^{H} p_{i,t-1}^{H} + \beta_i^{US} p_{i,t-1}^{US} + \beta_i^{Hindex} p_{i,t-1}^{Hindex} + \beta_i^{USindex} p_{i,t-1}^{USindex}) \\ &+ \gamma_i \Delta p_{i,t-1}^{H} + \delta_i \Delta p_{i,t-1}^{US} + \theta_i \Delta p_{i,t-1}^{Hindex} + \nu_i \Delta p_{i,t-1}^{USindex} + a_i^{USindex}\end{aligned} \tag{A.4.4}$$

To estimate the cointegrating vector, $\beta_i = (\beta_i^{H}, \beta_i^{US}, \beta_i^{Hindex}, \beta_i^{USindex})$, we normalize the coefficient for home market stock price, β_i^{H}, to 1, and expect the coefficient for the U.S. market stock price, β_i^{US}, to be insignificantly different from -1, and the coefficients for the U.S. and home market indices, β_i^{Hindex} and $\beta_i^{USindex}$ insignificantly different from 0.

The main parameters of interest are the short-run correction coefficients, α_i^{H} and α_i^{US}, which show how the U.S. and home market prices respond to a deviation between the two. When a cross-listed firm's U.S. and home market prices differ from each other, α_i^{H} indicates how the home market price subsequently adjusts to this divergence, whereas α_i^{US} indicates how the U.S. market price adjusts. Given the cointegrating vector β_i, we expect the sign of α_i^{H} to be negative and the sign of α_i^{US} to be positive. This is because we expect larger price corrections when the difference between a cross-listed firmâĂŹs U.S. and home prices is larger. Consider a case where $p_{i,t-1}^{H} > p_{i,t-1}^{US}$, and $(\beta_i^{H} p_{i,t-1}^{H} + \beta_i^{US} p_{i,t-1}^{US} + \beta_i^{Hindex} p_{i,t-1}^{Hindex} + \beta_i^{USindex} p_{i,t-1}^{USindex}) > 0$. We expect that (1) $p_{i,t}^{H}$ goes down, $\Delta p_{i,t}^{H} < 0$, thus $\alpha_i^{H} < 0$, and (2) $p_{i,t}^{US}$ goes up, $\Delta p_{i,t}^{US} > 0$, thus $\alpha_i^{US} > 0$. Similar results can be obtained by considering the case where $p_{i,t-1}^{H} < p_{i,t-1}^{US}$. For more details see Eun and Sabherwal (2003).

Appendix B

Appendix for Chapter 2

B.1 Variable Definitions

Variable	Definition
Panel A: Firm-level variables	
Is diversified	A firm is diversified if it has two or more operating segments by 2-digit SIC.
Is multinational	A firm is multi-national if it reports foreign sales.
Size	Total assets, in millions USD; the natural logarithm of total assets is used in regressions.
Cash holdings	(Cash + short-term investment) / total assets.
EBITDA	Earnings before interest, taxes, depreciation and amortization / total assets.
Operating cash flow	(Income before extraordinary items + depreciation and amortization) / total assets.
Tobin's Q	Market value of assets / (0.9*book value of assets + 0.1*market value of assets), where market value of assets is book assets - common equity + shares outstanding* share price - deferred taxes.
Leverage	Long term debt / total assets.
Net equity (debt) issuance	Calculated as change in common equity (total debt) / total assets.
Payout	(Dividends + share repurchases) / total assets.
R&D expense	R&D expenses / total assets.
R&D stock	Accumulated R&D capital, assuming a 15% depreciation year over year; R&D stock_t = R&D $\text{stock}_{t\text{-}1}$ (1-15%) + R&D expense_t.
CAPEX	Capital expenditure / total assets.
Net working capital	(Current assets - current liabilities - cash holdings) / total assets.
Price-cost margin	(Income before extraordinary items + depreciation and amortization) / sales.
Herhindahl-Hirschman Index	For a given industry, it is the sum of squared market shares of firms.
Sales growth volatility	The standard deviation of sales growth.
Productivity volatility	The standard deviation of productivity growth, which is the change in the error term from regressing a firm's operating income on capital stock.
Entrenchment index	An index based on a firm's governance provisions to measure management entrenchment, following Bebchuck et al. (2009). Whether CEO is also a board member is included as an additional item to construct the index.
Panel B: Cross-segment diversification and allocation measures	
Tobin's Q correlation	Following Duchin (2010) equation (7) and (8), it is the difference between a firm's sales-weighted volatility in Q considering actual inter-segment correlations and the volatility assuming perfect inter-segment correlation of 1.
Cash flow correlation	Calculation in analogue to Q correlation, using cash flow.
Q-Cash flow correlation	Sales-weighted correlation between Tobin's Q and cash flow.
Tobin's Q volatility	Sales-weighted volatility in Q assuming inter-segment correlation of 1.
cash flow volatility	Sales-weighted volatility in cash flow assuming inter-segment correlation of 1.
Efficiency of allocation	Following Rajan et al. (2000) equation (18) and Table V, it is the value added by inter-segment allocation; the absolute value added and the relative value added are used in alternative specifications of the regressions.
Panel C: Country-level variables	
Legal origin	A country's legal origin, identified by La Porta et al. (1998).
Shareholder rights	An index constructed by La Porta et al. (1998) and Spamann (2010) to capture the rights of minority shareholders.
Minority shareholder protection	A index based on the ease of shareholder suits, director liability and disclosure regulations, from the annual Doing Business Reports by the World Bank. The 2005 values are used for sample periods before 2005.
Financial market development	An index that measures a country's financial market development; the data is from World Bank and the calculations follow McLean and Zhao (2015).
Import penetration	The value of imports divided by the sum of imports and domestic production.

Appendix C

Appendix for Chapter 3

C.1 Variable Definitions

Appendix 1: Variable Definitions

Variable	Definition
RORWA	Return on risk-weighted assets, calculated as monthly net income divided by risk-weighted assets.
Conditional variance of RORWA	Predicted variance of RORWA from a GARCH(1,1) model.
Realized volatility of RORWA	Standard deviation of RORWA in a 3-year rolling window.
DI	The dummy variable is 1 for time periods after the change in the deposit insurance program, and 0 otherwise.
Demand deposit	Demand deposits divided by total deposits.
High-ratio mortgage	Residential real estate backed loans divided by total assets; the loans are uninsured with a loan-to-value ratio greater than 75%.
Net loans	Loan assets net of allowance for impairement divided by total assets.
Nonperforming loans	Loans in arrears divided by total assets.
Gap ratio, variable rate	Absolute value of the difference between variable-rate assets and liabilities, divided by the greater of variable-rate assets and liabilities.
Gap ratio, fixed rate 4-6 months	Similar as above, except the assets and liabilities are fixed rate with 4-6 months to maturity.
Size	The natural logarithm of total assets.
Liquid assets	Cash and liquidity investments, divided by total assets.
Capital-to-asset ratio	Primary and secondary capital minus capital deductions, divided by total assets.
Non-interest income	Non-interest income divided by the sum of non-interest income and interest income.
Leverage ratio	One minus capital-to-asset ratio. Alternatively, total assets is replaced with risk-weighted assets and other liabilities are excluded in the calculation.
Membership	The number of members. In regressions, the variable is the natural logarithm of the number of members.
Market share	Deposits at a credit union divided by total deposits at all credit unions.
Score on senior management	Rating assigned by a credit union's supervisor based on the assessment of the ability of the credit union's management team. The lowest score is 1, and the highest is 4.
Score on board oversignt	Rating assigned by a credit union's supervisor based on the assessment of the oversight and governance effort by the credit union's board of directors. The lowest score is 1, and the highest is 4.