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Liquidity and risk sharing benefits from opening an ETF market with liquidity providers: Evidence from the CAC 40 index[☆]

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ABSTRACT

This article examines how the introduction of an ETF replicating a stock index impacts on the liquidity of the underlying stocks when the ETF market involves liquidity providers (LPs). We find that index stock spreads decline, relative to those of non-index stocks, after the introduction of the ETF but this liquidity improvement is not driven by changes in adverse selection costs or recognition effects. By contrast, we show that it is mainly explained by a decrease in order processing and order imbalance costs. This most probably results from additional risk sharing capacities provided by increased cross-market trading and LPs' liquidity provision in low-liquidity times.

1. Introduction

Exchange-traded funds (ETFs) are widely acknowledged to be one of the most useful financial innovations of the past few decades, especially for index traders. They are essentially exchange-traded assets that represent a basket of securities comprising a particular index. ETFs allow investors to take positions in a given market without selecting individual securities, and provide them with an opportunity to trade indices easily, in small amounts, and at very low costs. They are thus generally not considered as redundant assets, but rather as new financial instruments that complete markets in an economic sense. They are particularly well suited for passive investors, and combine the advantages of closed-end and open-end mutual funds with much lower expense fees. On the one hand, as closed-end funds, ETFs can be traded throughout the day in the secondary market. On the other hand, they can be considered as open-end mutual funds, as the creation and redemption of ETF shares are allowed.

As a result of these attractive features, ETFs are now very popular investment vehicles. A BlackRock report[1] found that the number of ETFs available worldwide at the end of 2011 was 3011 ETFs, totaling assets under management of US$ 1351 billion, listed on 53 exchanges. In Europe, the ETF industry had 1232 ETFs, with assets of US$ 266.6 billion, on 23 exchanges. Understanding how and why ETFs contribute to the quality of stock markets is thus of great interest. Our research specifically investigates how the first introduction of an ETF tracking a stock index affects the liquidity of the underlying stocks. We find that the liquidity of underlying stocks improves relative to that of non-index stocks, and that this liquidity improvement mainly occurs by means of a reduction in order processing and order imbalance costs.

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[1] BlackRock (2012) ETF Landscape Global Handbook, Q4 2011, 157p.

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Investigating the liquidity effects of the introduction of ETFs is relevant not only because of the size and expansion of the ETF sector but also because of the lack of consensus about such effects in both the asset management industry and academia. A survey of 192 European ETF users conducted in 2010 by the EDHEC-Risk Institute[2] shows how mixed the views of practitioners were on this matter: 31% of the survey respondents observed an improved liquidity in the underlying market, but 35% did not. In the academic world, previous literature also provides diverse conclusions on the liquidity effect of ETF inception. Hegde and McDermott (2004) investigated the liquidity effects of the introduction of ETFs for the DJIA 30 and the Nasdaq 100 stock indices, the Diamonds index, and the QQQ, and found a liquidity improvement largely related to a decline in the asymmetric information costs of the underlying stocks. Richie and Madura (2007) also tested the impact of the creation of the QQQ fund on the liquidity of the component securities and the risk of the underlying securities. They found that the liquidity improvement following the creation of the QQQ was more pronounced for less heavily weighted stocks, and that the systematic risk of the underlying stocks declined relative to a control sample. However, using matched samples, Van Ness, Van Ness, and Warr (2005) did not find a similar improvement for the DJIA 30. They tested the hypothesis that uninformed traders prefer to invest in the Diamond ETF rather than in the individual stocks constituting the index, and found that, following the introduction of the Diamonds ETF, the bid–ask spreads of the DJIA 30 actually increased relative to the spreads of matching stocks. However they did not find a consistent change in the adverse selection components of the spreads of the Dow stocks.

Based on the introduction of the Lyxor CAC 40, the first Euronext-listed ETF to replicate the French CAC 40 index, our empirical work contributes to the literature in two ways. First, studying the inception of an ETF on Euronext[3] may provide a new insight because of the particular market design of the ETF market segment of this exchange. On Euronext, ETFs are traded in a hybrid, continuous, order-driven market, in which designated market makers, called liquidity providers (LPs), have to provide immediacy services. Using non-public complete order book data, we show that ETF LPs contribute greatly to the liquidity of the ETF market. Given the benefit of these LPs, liquidity effects may differ from those observed for ETFs listed on other exchanges. Second, we compare the theories that have been put forward to explain the liquidity improvement observed for CAC 40 stocks after the introduction of the Lyxor CAC 40. Our main contribution is to show that the tightening of index stock spreads is predominantly related to a decrease in the temporary price effect of order execution. This is in line with Fremault's (1991) arbitrage theory according to which cross-market trading has beneficial risk sharing effects.

This article is organized as follows. In Section 2, we describe the Lyxor CAC 40, present its market microstructure, and assess its economic role by estimating the implicit trading costs incurred by index traders in both the market for individual stocks and the ETF market. In Section 3, we review the theories predicting the effects of the inception of an ETF on the liquidity of the basket stocks, and derive testable hypotheses. Those hypotheses are then tested in Section 4. Section 5 provides a discussion of the findings and a validation of the arbitrage hypothesis based on risk sharing effects. It also includes evidence about the potential role of LPs in those effects. Section 6 presents our conclusions.

2. The Lyxor CAC 40: description, trading mechanisms, and associated cost savings

Whereas ETFs were created in the 1990s in North-America,[4] they were only introduced into European markets in the early 2000s. The Lyxor CAC 40, which tracks the performance of the CAC 40 index, was the first ETF to be listed on Euronext. ETFs which track national indices are the most popular equity ETFs: they represented more than 60% of the total volume traded in ETFs listed on Euronext during 2012. With €2.57 billion of assets under management on 28 February 2013, the Lyxor CAC 40 has now become one of the most actively traded funds on NextTrack, the Euronext segment dedicated to the listing and trading of ETFs. In February 2013, it ranked fourth, with an average daily turnover of €11.18 million and a market share of 4.43%.

2.1. The Lyxor CAC 40 fund

The CAC 40 index is the flagship French stock market index and comprises forty large capitalization stocks. It is a market-value weighted index whose composition is reviewed quarterly by an independent Index Steering Committee. The main criteria for inclusion in the CAC 40 are market size and turnover.[5] Its base value was set to 1000 on December 31, 1987. It serves as an underlying asset for futures contracts and options traded on Nyse Liffe.[6]

The Lyxor CAC 40 was the first ETF created to replicate the value of the CAC 40. It is a French mutual fund that complies with the UCITS IV European directive.[7] It was issued on NextTrack, on January 22, 2001, by Lyxor, a subsidiary of Société Générale. One unit of the ETF is worth 1/100 of the index and the objective is to track the index return. Several replication mechanisms can be employed by the fund manager in order to minimize the tracking error: physical replication, statistical sampling or swap-based replication. Lyxor systematically uses swap-based replication to manage the replication risk of its ETFs.[8] The fund invests in a basket of stocks with may differ from the CAC 40 portfolio and swaps the performance of the basket against the performance of the index. The swap counterparty for Lyxor is always the parent bank, Société Générale. With such a mechanism, the investor bears almost no replication risk,[9] but supports the counterparty default risk associated with the market value of the swap. Management fees are no more than 0.25% per year and no entrance or exit fees are charged. This allows investors to buy the index with perfect replication, even for small amounts, at low fees, and without the constraints of derivative markets (such as deposits and margin calls).

Subscriptions and redemptions for units in the fund are possible through transfer of shares or can be made exclusively in cash. The request must be transmitted to Société Générale's Securities and Stock Market Department during a trading day, for execution based on the net asset value published on this trading day. Subscriptions/redemptions are carried out for a whole number or fund units, corresponding to a minimum of €100,000 and charged €10,000 per subscription/

[2] EDHEC European ETF Survey 2010, EDHEC-Risk Institute Publication.

[3] In 2001, the European exchange Euronext comprised the former exchanges of Amsterdam, Brussels, and Paris. It then took over the Portuguese exchanges of Porto and Lisbon. In 2007, it merged with the NYSE and is now a subsidiary of the transatlantic group Nyse–Euronext.

[4] ETFs were first introduced on the Toronto Stock Exchange in March 1990 with the creation of TIPS (Toronto 35 Index Participation units). This was followed in 1993 by the inception of the SPY which replicates the S&P 500 on the AMEX. Currently, the three most active ETFs are the SPY, the QQQ which replicates the Nasdaq 100, and the DIA which tracks the DJIA 30.

[5] At each review date, the companies listed on Euronext Paris are ranked according to their free float capitalization and turnover over the last twelve months. From the top 100 companies in that ranking, forty are chosen to enter the CAC 40 in order to make it "a relevant benchmark for portfolio management" and "a suitable underlying asset for derivative products."

[6] NYSE Liffe is the global derivative business of the NYSE Euronext group.

[7] UCITS (Undertakings for Collective Investment in Transferable Securities) are a set of European Union (EU) directives that aim to allow collective investment schemes to operate freely throughout the EU on the basis of a single authorization from one member state. UCITS rules apply to funds marketed to retail investors.

[8] See Paul Amery (2008) 'More on counterparty risk (swap-based ETFs)', www.indexuniverse.eu.

[9] The tracking error never exceeds 1%.

redemption request. For subscription through transfer of shares, the subscriber must deliver a basket of shares making up the CAC 40 index (round down to the nearest share), plus an amount in cash in EUR (the "balance"). The cash balance solves the rounding problem and is equal to the difference between the net asset value of one unit multiplied by the number of units subscribed and the value of the shares delivered. The reverse mechanism is applicable for redemption through transfer of shares. Those primary market operations are effectively used by investors: for example, from July 2009 to July 2010, €2.8 billion of subscription and €3.0 billion of redemption were registered, these amounts being comparable to the value of assets under management.[10]

2.2. Trading mechanisms

The European stock markets of Nyse–Euronext currently rank among the most important trading venues in Europe. They rely on a homogeneous order-driven structure. The CAC 40 stocks are traded continuously in the Euronext electronic order book. The trading day starts with a call auction at 9.00 a.m. following a pre-opening phase beginning at 7.15 a.m. Then the market switches over to continuous trading and closes with a call auction at 5.30 p.m. following a five-minute pre-closing period. Both opening and closing prices are set by matching the supply and demand curves and selecting the price that maximizes the trading volume. The continuous trading system enforces a price–time order priority rule to arrange trades.

ETFs listed on NextTrack are also continuously traded but their trading session is delayed by 5 min relative to the cash stock market session, so that the price discovery process on underlying stocks precedes that on ETFs. In spite of its similarity with the cash market microstructure, the ETF market is different in two respects.

First, while CAC 40 stocks are traded in a pure limit order book market, market members may act as LPs on NextTrack. As market specialists for their stocks, LPs have a business agreement with Euronext whereby they undertake to quote two-way bid and ask prices in the limit order book, with a minimum volume and within a maximum spread. They commit to maintaining a spread of firm bid and offer prices during the 15 min preceding the market opening, and then throughout the trading day, including the order accumulation period preceding auctions. In return for those commitments, orders placed by LPs and their resulting trades are subject to tariff benefits which are conditioned on their performance in providing liquidity, and may not exceed 50% of explicit trading fees. LPs benefit from the maximum fee reduction of 50%, provided that they comply with 80% of their commitments in terms of quote time, quoted spreads, and quoted quantities.

Second, a large portion of the ETF order flow is executed in the over-the-counter market by LPs. As the Markets in Financial Instruments Directive (MiFID)[11] does not apply to ETF trading, there is no commitment to post-trade transparency for those OTC trades.

2.3. Cost savings related to the ETF and LPs' contribution

We assess the economic relevance of ETFs by comparing the implicit transaction costs associated with the Lyxor CAC 40 with those associated with the CAC 40 stock basket. Our analysis is based on the database used by De Winne and D'Hondt (2007). This database contains very detailed order book data during October 2002. Our sample contains the CAC 40 stocks and the Lyxor CAC 40 security. We know exactly what is registered in the limit order book for a given stock at every second: the set of the five best bid/ask quotes, both displayed and hidden quantities associated with these quotes, and the portion of these quantities stemming from client orders, principal orders, and LP orders. Additional information[12] about this database and about the process used to build the limit order book can be found in De Winne and D'Hondt (2007).

Using these order book data, we compare the cost of a round-trip trade in the CAC 40 stock basket and in the CAC 40 ETF. As suggested by Irvine, Benston, and Kandel (2000), an ex-ante liquidity measure is useful to indicate the upper bound of the transaction cost at which an order can be immediately executed. Of course, we know that many traders will try to obtain a better price for the whole bundle of shares by splitting their orders, but the cost of a round-trip trade (CRT) gives some idea of the implicit costs that can be expected from a naive order placement strategy. At any given point in time t, the CRT for a trade size T corresponds to the difference between the cost of buying T shares of a stock i ($B_{T,i,t}$) and the amount received from selling these T shares ($S_{T,i,t}$). For the purpose of comparison across stocks or across trade sizes, this difference is divided by the value of these T shares at the mid-point. The CRT for a trade size of T shares of stock i at time t is therefore computed as:

$$CRT_{T,i,t} = \frac{B_{T,i,t} - S_{T,i,t}}{T \times \frac{\left(B_{1,i,t} + S_{1,i,t}\right)}{2}}, \tag{1}$$

where both displayed and hidden orders are taken into account.[13]

For each stock in our sample and for the ETF, we computed this measure for every time a new order was placed. We measured the CRT for 5000 and 50,000 shares of the Lyxor CAC 40. According to the weight of each stock in the CAC 40 index measured at the opening auction every day, we computed the corresponding number of shares to be traded for 5000 and 50,000 shares of the ETF. These numbers were then used to measure the CRT of individual stocks according to Eq. (1). For each trading day, we first averaged the CRTs in every stock and then computed the average CRT of the basket according to the stock weights on that day. Finally, we averaged the daily CRTs across the 23 trading days in October 2002 to obtain the basket CRT.

Since the Lyxor CAC 40 security is traded in a hybrid market where LPs with market-making contractual commitments interact in the order book, we also estimated the relative contribution of LPs to the market liquidity using the 432,266 order book states observed for the ETF security during that month. Average relative quoted spreads, average depths at the first and the five best limits, as well as relative CRTs for 5000 and 50,000 shares, were first computed using all the orders waiting in the limit order book. Then these measures were recomputed without the orders submitted by LPs.

The results are presented in Table 1. The costs associated with trading the basket of stocks appear to be higher than that associated with trading the ETF. Buying and selling the underlying stocks cost 0.21% (compared to 0.15% for the ETF) for a trade size equivalent to 5000 ETF shares, or 0.27% (compared to 0.21%) for a trade size of 50,000 ETF shares. Translated into monetary units, these differences represent about €100 and €1000 respectively for the equivalent of 5000 and 50,000 ETF shares. Comparing the two last columns shows that LPs contribute greatly to the liquidity of the ETF market.

[10] While significant, volumes traded in the primary market remain very small in comparison with trading volumes in the secondary market.

[11] The MiFID is a European Union law which provides a harmonized regulatory regime for investment services across the 30 member states of the European Economic Area (the 27 Member States of the European Union plus Iceland, Norway and Liechtenstein). The main objectives of the Directive are to increase competition and consumer protection in investment services. As of November 1, 2007, it replaced the Investment Services Directive.

[12] A note describing the methodology applied to build the limit-order book from Euronext order and trade files is available on request. The analysis performed in this section relies on the availability of such detailed data, which in turn justifies the choice of this particular period.

[13] On Euronext and NextTrack, hidden orders are allowed and undisclosed depth is likely to lower this cost compared with the cost that might be expected from the depth displayed on the screens.

Omitting orders placed by LPs multiplies the CRT by a factor of about four.[14]

3. Related theories and testable hypotheses

Since the introduction of the Lyxor CAC 40 allows the CAC 40 index to be traded in smaller denominations and at lower costs, it may have diverse effects (such as attracting new investors to the stock market or diverting particular categories of traders from the market of the underlying stocks to the ETF market). These effects are likely to impact the liquidity of the basket of underlying stocks, either positively or negatively. This section presents the theoretical hypotheses that may explain how the inception of an ETF can alter the liquidity of the index components. The theories which are most often cited in the literature are the *adverse selection hypothesis* and the *arbitrage hypothesis*. Richie and Madura (2007) also put forward the *recognition hypothesis*. From these theories, we derive a set of hypotheses that will be tested in Section 4.

3.1. The adverse selection hypothesis

The consequences of the introduction of a basket security for liquidity have been modeled by Subrahmanyam (1991) in the theoretical settings chosen by Admati and Pfleiderer (1988). In this model, a population of informed and uninformed traders can choose to trade either in N individual asset markets or in the N-assets index stock market. Informed traders can receive two types of signals: either specific private information or systematic private information. At equilibrium, specific-information traders preferably trade in the underlying stock market while systematic-information traders choose the basket market for trading, and discretionary liquidity traders go to the basket market, where their losses to informed traders are expected to be lower.

This is very similar to Gorton and Pennacchi's (1993) model, in which less informed agents reduce their trading losses by trading in composite rather than individual securities. As a result of reduced liquidity trading in the component securities, adverse selection costs and spreads may increase in the underlying security markets, and this increase is predicted to be more significant for securities with smaller weights in the basket than for heavily weighted securities.[15] These effects could be even more pronounced when the newly created index market involves market-making intermediaries such as the Lyxor CAC 40 LPs because this category of market participants is acknowledged to be able to skim off the most profitable orders, that is the least informed (see Easley, Kiefer, & O'Hara, 1996).

3.2. The arbitrage hypothesis

Introducing financial instruments derived from existing securities, such as futures, options, or ETFs, may reduce market incompleteness and expand the investment and arbitrage opportunities facing investors (Hakansson, 1982; Ross, 1976). If these new instruments generate additional arbitrage trading, price efficiency and liquidity in the underlying markets are improved. For instance, Kumar, Sarin, and Shastri (1998) provide unambiguous evidence of improved market liquidity after option listings. Kurov and Lasser (2002) and Deville, Gresse, and de Séverac (2014) have shown that index cash-futures arbitrage profits decrease in frequency and magnitude following the introduction of an ETF.

Table 1
Comparing the cost of trading the CAC 40 index in the stock market and the Lyxor CAC 40 market.

	Basket of index stocks	With LPs	Without LPs
Relative quoted spread	–	0.13%	0.62%
Depth at the best limit	–	45,763	9540
Depth at the five best limits	–	225,059	23,800
CRT for 5000 shares in %	0.21%	0.15%	0.56%
CRT for 50,000 shares in %	0.27%	0.21%	0.80%

Note: This table shows the time-weighted averages of the relative quoted spread and the quoted depth in the number of shares for the Lyxor CAC 40 security, and it compares the cost of a round-trip trade (CRT) in the ETF market with that of a trade of the same size in the underlying stock market. Depth is measured at the best-limit level and at the five-best-limit level, and refers to the total of displayed and hidden quantities. CRTs are computed for the equivalent of 5000 and 50,000 shares on the Lyxor CAC 40. The spreads, depth, and CRTs of the ETF were computed using all the orders waiting in the limit order book, both including (with LPs) and excluding (without LPs) those placed by LPs. The statistics are based on the detailed order book data recorded during October 2002.

The introduction of ETFs may create arbitrage benefits in two ways. First, assuming that markets are informationally segmented, the introduction of an index security mitigates the structural problems that beset inter-market arbitrage: it lowers arbitrage costs such as tracking errors and the randomness in the intervening dividend payoffs, and it therefore favors arbitrage trading (Hegde & McDermott, 2004). Second, upon introduction of the ETF, traders or ETF LPs can exploit new arbitrage opportunities by creating and redeeming shares in the new ETF (Richie & Madura, 2007). However, the arbitrage opportunities resulting from the creation and redemption of ETF shares seem difficult to exploit on the Lyxor CAC 40, because of the prohibitive costs charged in the ETF primary market.[16] New arbitrage opportunities should essentially arise in the ETF secondary market.

Fremault (1991) modeled the benefits of arbitrage between cash and futures index markets under rational expectations, and showed that increased index arbitrage:

1. adds liquidity and allows risk to be reallocated from hedgers of one market to speculators on another market;
2. adds risk bearing capacity to markets and provides buying and selling support in market order imbalances;
3. has a stabilizing effect on prices if the variances of aggregate supply in the respective markets are not too divergent.

If we transpose this theory to the introduction of an ETF, arbitrage trading across the underlying-stock market and the ETF market should improve stock liquidity by allowing risk to be reallocated between the markets, and reducing the impact of order imbalances. This risk sharing effect could be greater for an ETF market whose structure involves LPs if the LPs contribute to the risk allocation process.

3.3. The recognition hypothesis

The inclusion of a stock in an index is generally accompanied by a positive permanent price increase (see, for example, Beneish & Whaley, 1996; Harris & Gurel, 1986) and an improvement in liquidity (Hegde & McDermott, 2003). Chen, Noronha, and Singal (2004) consider that those positive effects are consistent with Merton's (1987) *investor recognition theory*, because the price responses to additions to and deletions from the S&P 500 index are asymmetric, with no permanent price decrease following index deletions. According to Merton (1987), with increased investor recognition, the shareholder base broadens, resulting in lower required returns and higher liquidity. Investor

[14] This result is actually downward biased, since, for some states of the order book, CRTs were not computed because the five best limits were insufficient for trading 5000 or 50,000 shares.

[15] In Subrahmanyam's model, it is profitable for informed traders with specific private information to submit orders in the index market because "possessing information about a security is tantamount to possessing noisy information about the basket". The greater the weight of the security in the index, the more profitable the specific-information based order in the index market. For that reason, for large index components, the increase in adverse selection costs due to the diversion of liquidity traders from the security market to the index market may be mitigated by the diversion of a part of the security-specific informed demand to the index market. As a result, the increase in adverse selection costs is predicted to be more strongly evident for small index components than for large ones.

[16] A minimum number of 50,000 units is required to create or redeem ETF shares. Each subscription request is charged €10,000.

awareness of a stock increases following its addition to the index, which results in a positive price response. Because investor awareness does not necessarily decrease after a deletion from the index, the opposite effect is not found.

With the introduction of an ETF on a stock index, similar recognition effects may occur. First, the inception of an ETF is an unusual event that may attract the attention of investors to index securities, and thereby induce new investors to trade in them (Barber & Odean, 2008). Second, the inception of an ETF gives the index components some useful publicity. As shown by Grullon, Kanataas, and Weston (2004), increased advertising results in increased stock liquidity because new-found individual and institutional investors participate in the market. The recognition hypothesis thus predicts increased liquidity after the inception of an ETF, and this effect is expected to be more pronounced for index components that were less traded prior to the ETF introduction, that is the smallest components of the index (see Richie & Madura, 2007).

3.4. Testable hypotheses

According to the adverse selection hypothesis, the liquidity of the basket of stocks is reduced after the introduction of the ETF, because adverse selection increases in the cash stock market. This theory can be examined by testing the hypotheses that:

immediately after the inception of the ETF,

H1a. the trading volumes of index stocks decrease relative to those of non-index stocks;

H2a. the spreads and depth of index stocks deteriorate relative to those of non-index stocks;

H3. the adverse selection costs of index stocks increase relative to those of non-index stocks;

H4. provided H3 holds, adverse selection costs increase more for stocks with smaller weights in the index.

Alternatively, according to the arbitrage and recognition hypotheses, the liquidity of the underlying stocks is improved with the introduction of the ETF, so that these two theories may hold if we find evidence to support H1b and H2b (below), which are the opposite of H1a and H2a:

immediately after the inception of the ETF,

H1b. the trading volumes of index stocks increase relative to those of non-index stocks;

H2b. the spreads and depth of index stocks improve relative to those of non-index stocks.

According to Fremault (1991), under some market conditions, increased arbitrage trading may help stabilize prices. This leads us to test the hypothesis that:

H5. immediately after the inception of the ETF, the temporary volatility of index stocks decreases relative to that of non-index stocks.

While support for H5 would favor the arbitrage hypothesis, rejecting H5 would still be compatible with Fremault's (1991) arbitrage theory, as she identifies market conditions under which increased arbitrage does not necessarily stabilize prices.

Finally, while Fremault's (1991) arbitrage theory does not predict any differential effect between small and large index components, the recognition effect should affect the smallest constituents most. Subsequently, if we find support for H1b and H2b, additional evidence for the recognition hypothesis would come from support for H6:

H6. when support for H1b and H2b is present, the increase in liquidity is greatest for the smallest components of the index;

whereas rejecting H6 would lead us to eliminate the recognition hypothesis and retain the arbitrage hypothesis only.

4. The impact of the introduction of an ETF on the liquidity of underlying stocks

In order to test the competing hypotheses related to the introduction of a basket security, we examined the variation in several liquidity measures for the stocks of the CAC 40 index and for a sample of control stocks on two 3-month intervals surrounding the date (January 22, 2001) of the inception of the ETF. The motivations for choosing those two sixty-day trading windows are very close to those put forward by Hegde and McDermott (2004) for their choice of fifty-day trading windows. On the one hand, the post-ETF period should be long enough to include days when the ETF is sizeable enough and thus capture liquidity effects related to its trading activity. On the other hand, the trading window should be short enough to minimize the probability that exogenous factors, not controlled for in the analysis, confound the results. The pre-introduction observation period is defined as the 60 trading days between October 19, 2000 and January 15, 2001, while the post-introduction period covers the 60 trading days from February 1, 2001 to April 27, 2001. These two observation periods do not include the two weeks immediately surrounding the inception of the Lyxor CAC 40. We eliminate those trading days as a precaution, as we fear that uncharacteristic portfolio strategies implemented at the time of the introduction may create non-permanent liquidity pressures, and thereby blur the permanent effects that we want to grasp.[17]

Our sample of interest comprises the constituents of the CAC 40 index during the defined observation periods. After excluding securities added to and deleted from the CAC 40 index in those periods, and a stock for which a major corporate event occurred, we were left with a sample of 37 stocks. The control sample was formed by selecting 37 non-CAC 40 stocks in the SBF 120 index. The SBF 120 includes the constituents of the CAC 40 index plus the next 80 most actively traded stocks listed on Euronext Paris. In this set of 80 securities, we selected our control stocks by following the same matching procedure as Van Ness et al. (2005). This procedure is based on four stock attributes: market capitalization, return volatility, share price, and trade size. Market capitalization is the market value of the equity as observed on the first day of the pre-ETF period. Return volatility, share price, and trade size are respectively the standard deviation of the daily close returns in logarithm, the average close price, and the average trade size, as estimated over the pre-ETF 60-days trading window. The matching algorithm consists of matching each CAC 40 constituent with the non-CAC 40 stock that minimizes the following composite match score (CMS):

$$\mathrm{CMS} = \sum_{k=1}^{4}\left[\frac{Y_k^{CAC} - Y_k^{SBF}}{\left(Y_k^{CAC} + Y_k^{SBF}\right)/2}\right]^2, \tag{2}$$

where Y_k represents one of the four matching factors, superscript *CAC* refers to the index stock, and superscript *SBF* refers to the non-index potential match stock. A maximum value of one was imposed on the value of the $\frac{Y_k^{CAC} - Y_k^{SBF}}{\left(Y_k^{CAC} + Y_k^{SBF}\right)/2}$ ratio for the volatility factor and the share price factor,[18] and the total CMS never exceeded four. The 37 stock pairs resulting from this matching procedure are listed in Appendix A.

After describing the data, we test the hypotheses derived in Section 3 by conducting univariate and multivariate analyses of liquidity and

[17] We deliberately excluded from our observation periods two weeks of trading around the date of introduction of the Lyxor CAC 40 ETF to avoid uncharacteristic liquidity patterns that could have arisen at the time of the introduction. Reincorporating those two censored weeks in the observation periods leaves our findings identical in all ways.

[18] This constraint ensures that the greatest of the two values does not exceed 300% of the lowest.

price stability measures for both the CAC 40 sample and the control sample in the pre-ETF and post-ETF periods.

4.1. Data

The high frequency trade and quote data used in this section were extracted from the Euronext BDM (*Base de Données de Marché*) market database. Trade files provided the date, time, price, and volume of each trade executed during the opening auction, the continuous session, and the closing auction. The quote data cover best bid and ask limit prices with associated displayed quantities as posted during the trading session. Hidden quantities are not provided.

Quote and trade timestamps are based on a second-by-second frequency. In the best-quote files, a new record appears each time any feature of the best limits, either a price or a quantity, changes. In the trade database, if one buy (sell) marketable order executes against n sell (buy) orders with the same limit price, then n trades with the same timestamp and price will be recorded. In addition, each time an order is executed against a pending limit order, it modifies the best bid and ask quotes, so that a new best quote record is automatically produced with the same timestamp as the trade from which it results. If a trade is executed against several orders, there will be several successive quotes produced by the trade and they will be recorded in chronological order in the quote file.

We aggregated trade records with the same timestamp and price into a single trade record. When several quote records had the same timestamp, we kept the last one recorded in the best quote file. When ordering trades and best quotes, if a trade and a quote had the same timestamp, the quote was considered as following the trade. Trades were then signed according to their price relative to the prevailing mid-quote at the time of the trade. Like Lee and Ready (1991), we considered trades whose prices were higher than the mid-quote to be buyer-initiated and those whose prices were lower than the mid-quote to be seller-initiated.

Euronext defines a normal block size (NBS) to stocks that are eligible for block trading. The NBS is the minimum share quantity to which the block trading procedure applies. Euronext continuously reports the bid–ask spread that would result from buying and selling the NBS against orders in the order book. This spread, designated hereafter as the block spread, is obtained by weighting the different bid and ask limit prices hit to execute the NBS with associated quantities.

4.2. Univariate analysis

The univariate analysis consists of testing the difference between the pre-ETF and the post-ETF observation periods in the cross-sectional means of several variables. We performed statistical tests in two ways: first, the cross-sectional means of each variable were compared for the CAC 40 sample and for the control sample in the pre- and post-ETF periods, using a paired t-test. We tested both for the difference in the absolute and the percentage variation. Second, we used a difference-in-difference approach to compare cross-sectional absolute and percentage variations from the pre-ETF to the post-ETF period across samples. The variables reported in Tables 2 to 4 do not always exhibit similar level for the CAC 40 and the control sample stocks. For that reason, the results of the difference in difference tests based on the percentage variation are more economically meaningful.

In order to test hypotheses H1a, H1b, H2a, and H2b, we started by considering measures related to trading volumes, trading frequency, spreads, and depth. The average daily trading volume in euros, the total trading volume in number of shares, the average daily number of trades, and the average trade size were measured by the volume and trading frequency. According to H1a, there should be a significant decrease in measures of volume for the CAC 40 sample, with no similar effect for the control sample. Conversely, H1b predicts a significant increase in measures of volume for the CAC 40 sample. We then compared bid–ask spread measures. The average quoted spread for stock i over a given sub-period is computed on a time-weighted basis as follows:

$$DWQS_i = \frac{1}{\sum_{n=1}^{N_i} d_{i,n}} \sum_{n=1}^{N_i} d_{i,n} \frac{ask_{i,n} - bid_{i,n}}{mid_{i,n}}, \quad (3)$$

where $bid_{i,n}$, $ask_{i,n}$, and $mid_{i,n}$ are respectively the best bid, best ask, and middle prices at the time of the nth quoted spread for stock i; $d_{i,n}$ designates the number of seconds for which the nth quoted spread was in effect in the market for stock i; and N_i is the number of quoted spreads for stock i during a given sub-period. Specific reference to the sub-period in the notation has been omitted for the sake of brevity.

The average effective spread is defined as:

$$ES_i = \frac{1}{T_i} \sum_{s=1}^{T_i} 2 \times \frac{P_{i,s} - mid_{i,s}}{mid_{i,s}} \times I_{i,s}, \quad (4)$$

where $P_{i,s}$, $mid_{i,s}$ and $I_{i,s}$ are respectively the sth transaction price for stock i, the middle price prevailing before the sth transaction and the sign of the trade (+1 if the trade is buyer-initiated and −1 if the trade is seller-initiated), and T_i is the number of trades for stock i during the sub-period.

For stocks eligible for the block trading procedure, we compute the time-weighted average of their adjusted block spreads (ABS) as:

$$\mathrm{ABS}_i = \frac{1}{\sum_{m=1}^{M_i} \delta_{i,m}} \times \sum_{m=1}^{M_i} \frac{\delta_{i,m}}{2 \times NBS_{i,m}} BS_{i,m}, \quad (5)$$

where $BS_{i,m}$, $\delta_{i,m}$ and $NBS_{i,m}$ are respectively the mth block spread (as a percentage of the mid-price) for stock i, the time for which the mth block spread prevails in the market for stock i, and the normal block size defined by Euronext at the time of the mth block spread, and M_i is the number of block spreads reported for stock i during the sub-period. We chose to normalize the block spread by the normal block size prevailing on the day under consideration because normal block sizes change for several stocks during the sample period. Those changes mechanically impact the size of the block spread and are likely to bias variation tests. We then multiplied this quantity by a scaling factor of 100,000 for convenience of presentation.

We also examined the market depth, as measured by the euro volumes associated with the best limits, as

$$D_i = \frac{1}{\sum_{n=1}^{N_i} d_{i,n}} \sum_{n=1}^{N_i} d_{i,n} \left(Qbid_{i,n} \times bid_{i,n} + Qask_{i,n} \times ask_{i,n} \right) \quad (6)$$

where $Qbid_{i,n}$ is the number of shares demanded at the best bid price and $Qask_{i,n}$ is the number of shares offered at the best ask price at the time of the nth quoted spread for stock i. Finding a significant increase in spread measures and a significant decrease in depth measures for the CAC 40 stocks, in comparison with the control stocks, would be in favor of H2a, while the opposite would support H2b.

Tests of H3 are based on information asymmetry measures. Following Aktas, de Bodt, Declerck, and Van Oppens (2007), we used the relative order imbalance (OIB) as a proxy for the probability of information-based trading (PIN) introduced by Easley, Kiefer, O'Hara, and Paperman (1996). The average order imbalance for

Table 2
A comparison of liquidity measures before and after the introduction of an ETF.

	CAC 40 sample		Control sample		Difference in differences	
	Absolute mean variation	% mean variation	Absolute mean variation	% mean variation	Absolute mean variation	% mean variation
Daily trading volume (in thousands of euros)	4368	16.98**	174	3.32	4194	13.66
	(0.2403)	(0.0362)	(0.7949)	(0.6227)	(0.2664)	(0.1884)
Total trading volume (in thousands of shares)	17,907***	23.38***	770	5.36	17,137**	18.01*
	(0.0096)	(0.0019)	(0.3853)	(0.3652)	(0.0135)	(0.0514)
Daily number of trades	55	4.16	−25	−5.59	81	9.75*
	(0.4312)	(0.1778)	(0.3839)	(0.1779)	(0.2878)	(0.0585)
Average trade size (in euros)	2239	9.75**	1940	9.45*	299	0.30
	(0.1982)	(0.0340)	(0.1191)	(0.0774)	(0.8870)	(0.9647)
Quoted spreads (as % of mid-price)	−0.0222***	−8.92***	−0.0006	−2.43	−0.0216	−8.68***
	(<0.0001)	(<0.0001)	(0.9719)	(0.9249)	(0.1961)	(0.0060)
Effective spread (as % of mid-price)	−0.0256***	−10.55***	−0.0117	−2.49	−0.0138	−8.06**
	(<0.0001)	(<0.0001)	(0.4865)	(0.3553)	(0.4279)	(0.0133)
Best-limit depth (in euros)	5382*	11.67**	720	4.36	4662	7.30
	(0.0779)	(0.0132)	(0.4772)	(0.3308)	(0.1436)	(0.2494)
Adjusted block spreads (as % of mid-price)	0.0687***	66.17***	0.3347***	48.72***	−0.2660***	17.44**
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0351)

Note: For each liquidity variable, the absolute mean variation and the percentage mean variation are computed for the CAC 40 and the control samples as the equally-weighted cross-sectional mean difference between the two 60-trading-day periods surrounding the ETF inception on January 22, 2001. The statistical test is a paired *t*-test on the mean difference. The *p*-values are reported in the table under parenthesis. For the difference-in-difference approach, the test is an independent group *t*-test on the cross-sectional mean difference between CAC 40 and control stocks, based on the absolute variation and the percentage variation between the two 60-day periods. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

stock *i* during a given period was calculated as a percentage of the euro traded volume:

$$OIB_i = \frac{\sum_{s=1}^{T_i} P_{i,s} Q_{i,s} I_{i,s}}{\sum_{s=1}^{T_i} P_{i,s} Q_{i,s}}, \tag{7}$$

where $Q_{i,s}$ is the unsigned quantity of the *s*th transaction for stock *i*. This measure is complemented by spread decomposition methods to distinguish the non-informational (inventory and order processing) and the informational component of the spread. We used two alternative methods: (1) the decomposition of the effective spread into a realized spread and a permanent price impact within a given time interval (see Bessembinder & Kaufman, 1997); and (2) the approach of Lin, Sanger, and Booth (1995) (hereafter, LSB).[19] An increase in the permanent price impact and the LSB adverse selection component for the CAC 40 stocks, in comparison with the control stocks, would support H3.

Using the notations introduced above, the proportion of asymmetric information was measured by the average price impact at an *x*-minute interval, calculated for stock *i*:

$$PI_{x\,\min,i} = \frac{1}{T_i} \sum_{s=1}^{T_i} 2 \times \frac{mid_{i,s+x\,\min} - mid_{i,s}}{mid_{i,s}} \times I_{i,s}. \tag{8}$$

As there is no unanimous choice of the benchmark price to be used after a transaction, we measured the price impact at three time horizons: 5, 15 and 30 min. The corresponding non-informational cost was measured by the realized spread at an *x*-minute interval, defined for stock *i* as:

$$RS_{x\,\min,i} = \frac{1}{T_i} \sum_{s=1}^{T_i} 2 \times \frac{P_{i,s} - mid_{i,s+x\,\min}}{mid_{i,s}} \times I_{i,s}. \tag{9}$$

[19] Huang and Stoll's (1997) two- and three-factor spread decomposition models were also tested, but we experienced convergence problems for some stocks. Thus an average coefficient across stocks could not be computed.

The LSB adverse selection component was estimated as the sensitivity, λ, of mid-price revisions to trade directions, using the following regression model for each stock *i*:

$$mid_{i,s+1} - mid_{i,s} = \lambda_i \left(P_{i,s} - mid_{i,s}\right) + e_{i,s+1}. \tag{10}$$

We used the same estimation procedure as in Lin et al.'s (1995) original paper (i.e. we ran Regression (10) using the log prices); $mid_{i,s+1}$ is the mid-price valid at the $(s + 1)$th transaction. Adverse selection costs were then estimated as a part of the spread by multiplying λ_i by the average effective spread of stock *i*, ES_i, as defined in Eq. (4). The extent of order persistence θ was captured through the following regression run for each stock:

$$P_{i,s+1} - mid_{i,s+1} = \theta_i \left(P_{i,s} - mid_{i,s}\right) + \eta_{i,s+1}, \tag{11}$$

where the disturbance terms *e* and η are uncorrelated. The expected profit as a fraction of the effective spread when submitting an order is $\gamma_i = 1 - \lambda_i - \theta_i$. Multiplying γ_i by the average effective spread ES_i provides the part of the spread reflecting order processing costs.

The results of the paired *t*-tests reported in Table 2 indicate an improvement in liquidity at the best-limit level, with a significant reduction in average quoted spreads and effective spreads, and a significant increase in the best-limit depth for the CAC 40 stock sample. The variations of those measures are not significant for the control sample. The reduction in spreads for the CAC 40 stocks cannot be attributed to an increase in the daily number of trades. Only the number of traded shares increased significantly in level and in percentage for the index stocks after the ETF inception. The difference-in-difference tests on the percentage variations show a significant reduction in spreads and an increase in the number of trades and traded shares for the CAC 40 sample stocks, relative to the control sample stocks. There was an opposite liquidity effect at the upper limits, for both the CAC 40 and the control samples: adjusted block spreads widened significantly in the post-ETF period, meaning that the cost of immediacy on large trades increased for all stocks. The post-ETF increase in the mean adjusted block spread as a percentage of the mid-price was larger for the control stocks. However, the difference-in-difference test on percentage variations shows that this increase was significantly higher for the CAC 40 stocks.

Table 3
A comparison of order imbalance and spread components before and after the introduction of the ETF.

	CAC 40 sample		Control sample		Difference in differences	
	Absolute mean variation	% mean variation	Absolute mean variation	% mean variation	Absolute mean variation	% mean variation
Average order imbalance	−1.6821*	161.71*	1.7658	321.03**	−3.4479*	−159.32
	(0.0824)	(0.0533)	(0.2764)	(0.0181)	(0.0680)	(0.3015)
5-minute price impact	−0.0033	−0.98	−0.0342**	−8.79**	0.0309*	7.80*
	(0.3579)	(0.7172)	(0.0280)	(0.0127)	(0.0507)	(0.0744)
5-minute realized spread	−0.0261***	−25.45***	−0.0093	−4.90	−0.0168	−20.55***
	(<0.0001)	(<0.0001)	(0.4031)	(0.1826)	(0.1508)	(<0.0001)
15-minute price impact	−0.0035	−0.63	−0.0330**	−7.51**	0.0295*	6.88
	(0.3688)	(0.1424)	(0.0378)	(0.0339)	(0.0703)	(0.1430)
15-minute realized spread	−0.0259***	−24.33***	−0.0105	−4.57	−0.0154	−19.75***
	(<0.0001)	(<0.0001)	(0.3354)	(0.2327)	(0.1849)	(0.0002)
30-minute price impact	−0.0012	1.78	−0.0223	−2.85	0.0211	4.63
	(0.7900)	(0.6360)	(0.1978)	(0.5024)	(0.2376)	(0.4140)
30-minute realized spread	−0.0281***	−25.35***	−0.0212*	−4.82	−0.0070	−20.53***
	(<0.0001)	(<0.0001)	(0.0534)	(0.2910)	(0.5429)	(0.0007)
LSB adverse selection cost	−0.0027	4.81	0.0035	17.69	−0.0062*	−17.21
	(0.1255)	(0.9453)	(0.2380)	(0.1696)	(0.0726)	(0.2363)
LSB order processing cost	−0.0139***	−15.49***	−0.0027	2.77	−0.0111*	−18.27***
	(<0.0001)	(0.0008)	(0.5934)	(0.5168)	(0.0575)	(0.0032)

Note: For the order imbalance and spread component measures, the absolute mean variation and the percentage mean variation are computed for the CAC 40 and the control samples as the equally-weighted cross-sectional mean difference between the two 60-trading-day periods surrounding the ETF inception on January 22, 2001. The statistical test is a paired *t*-test on the mean difference. The *p*-values are reported in the table under parenthesis. Spread measures are expressed in percentage of the mid-price and the order imbalance is in percentage of total trading volumes. An independent group *t*-test on the cross-sectional mean difference between CAC 40 and control stocks, based on the absolute variation and the percentage variation between the two 60-day periods, is used for the difference-in-difference test. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4
A comparison of the variance ratios of the returns before and after the introduction of the ETF.

	CAC 40 sample		Control sample		Difference in differences	
	Absolute mean variation	% mean variation	Absolute mean variation	% mean variation	Absolute mean variation	% mean variation
1-minute to 5-minute variance ratios	−0.0090***	−3.53**	0.0073*	3.13*	−0.0162***	−6.66***
	(0.0089)	(0.0161)	(0.0959)	(0.0902)	(0.0034)	(0.0046)
1-minute to 30-minute variance ratios	−0.0020**	−3.77	0.0020	5.52*	−0.0040**	−9.28**
	(0.0471)	(0.1084)	(0.1490)	(0.0789)	(0.0188)	(0.0174)
5-minute to 30-minute variance ratios	−0.0015	−0.55	0.0021	2.01	−0.0036	−2.56
	(0.5468)	(0.6952)	(0.6121)	(0.3687)	(0.4535)	(0.3304)

Note: For all the variance ratios reported in this table, the absolute and percentage mean variation for the CAC 40 and the control samples equal the equally-weighted cross-sectional mean difference between the two 60-trading-day periods surrounding the ETF inception on January 22, 2001. The statistical test is a paired *t*-test on the mean difference. The *p*-values are reported in the table under parenthesis. An independent group *t*-test on the cross-sectional mean difference between CAC 40 and control stocks, based on the absolute and percentage variations between the two 60-day periods, was used for the difference-in-difference test. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Comparative results for the relative order imbalance and the spread components are presented in Table 3. The relative order imbalance and price impact measures converge to show that adverse selection costs did not vary significantly after the inception of the ETF and that information asymmetry in individual stocks did not increase when the basket security was introduced. The only exception is a slight and weakly significant decrease in the 5-minute price impact of control stocks relative to index stocks. In contrast, the realized spreads at various time intervals and the LSB order processing cost strongly diminished during the second sub-period for the CAC 40 sample stocks, with no similar effect for the control sample stocks.

To test H5, we compared the variance ratios of the returns from the CAC 40 and control stocks in the pre- and post-ETF periods (see Table 4). We considered three variance ratios: the variance of 1-minute returns divided by that of 5-minute returns; the variance of 1-minute returns divided by that of 30-minute returns; and the variance of 5-minute returns divided by that of 30-minute returns. 1-minute, 5-minute and 30-minute returns were computed between 9.15 a.m. and 5.15 p.m. The temporary price volatility of index stocks decreased significantly after the introduction of the ETF when measured over very short horizons with the 1-minute/5-minute variance ratio. The difference-in-difference approach also shows that the 1-minute/30-minute variance ratio decreased more for index stocks than for the matched stocks. Yet no significant change is found for the 5-minute/30-minute ratio. This does not give strong economic support to the hypothesis that the introduction of the ETF has a price stabilization effect.

4.3. Multivariate analysis

The univariate tests conducted on spreads, depth, price impact, and variance ratios were complemented by multiple panel regressions that controlled for volatility, trading volume, price level, and order imbalance, as well as market wide and macroeconomic factors following the method of Chordia, Roll, and Subrahmanyam (2001), also used by Van Ness et al. (2005). We considered six liquidity variables: (1) the time-weighted average of the relative quoted spread; (2) the average of the relative effective spread; (3) the average time-weighted adjusted block spread; (4) the time-weighted mean of the quantities available at the best-limit quotes, measured in euros and taken in logarithms, referred to as the best-limit depth; (5) the average realized spread over a 5-minute time interval; and (6) the average 5-minute price impact.[20] We computed these variables on a daily basis for the 37 CAC 40 stocks and their matched control stocks. We thus have 74 stocks with 120 daily observations per cross-section.

[20] The panel regressions of 5-minute realized spread and price impact were replicated by computing realized spreads and price impacts over time intervals of 15 min and 30 min. The findings are very similar to those obtained at the 5-minute horizon.

For each liquidity variable, denoted LV_{it} on day t for stock i, the regression model is initially designed as follows:

$$\begin{aligned}LV_{i,t} &= a_0 + a_1 CAC40_i + a_2\sigma_{i,t} + a_3 \ln V_{i,t} + a_4 \ln P_{i,t} + a_5 OIB_{i,t}\\ &+ b_1 MarketUp_t + b_2 MarketDown_t\\ &+ c_1 Monday_t + c_2 Tuesday_t + c_3 Wednesday_t + c_4 Thursday_t + c_5 Holiday_t\\ &+ dETF_t + eTEC10_t + fQualitySpread_t\\ &+ gETF_t \times CAC40_i + hETF_t \times w_i + u_{i,t}.\end{aligned} \quad (12)$$

In Eq. (12): $CAC40_i$ is a binary variable that is set to one if stock i belongs to the CAC 40 index, and zero otherwise; $\sigma_{i,t}$ denotes the price range calculated as the difference between the highest and lowest price, divided by the lowest price during day t for stock i; $\ln V_{i,t}$ is the logarithm of the euro volume traded on stock i at date t; $\ln P_{i,t}$ is the logarithm of stock i's open price on day t; $OIB_{i,t}$ is the absolute value of the difference between sell trade volumes and buy trade volumes as a proportion of the total trade volume for stock i on day t; $MarketUp_t$ equals the CAC 40 index return when positive, zero otherwise; $MarketDown_t$ equals the CAC 40 index return when negative, zero otherwise; $Monday_t$, $Tuesday_t$, $Wednesday_t$, and $Thursday_t$ are day-of-the-week dummies; $Holiday_t$ equals one when the day preceding or the day following t is a banking holiday; ETF_t is zero before the introduction of the ETF and one afterward; $TEC10_t$ is the value of the 10-year constant maturity French Treasury yield on date t[21]; $QualitySpread_t$ is the difference between the daily return of the clean price index for French 10-year sovereign bonds and the daily return of the Barclays index for French B or better rated corporate bonds; w_i is the weight of stock i in the CAC 40 index expressed as a decimal at the ETF inception date when i is a CAC 40 stock, zero otherwise; and $u_{i,t}$ is a residual term.

Dummy $CAC40_i$ controls for structural differences between CAC 40 stocks and their matched stocks. Volatility, volumes, price level, and order imbalance are commonly-admitted determinants of liquidity. Dummy ETF_t, $MarketUp_t$, $MarketDown_t$, $TEC10_t$, and $QualitySpread_t$ control for the general trend of spreads from one period to the other and proxy for macroeconomic factors that might have affected the level and general liquidity of the market. Interacted variables $ETF_t \times CAC40_i$ and $ETF_t \times w_i$ are our variables of interest.

According to H2a, the total value of $g + hw_i$ should be significantly positive when LV_{it} is a spread measure and significantly negative when LV_{it} is the best-limit depth, whereas H2b predicts the opposite. Finding a positive value for $g + hw_i$ in the regressions of the price impact would support H3. Finding that these positive values are, in addition, associated with a significantly negative value of h would provide evidence for H4. Finally, the value of h coefficients in spread and depth regressions provides a statistical test for H6, which relates to the recognition hypothesis and predicts that the liquidity of small components of the CAC 40 index should improve more than that of large components. The non-rejection of H6 would rely on both a statistically negative value of $g + hw_i$ plus a statistically positive value of h in regressions of spreads, and a statistically positive value of $g + hw_i$ plus a statistically negative value of h in regressions of depth.

Panel regressions (12) were estimated by clustering standard errors by stock, so that standard errors are robust to clusters of volatility, by either stock group or genuine stock, and any kind of correlation across time. Results based on 60-day windows are displayed in Panel A of Table 5. In order to check to what extent our results were sensitive to the choice of the trading windows preceding and following the opening of the ETF market, we reduced those windows to 30 trading days. Estimations were conducted with a pre-ETF period starting on 30 November 2000 and ending on 15 January 2001, and a post-ETF period spreading alternatively from 1 February to 14 March 2001 (Panel B of Table 5) and from 15 March to 27 April 2001 (Panel C of Table 5). The estimates of g (variable $ETF_t \times CAC40_i$) in Panel A of Table 5 indicate that the quoted, effective, realized, and adjusted block spreads of CAC 40 stocks significantly decreased in the post-ETF period in comparison with the control sample. The h coefficients (variable $ETF_t \times w_i$) are significantly positive at the 1% level for the four measures of spread: spreads reduced more for low-weighted index components, although the economic magnitude of this differential effect is relatively small. The total economic impact of the introduction of the ETF on the spreads of a given stock i is represented by $g + hw_i$, with w_i ranging from 0.003526 to 0.094201. For the quoted spreads, the estimated values of g and h are -0.0427 and 0.0172 respectively, which means that the decrease in quoted spread for the smallest CAC 40 component was -0.0426% ($-0.0427 + 0.0172 \times 0.003526 = -0.0426$ as a percentage of the mid-quote) while it was -0.0411% for the largest component. Similar calculations for other spread measures indicate that the post-ETF decrease in spread for index stocks ranged from -0.0405% to -0.0388% for effective spreads, from -0.0452% to -0.0437% for realized spreads, and from -0.3031% to -0.3000% for the adjusted block spread. This tends to support H2b at the detriment of H2a. Depth measured at the best quotes is found to deteriorate for index components after the ETF introduction, which mitigates our results in favor of H2b. However, the economic size of spread improvements prevails over that of depth reduction. The values of the g and h coefficients reported to the average values of spreads and depth in the pre-ETF period imply that, for a security with an average weight of 1/40 in the CAC 40 index, the quoted bid–ask spread, the effective spread, and the realized spread decreased by 19.04%, 18.32%, and 44.07% of their initial average values respectively with the ETF introduction, whereas depth decreased by 15.46%. Those figures, plus the sizeable reduction of the adjusted block spread, support the liquidity improvement hypothesis H2b, the driving force of this improvement being the fall in realized spreads. Further, the analysis by sub-periods of 30 days (Panels A and B of Table 5) shows that those effects start being significant only from 15 March 2001, date at which the size of the ETF fund has just doubled relative to its initial size on 22 January. In other words, it requires a critical size of the ETF for those effects to realize. This tends to rule out the recognition hypothesis (H6), even though coefficients h are all significantly positive, because recognition effects should occur immediately at the time of the ETF inception. Last, regressions of the price impact produced significantly negative values of g and negative values of $g + hw_i$ for all components of the CAC 40. This leads us to reject H3 and makes H4 irrelevant.

Panel regressions were also estimated for daily variance ratios with the following design:

$$VR_{i,t} = \alpha + \beta'.CV_{it} + \gamma\, ETF_t \times CAC40_i + z_{i,t}. \quad (13)$$

where: $VR_{i,t}$ is alternatively the 1-minute/5-minute variance ratio, the 1-minute/30-minute variance ratio, and the 5-minute/30-minute variance ratio; CV_{it} is the same set of control variables as those used in Regressions (12) and β is the associated coefficient vector; and $z_{i,t}$ is a white noise. In the estimation, standard errors were clustered by stock.

Regressions (13) test H5: a significantly negative g in these regressions would indicate a price stabilization effect of the ETF introduction for underlying stocks and would support H5. Results, reported in Table 6, are strictly consistent with those of the univariate tests: g is significantly negative for the 1-minute/5-minute variance ratio but is not significantly different from zero for other variance ratios. This leaves us with very weak evidence for H5.

[21] The Central Bank short rate variable used in Chordia et al. (2001) and Van Ness et al. (2005) is not included in the model as the key interest rates of the European Central Bank remained unchanged from 11 October 2000 to 10 May 2001 included. The refinancing rate was constantly equal to 4.75%, the marginal deposit facility rate was equal to 3.50%, and the marginal lending facility was 5.50%. For the same reason, variable *TermSpread* in Chordia et al. (2001) and Van Ness et al. (2005), i.e., the spread between the 10-year sovereign yield and the Central Bank short rate is here replaced by the 10-year sovereign yield (TEC10).

Table 5
Panel regressions of liquidity measures.

	Quoted spread		Effective spread		Best-limit depth		Adjusted block spread		5-minute price impact		5-minute realized spread	
	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value
Panel A — pre- and post-ETF periods of 60 days												
Intercept	1.3402***	0.000	1.2092***	0.000	5.3832***	0.000	−3.7750***	0.000	0.0417	0.796	0.8727***	0.000
$CAC40_i$	−0.0186	0.504	−0.0291	0.268	0.0549	0.376	−0.0048	0.947	−0.0546**	0.029	0.0030	0.899
σ_{it}	4.2636***	0.000	5.2961***	0.000	−6.3702***	0.000	7.4681***	0.000	4.3064***	0.000	0.8152**	0.019
$\ln V_{it}$	−0.1035***	0.000	−0.1011***	0.000	0.3639***	0.000	−0.2362***	0.000	−0.0399***	0.000	−0.0634***	0.000
$\ln P_{it}$	0.0281***	0.008	0.0251**	0.013	0.3744***	0.000	0.3513***	0.000	0.0254***	0.002	0.0011	0.888
OIB_{it}	0.0013***	0.000	0.0013***	0.000	−0.0027***	0.000	0.0020***	0.080	0.0004***	0.001	0.0011***	0.000
$MarketUp_t$	0.0101***	0.009	−0.0041	0.218	0.0023	0.714	−0.0405***	0.000	0.0090	0.206	0.0023	0.437
$MarketDown_t$	0.0026	0.419	0.0088***	0.009	−0.0079	0.124	0.0347***	0.000	0.0053**	0.031	0.0064**	0.010
$Monday_t$	−0.0207***	0.000	−0.0140**	0.013	−0.0256**	0.023	0.3748***	0.000	0.0077**	0.047	−0.0180***	0.001
$Tuesday_t$	−0.0225***	0.000	−0.0160***	0.004	−0.0113	0.300	0.0038	0.636	−0.0036	0.355	−0.0151***	0.002
$Wednesday_t$	−0.0123**	0.028	−0.0143**	0.014	0.0012	0.902	0.0055	0.441	0.0060	0.106	−0.0151***	0.007
$Thursday_t$	−0.0048	0.309	−0.0056	0.221	−0.0163*	0.087	0.0035	0.612	0.0367**	0.017	−0.0085*	0.084
$Holiday_t$	−0.0023	0.807	0.0007	0.947	−0.0422***	0.009	0.0450***	0.005	−0.0220***	0.006	0.0087	0.275
$TEC10_t$	−5.6201***	0.001	−3.7962**	0.026	3.8825	0.215	87.5674***	0.000	5.1029*	0.080	−2.5471*	0.078
$QualitySpread_t$	0.4734	0.608	0.9981	0.274	−5.4681***	0.001	−28.3216***	0.000	−9.1589**	0.013	1.4148*	0.088
ETF_t	−0.0136	0.320	−0.0193	0.154	0.0486**	0.041	0.5906***	0.000	−0.0129	0.162	−0.0188*	0.079
$ETF_t \times CAC40_i$	−0.0427**	0.036	−0.0406**	0.042	−0.1698***	0.000	−0.3032***	0.000	0.0325*	0.051	−0.0453***	0.004
$ETF_t \times w_i$	0.0172***	0.000	0.0186***	0.000	0.0752***	0.000	0.0336***	0.006	0.0023	0.375	0.0169***	0.000
Centered R^2	57.14%		58.79%		81.84%		18.43%		10.31%		38.54%	
Uncentered R^2	85.17%		85.38%		99.87%		29.70%		30.35%		67.85%	
Panel B — pre- and post-ETF periods of 30 days — post-ETF period from 1 February to 14 March 2001												
$ETF_t \times CAC40_i$	0.0118	0.548	0.0115	0.538	0.0115	0.772	0.0254**	0.041	−0.0132	0.374	0.0118	0.548
$ETF_t \times w_i$	0.0147***	0.000	0.0144***	0.000	0.0417***	0.000	0.0015	0.547	0.0134***	0.000	0.0147***	0.000
Centered R^2	59.35%		61.12%		66.21%		46.19%		40.33%		59.35%	
Uncentered R^2	86.65%		86.96%		79.15%		76.32%		71.77%		86.65%	
Panel C — pre- and post-ETF periods of 30 days — post-ETF period from 15 March to 27 April 2001												
$ETF_t \times CAC40_i$	−0.0753***	0.009	−0.0776***	0.007	−0.2160***	0.000	−0.5738***	0.000	−0.0023	0.826	−0.0750***	0.001
$ETF_t \times w_i$	0.0195***	0.000	0.0228***	0.000	0.0734***	0.000	0.0302**	0.049	0.0042*	0.061	0.0189***	0.000
Centered R^2	58.59%		59.55%		83.15%		22.66%		46.45%		39.74%	
Uncentered R^2	85.37%		85.31%		99.88%		31.97%		77.97%		67.25%	

Note: Panel A of this table shows the estimates of panel regressions conducted on 120 daily observations for 74 stocks. Panel B shows the estimates for 60 daily observations where the post-ETF period is taken immediately following the ETF introduction from 1 February to 14 March 2001. Panel C shows the estimates for 60 daily observations where the post-ETF period is taken from 15 March to 27 April 2001. The dependent variables are the time-weighted average bid–ask spread, the average effective spread per trade, the time-weighted average adjusted block spreads, the average 5-minute realized spread, the average 5-minute price impact, and the time-weighted average best-limit depth measured in euros and taken in logarithms. σ_{it}, $\ln V_{it}$, $\ln P_{it}$, and I_{it} are, respectively, the price range, the euro trading volume in logarithm, the close price in logarithm, and the imbalance between buy and sell traded volumes as a percentage of the total traded volume, for stock *i* on day *t*. $MarketUp_t$ ($MarketDown_t$) is the index return when positive (negative), 0 otherwise. $Monday_t$, $Tuesday_t$, $Wednesday_t$, and $Thursday_t$ are day-of-the-week dummies. $Holiday_t$ equals 1 when the day preceding or the day following *t* is a banking holiday. $TEC10_t$ is the value of the 10-year constant maturity French Treasury yield on date *t*. $QualitySpread_t$ is the difference between the daily return of the clean price index for French 10-year sovereign bonds and the daily return of the Barclays index for French B or better rated corporate bonds. ETF_t is a variable set to 0 before the introduction of the ETF and to 1 afterwards. $CAC40_i$ is set to 1 for CAC 40 stocks, 0 otherwise. w_i is the weight of stock *i* in the CAC 40 index at the ETF inception date and is set to 0 for non-CAC 40 stocks. Errors are clustered by stock. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

5. Interpreting the findings and discussing the theoretical hypotheses

Difference-in-difference tests on measures of trading volumes produced significant results only for the total trading volume, which significantly increased for index stocks at the 10% threshold. This allows us to reject H1a and leaves us with very weak evidence in support of H1b. However with respect to spreads, the difference-in-difference approach and the multivariate analysis converged to show a very significant tightening of quoted and effective spreads for CAC 40 stocks in the post-ETF period. Adjusted block spreads of index stocks were also found to decrease significantly relative to those of non-index stocks in the panel regressions, although this was not as strongly supported by the univariate tests. Regarding depth, the paired *t*-test identified an improvement in depth for index stocks whereas the multivariate approach exhibits a depth decrease. However, when analyzing the coefficients of the regressions, this depth decrease is dominated by the spread reduction effect. Taken together, these findings provide support for H2b and rejection of H2a. The rejection of H1a and H2a combined with the rejection of H3 and H4 resulting from all the tests conducted on adverse selection measures clearly rules out the adverse selection hypothesis (which predicts a deterioration of index-stock liquidity following the introduction of an index security). We found a very significant improvement in liquidity, that occurred more through the tightening of spreads (strong evidence supporting H2b) than through increased trading volumes (weak evidence supporting H1b), and both the arbitrage and the recognition hypotheses can explain this liquidity effect.

The tests of H5 based on variance ratios and those of H6 based on the differential effects for low- and heavy-weight index components were designed to bring additional evidence on the arbitrage and the recognition hypotheses. There is very little evidence of index-stock price stabilization following the introduction of the ETF. The analysis of variance ratios provides weak support for H5: short-term price volatility measured by the 1-minute/5-minute variance ratio significantly decreased for index stocks relative to control stocks but did not change significantly when measured with other ratios. However, as discussed in Section 3, weak evidence for or the rejection of H5 does not rule out the Fremault's (1991) arbitrage theory.

Differential effects for low- and heavy-weight index components as predicted by the recognition theory were captured through the estimates of coefficients *h* in the panel regressions of Table 5. According to the positive estimated values of *h* in Panel A of Table 5, the liquidity improvement following the ETF inception would have been greater for smaller index components which is consistent with the recognition hypothesis (H6). However, the insignificance of the liquidity effect immediately after the ETF inception (Panel B of Table 5) is in contradiction with H6. We check

Table 6
Panel regressions of variance ratios.

	1-minute-to-5-minute variance ratio		1-minute-to-30-minute variance ratio		5-minute-to-30-minute variance ratio	
	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value
Intercept	0.3451***	0.000	0.1211***	0.000	0.3616***	0.000
$CAC40_i$	−0.0105	0.118	−0.0014	0.641	0.0045	0.560
σ_{it}	−0.6082***	0.000	−0.4104***	0.000	−1.0943***	0.000
$\ln V_{it}$	−0.0046***	0.007	−0.0028***	0.000	−0.0060***	0.004
$\ln P_{it}$	−0.0078**	0.014	−0.0038***	0.006	−0.0065*	0.079
OIB_{it}	0.0001*	0.082	0.0001***	0.003	0.0002***	0.002
$MarketUp_t$	−0.0001	0.960	0.0006	0.453	0.0023	0.392
$MarketDown_t$	−0.0004	0.753	−0.0004	0.486	−0.0024	0.243
$Monday_t$	−0.0024	0.321	−0.0022	0.134	−0.0076	0.173
$Tuesday_t$	−0.0034	0.218	−0.0049***	0.000	−0.0159***	0.000
$Wednesday_t$	−0.0031	0.200	−0.0010	0.404	−0.0008	0.842
$Thursday_t$	0.0004	0.863	−0.0024	0.105	−0.0087*	0.091
$Holiday_t$	0.0149***	0.000	0.0041	0.110	−0.0043	0.567
$TEC10_t$	0.1402	0.830	−0.0237	0.949	0.1317	0.915
$QualitySpread_t$	0.4017	0.286	0.1212	0.619	−0.3142	0.723
ETF_t	0.0041	0.248	−0.0004	0.835	−0.0021	0.729
$ETF_t \times CAC40_i$	−0.0097***	0.008	−0.0017	0.438	−0.0012	0.868
Centered R^2	8.04%		7.11%		3.25%	
Uncentered R^2	91.28%		66.83%		71.94%	

Note: This table shows the estimates of panel regressions conducted on 120 daily observations for 74 stocks. The dependent variables are the 1-minute/5-minute, the 1-minute/30-minute, and the 5-minute/30-minute return variance ratios. σ_{it}, $\ln V_{it}$, $\ln P_{it}$, and I_{it} are, respectively, the price range, the euro trading volume in logarithm, the close price in logarithm, and the imbalance between buy and sell traded volumes as a percentage of the total traded volume, for stock *i* on day *t*. $MarketUp_t$ ($MarketDown_t$) is the index return when positive (negative), 0 otherwise. $Monday_t$, $Tuesday_t$, $Wednesday_t$, and $Thursday_t$ are day-of-the-week dummies. $Holiday_t$ equals 1 when the day preceding or the day following *t* is a banking holiday. $TEC10_t$ is the value of the 10-year constant maturity French Treasury yield on date *t*. $QualitySpread_t$ is the difference between the daily return of the clean price index for French 10-year sovereign bonds and the daily return of the Barclays index for French B or better rated corporate bonds. ETF_t is a variable set to 0 before the introduction of the ETF and to 1 afterwards. $CAC40_i$ is set to 1 for CAC 40 stocks, 0 otherwise. Errors are clustered by stock. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

this finding by building another test of H6 based on the relation between liquidity variations around the ETF introduction date for a given stock *i* of the index and its weight in the index w_i at the time of the inception of the ETF, and we ran the following cross-sectional OLS regression on the CAC 40 stock sample:

$$\Delta DV_i = \alpha_0 + \alpha_1 \Delta\sigma_i + \alpha_2 \Delta X_i + \alpha_3 w_i + \varepsilon_i. \quad (14)$$

ΔDV_i is the pre-/post-ETF relative variation in a given liquidity measure for stock *i*. Measures of liquidity are the average quoted spread, the average effective spread, the 5-minute realized spread, the best-limit depth, and the adjusted block spread. The pre-/post-ETF relative variations in the average price range ($\Delta\sigma_i$) and the trading volume in number of shares (ΔX_i) are taken as control variables. ΔX_i was also regressed on w_i, but the control variables were omitted in that case. Table 7 shows the results. The α_3 coefficient does not significantly differ from zero in any of the regressions. This finding leads us to conclude that the spread decrease which occurred for CAC 40 stocks after the inception of the Lyxor CAC 40 ETF cannot be explained by a recognition effect.

In contrast, the strong evidence of spread reduction for ETF underlying stocks is fairly consistent with the risk sharing benefits of cross-market arbitrage modeled by Fremault (1991). This interpretation is reinforced by the fact that the order processing cost component of index-stock spreads decreased much more than their adverse selection costs, as shown by the paired *t*-test. The findings of the tests displayed in Table 3 indicate that the average price impacts and the LSB adverse selection costs do not significantly decrease for index stocks relative to non-index stocks, while the realized spreads and the LSB order processing costs tighten significantly at the 1% threshold. Then, comparing the estimates of the regressions of effective spreads, realized spreads, and price impacts (cf. Table 5) indicates that the post-ETF decrease in the effective spread of index stocks is fully attributable to the ETF-related reduction in the realized spread. We therefore conclude that the opening of the ETF market contributes to improving the liquidity of underlying securities by means of positive risk sharing effects because it plays the role of a new liquidity pool which helps reduce order imbalances incurred by index traders.

Those positive risk sharing effects oppose the findings of Van Ness et al. (2005) for the Diamond index security replicating the Dow 30, and they also differ from those of Hegde and McDermott (2004) who attributed the liquidity improvement at the Diamonds and QQQ introduction to a decline in information asymmetry. We believe that the difference between the evidence in our work and the evidence found in the previous literature can be assigned to the specific microstructure of the Lyxor CAC 40 market which involves active LPs as shown in Section 2.3. In order to confirm this, we used the detailed data on LPs' orders and trades already presented at Section 2.3 for October 2002,[22] and we investigated their actual role in the provision of liquidity in the ETF market. We identified regimes of high and low liquidity to test in which regime they contributed more to improving market liquidity. High- and low-liquidity days were classified based on the average cost of round trip trade (CRT) measured for the CAC 40 stocks.[23] We computed 23 daily average CRTs. Days with a CRT belonging to the highest (lowest) quartile were defined as low (high) liquidity days. We then followed Menkveld and Wang (2013) to assess the LPs' contribution within the ETF order book depending on the liquidity regime. For order book state observed at time *s* on day *t*, we computed the liquidity improvement due to LPs' orders along three dimensions: spread ($Svar_{t,s}$), depth at the best quotes ($D1var_{t,s}$), and depth at the five best quotes ($D5var_{t,s}$). Then we estimated the following regression:

$$Z_{t,s} = \alpha_0 + \alpha_1 Illiq_t + \alpha_2 Liq_t + \varepsilon_{t,s}. \quad (15)$$

$Z_{t,s}$ alternatively represents $Svar_{t,s}$, $D1var_{t,s}$, and $D5var_{t,s}$. $Illiq_t$ and Liq_t are dummy variables which are equal to one during low and high liquidity regimes respectively, and equal to zero otherwise. By construction, $Z_{t,s}$ is positive when LPs improve liquidity in the limit order book. $Z_{t,s}$ cannot be negative since having no LP in the limit order book implies $Z_{t,s}$ being equal to zero.

All estimates reported in Table 8 are highly significant and converge to show that LPs provide more liquidity in low-liquidity times. First, the difference between α_1 and α_2 is significantly positive for the three measures

[22] We cannot conduct this analysis on the post-ETF period of 2001 as we do not hold detailed LP data for that period.

[23] These high/low liquidity regimes are nearly identical if we use 5000, 10,000 or 50,000 shares to compute de CRTs.

Table 7
Cross-sectional regressions of liquidity variations.

Dependent variable	Intercept	$\Delta\sigma_i$	ΔX_i	w_i	Adjusted R^2
ΔX_i	0.2280**			0.2357	−2.84%
	(2.20)			(0.08)	
$\Delta DWQS_i$	−0.0796***	0.3795***	−0.0824**	0.7279	32.24%
	(−3.71)	(3.97)	(−2.50)	(1.21)	
ΔES_i	−0.1042***	0.4782***	−0.0743**	1.0751*	46.83%
	(−5.32)	(5.48)	(−2.47)	(1.96)	
$\Delta RS_{5\ \min,i}$	−0.3064***	0.0418	0.0109	1.7197	−3.48%
	(−6.59)	(0.20)	(0.15)	(1.32)	
ΔD_i	0.0829	−0.0929	0.3951***	−2.4612	35.63%
	(1.47)	(−0.37)	(4.55)	(−1.56)	
ΔABS_i	0.7488***	1.1977***	−0.3185**	0.5438	28.44%
	(9.79)	(3.51)	(−2.71)	(0.25)	

Note: This table displays the estimates of the OLS regressions run over the 37-index-stock sample. The relative variations of liquidity measures around the date of the introduction of the ETF are regressed on weights in the index w_i. The liquidity measures used are, in turn: the total trading volume in number of shares (X_i), the time-weighted average quoted spread ($DWQS_i$), the average affective spread (ES_i), the average 5-minute realized spread ($RS_{5\ \min,i}$), the time-weighted average best-limit depth (D_i), and the time-weighted average adjusted block spread (ABS_i). The variation of the average price range ($\Delta\sigma_i$) and the trading volume variation (ΔX_i) serve as control variables. *t*-Statistics are in brackets. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

(third column of Table 8), which means that LPs are more active in low-liquidity periods than in high liquidity periods. Second, the significantly positive values of α_1 in the regressions of $Svar_{t,s}$ and $D5var_{t,s}$ indicate that LPs contribute to reducing spreads and increasing the five-best-quote depth more strongly on low liquidity days than on any other day. The negative values of α_1 and α_2 estimates for $D1var_{t,s}$ indicate that LPs provide more depth at the best quotes when liquidity is intermediate (neither low nor high), yet as the value of $\alpha_1 - \alpha_2$ is also significantly positive for this variable, the LPs' contribution to best-quote depth is still greater in the low-liquidity than in the high-liquidity regime. We consider those findings as representative of the role played by LPs from the ETF introduction and we interpret the risk sharing benefits of the ETF market opening as the result of the additional liquidity provided by ETF LPs for the index, in particular in periods of low liquidity.

6. Conclusion

Using detailed data from the French stock market, we tested the impact of the introduction of the first ETF replicating the CAC 40 index on the liquidity of the underlying securities. By analyzing ETF and index stocks order book data over one month, we show that trading the ETF is less costly than trading the index in the market for index components, and that ETF LPs are substantially responsible for this relative advantage. More importantly, using high-frequency data for a sample of index stocks and for a control sample of stocks over the six months surrounding the date on which the ETF was introduced, we examined the change in the liquidity of the underlying stocks through a difference-in-difference approach and a multivariate panel approach. We explore the theories that could possibly explain this change.

Consistent with the findings of Hegde and McDermott (2004) and Richie and Madura (2007), and unlike those of Van Ness et al. (2005), we found that index-stock spreads tighten more than non-index stocks after the introduction of the ETF. Nevertheless, our conclusions are not the same as Hegde and McDermott's (2004) in that we did not find that adverse selection was the main factor explaining the liquidity improvement. Our conclusions also differ from Richie and Madura's (2007) in that we reject the Merton's recognition theory to explain liquidity gains.

In contrast, we establish that the index-stock spread reduction is essentially driven by a decrease in the temporary price impact of trades or, in other words, is due to a decrease in the order processing and order imbalance cost component of spreads. Although we did not find strong evidence of price stabilization, we consider that our empirical findings are consistent with the arbitrage theory of Fremault (1991) according to which increased arbitrage trading between individual stock markets and index security markets adds risk bearing capacity to markets and provides buying and selling support to order imbalances. Further, those increased risk sharing capacities may well be enhanced when the new index security market involves LPs as they improve the liquidity for the trading of the index more substantially in period of very low liquidity.

Table 8
LPs' contribution to liquidity in high and low liquidity regimes.

Dependent variable	Intercept	$Illiq_t$	Liq_t	$(Illiq_t - Liq_t)$
$Svar_{t,s}$	0.6173***	0.0315***	−0.0562***	0.0877***
	(1021.71)	(27.60)	(−49.13)	(63.93)
$D1var_{t,s}$	85.1193***	−22.1729***	−28.0130**	5.8401***
	(252,80)	(−34.84)	(−43.94)	(7.64)
$D5var_{t,s}$	34.1131***	2.1300***	−9.6102***	11.7401***
	(373.03)	(12.32)	(−55.50)	(56.52)

Note: This table displays the estimates of the OLS regressions run over 428,786 states of the limit order book of the ETF observed during October 2002. $Svar_{t,s}$ represents the improvement in spread ($Svar_{t,s}$ is positive when the spread is reduced thanks to LPs' activity). $D1var_{t,s}$ and $D5var_{t,s}$ are the increases in depth at the best quotes and the five best quotes due to LPs. $Illiq_t$ is a dummy variable which is equal to one in low-liquidity days and zero otherwise. Liq_t is a dummy variable which is equal to one in high-liquidity days and zero otherwise. *t*-Statistics are in brackets. One, two and three asterisks (*, **, and ***) indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix A. List of the CAC 40 stocks and their matching stocks

Index stock	Matching stock
Stock name	Stock name
TOTAL FINA ELF	COFACE
FRANCE TELECOM	UNILOG
ALCATEL	GEOPHYSIQUE(GLE)
AVENTIS	CLUB MEDITERRANEE
AXA	IMERYS
CARREFOUR	RALLYE
OREAL	MARINE WENDEL
STMICROELEC.SICO.	PERNOD-RICARD
SANOFI SYNTHELABO	SCOR
BNP PARIBAS	GECINA
LVMH MOET VUITTON	BOUYGUES OFFSHORE
SUEZ LYON.DES EAUX	CASTORAMA DUBOIS
SOCIETE GENERALE A	CHRISTIAN DIOR
CAP GEMINI	SAGEM PROV.ECH.
GROUPE DANONE	COFLEXIP
PINAULT PRINTEMPS	ZODIAC
BOUYGUES	METROPOLE TV
EADS	RHODIA
DEXIA SICO.	UNIBAIL
THOMSON MULTIMEDIA	NRJ GROUP
CREDIT LYONNAIS	BIC
TF1	ATOS
SAINT-GOBAIN	TECHNIP
RENAULT	PUBLICIS GROUPE
AIR LIQUIDE	HERMES INTL
AGF	VINCI
PEUGEOT	ESSILOR INTL
CASINO GUICHARD	SIMCO
ACCOR	CNP ASSURANCES
THOMSON-CSF	CGIP
LAFARGE	REXEL
LAGARDERE	ERIDANIA BEGHIN
EQUANT SICO.	HAVAS ADVERTISING
SODEXHO ALLIANCE	GALERIES LAFAYETTE
ALSTOM	AIR FRANCE
MICHELIN	CIMENTS FRANCAIS
VALEO	PECHINEY

The procedure used to match stocks is based on four stock attributes: market capitalization, return volatility, share price, and trade size. Market capitalization is the market value of the firm as observed on the first day of the pre-ETF period. Return volatility, share price, and trade size are respectively the standard deviation of the daily close returns in logarithm, the average close price, and the average trade size, as estimated over the pre-ETF 60-days trading window. The matching algorithm consists of matching each CAC 40 constituent with the non-CAC 40 stock that minimizes the following composite match score (CMS): $CMS = \sum_{k=1}^{4}\left[\frac{Y_k^{CAC} - Y_k^{SBF}}{\left(Y_k^{CAC} + Y_k^{SBF}\right)/2}\right]^2$ where Y_k represents on the four matching factors, superscript *CAC* refers to the index stock and superscript *SBF* refers to the non-index potential match stock. A maximum value of one was imposed on the value of the ratio for the volatility factor and the share price factor, and the total CMS never exceeded four.

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