How and When do Markets Tip?
Lessons from the Battle of the Bund*

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Abstract

In a famous episode of financial history which lasted over eight years, the market for the future on the Bund moved entirely from LIFFE, a London-based derivatives exchange, to DTB, a Frankfurt-based exchange. This paper studies the determinants of exchange choice, using a novel panel dataset that contains individual trading firms' membership status at each exchange together with other firms characteristics, and pricing, marketing and product portfolio strategies by each exchange. Our data allows us to evaluate different sources of heterogeneity among trading firms and thus, to distinguish between different explanations for the observed phenomenon. The story the data tells is one of horizontal differentiation induced artificially by national access barriers that came down following the European Investment Services Directive and access deregulation in the US, with secondary roles played by liquidity and product portfolio effects. DTB won the Battle of the Bun because it won a membership war.

Preliminary and incomplete - comments welcome

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1 Introduction

In a famous episode of financial history that lasted over eight years, the market for the future on the German long-term government bond, the Bund, moved entirely from LIFFE, a derivatives exchange based in London, to DTB, a Frankfurt-based exchange (Figure 1 illustrates the market shares of the traded volumes). Since then, the "Battle of the Bund", as this episode became known, has served to illustrate that financial markets can tip and thus, implicitly, that competition is feasible and that there is a role for firms' strategies.

Traders value liquidity in financial markets. This creates a tendency for trading to concentrate on a single exchange and gives incumbent exchanges an advantage. Given this, the only way to explain Figure 1 is that traders were heterogenous in the way they valued liquidity or on any other dimension along which DTB and LIFFE differentiated themselves.

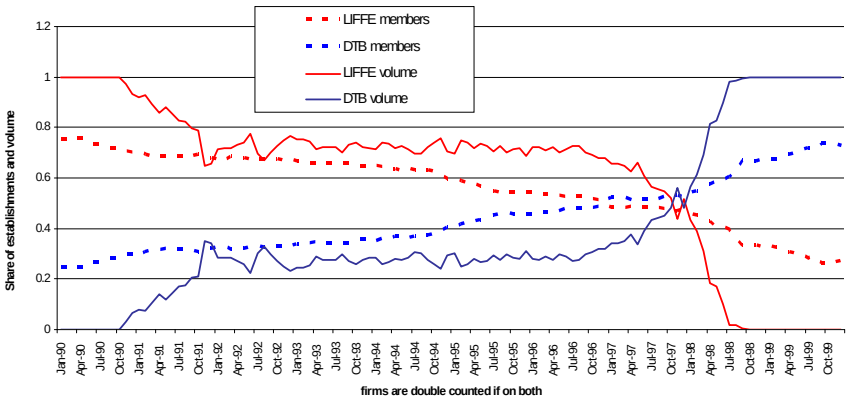


Figure 1: Market share of members and of Bund trading volume

After briefly describing the events and actions that took place during the Battle of the Bund, we propose four non-exclusive explanations for the observed outcome. Each corresponds to a different source of trader heterogeneity. If traders value liquidity differently, DTB could have attracted early on those traders who did not care so much about liquidity by charging them lower transaction fees. As more traders joined DTB, the difference in liquidity between the two exchanges decreased and new traders were attracted to DTB. A snowball effect resulted. Figure 1 can also be explained if the exchanges were instead horizontally differentiated. Exchanges are multiproduct firms. Even if the Bund was the main product for both exchanges during this period, each exchange organized markets for many other products. If traders have different values for these other products, DTB could have attracted those traders that preferred its product portfolio. Another dimension of horizontal differentiation is geography-determined access costs. At the beginning of the decade, traders had to

have an office in London to trade on LIFFE and they had to have an office in Germany to trade on DTB. Because DTB was an electronic exchange, remote access from other countries became possible as access deregulation progressed. Finally, we consider the conjecture according to which DTB's success is the result of political pressure on German traders.

In this paper, we exploit a new panel dataset to evaluate the sources of trader heterogeneity and study the determinants of the observed dynamics. Individual trading volumes are not observed, so we focus on the observable traders' choice of an exchange instead. While different, trading decisions and membership decisions are clearly connected (the dotted lines in Figure 1 represent the membership shares of both exchanges).[1] A trader must be a member to trade directly on an exchange. He must go through a broker otherwise. When deciding to become a member of an exchange, traders trade-off the fixed costs of exchange membership with the lower marginal costs of trading that membership entails. As a result, we argue that liquidity and other transaction costs affect both the decision of where to trade and the decision of which exchange to join as a member. In addition, other factors affect the decision to become a member of an exchange. These include adoption costs, fixed costs of membership and the value traders attach to an exchange's product portfolio. We account for these in our analysis.

Our dataset contains all the establishments that were members of DTB or LIFFE at any point of time between January 1990 to December 1999. For each of these establishments, we have tracked their location, their inception and exit dates, their historical group affiliation, their business lines and the products they traded. This allowed us to match establishments from different locations at their group level and allows us to distinguish between groups holding memberships at both exchanges and groups holding a single membership. Group affiliations and entry and exit histories also allow us to distinguish between new memberships and membership resignations that are the results of organizational changes (mergers, closure of one establishment, bankruptcy) and those that aren't. We have also constructed a dataset of exchange characteristics over the same period. For each exchange, we have their fee structures, the value of the deposits required to guarantee the trades on that exchange, measures of liquidity, the products traded, and a record of all events that could affect the decisions by traders to trade on them. The end result is a panel dataset with financial groups' monthly membership status as a function of group and exchange characteristics.

Simple descriptive statistics of our data highlights four salient aspects of our environment. First, the timing of DTB memberships differs significantly depending on the geographical presence of groups and displays patterns consistent with the timing access deregulation. Second, the timing of DTB adoption differs also accross groups with different business lines in a way not captured by geography. Third, even though some groups do not change membership status, 18% of our groups change membership status more than twice even after controlling for changes in membership status due to internal organizational

[1] During the period, the Bund consistently ranked among DTB and LIFFE's top 3 products and it often ranked first at both exchanges.

changes (acquisition, mergers, bankruptcy, ...). Fourth, most of DTB new members were groups that were not LIFFE members initially suggesting a story of newcomers rather than switchers.

We incorporate these salient features in a simple econometric model of traders' membership decision. We assume that traders choose every month whether to be a member of DTB, LIFFE, both exchanges or none of them. We abtract from strategic considerations given the large number of traders and assume that traders choose myopically based on their expected period payoff. Joining an exchange entails adoption costs that are geographically determined and vary with the state of access deregulation. The rest of the payoff to membership includes a component that is specific to the Bund (the variable profit component) and one that consists of all the costs and benefits conferred to memberships beyond the Bund (the fixed profit component). We allow for trader heterogeneity in the variable profit component by allowing groups having different business lines to care about liquidity differently (vertical differentiation). Trader heterogeneity also comes in the fixed profit component through exchange - business types - headquarter locations fixed effects.

Our preliminary findings are as follows. First, access deregulation played an important role in helping DTB attract newcomers. "Implicit" adoption costs, that is, the cost for new members to join an exchange, beyond the explicit admission fees charged by the exchanges, were of the order of three to four times larger than admission fees. Access deregulation reduced them significantly to the advantage of DTB. Second, even though traders value liquidty, we did not find much evidence that traders were heterogenous in the way they valued liquidity and thus that competition hinged on implicit vertical differentiation on this dimension. However, the coefficients are sensitive to the chosen specification and warrant further analysis.Finally, we found evidence of heterogeneity in the match between traders and exchanges suggesting that other dimensions of horizontal differentation beyond geography played a role. All in all, these results suggest a richer view of exchanges than the established "exchanges as natural monopolies" view.

Related literature. This paper is related to the literature on technology adoption, the literature on competition between networks and the finance literature on multiple trading venues. A fuller literature review will be included in a future version.

The rest of the paper is organized as follows. In the next section, we summarize how competition between LIFFE and DTB played out. Section 3 discusses four possible stories that may have explained the observed dynamics. We use these sections to motivate our empirical model and the data we collected. Section 4 describes the data we collected. Section 5 introduces our benchmark empirical model. Section 6 reports our results. Section 7 concludes.

2 The Battle of the Bund

This section summarizes the relevant aspects of the competition between LIFFE and DTB. It motivates the choice of data we collected, the hypotheses we consider for explaining the events and our econometric model. Appendix B summarizes the key economics of futures trading for the readers not familiar with the workings of derivatives markets.

The London International Financial Futures and Options Exchange (LIFFE) was established in 1982 as a member-owned exchange. Two hundred sixty one members were signed up at launch time, a good third of them coming from outside the UK.[2] Trading was initially organized exclusively by open outcry. LIFFE's first products were currency contracts, two short term interest rate contracts, and one future on the British long term government bond. Its debuts were relatively modest, but trading progressively garnered pace after the exchange lowered transaction fees, negotiated a lowering of margins costs with the clearing house, and encouraged participation by locals - individuals trading on their own account. LIFFE introduced an automated trading platform (APT) in 1989 for electronic trading outside the pit hours.

New products were progressively added, among them the Bund contract in September 1988. The Bund launch was controversial. There was clearly a need for such a contract: the underlying cash market was one of the biggest in the world, yet it did not have a proper hedging instrument. However, German financial institutions were keen on developing such a market in Germany and they were pushing for new laws that would make it possible to set up a derivatives exchange in Germany.

The Bund contract was an instant success on LIFFE. It was its second biggest contract within 6 months of its launch and became its top contract less than a year later. German banks used the contract from the very beginning, providing up to a sixth of the volume according to an informal LIFFE survey.[3] An option on the Bund was added in April 1989.

Deutsche Terminbörse (DTB) was established in January 1990 by seventeen leading German banks. Trading was conducted electronically from the very beginning. Unlike LIFFE, members did not own shares or voting rights in DTB. Fifty members had joined at launch time, of which 80% were German institutions. Its first products were an equity index future and 14 stock option contracts. After some technical delays, DTB launched a Bund contract on November 23, 1990. The contract was essentially identical to the LIFFE contract.[4] Clearing was provided by DKV, a German company.

The beginnings. Shortly before DTB's launch of the Bund contract, LIFFE geared up for competition and trading was moved one hour earlier in order to match DTB's hours. Grand declarations were made in the press about where volume would go. In practice, the first days of trading on DTB were very disappointing: volumes were low and participation seemed limited to German banks. It

[2] Kynaston (1997), p. 71.

[3] Kynaston (1997), pp. 218-219.

[4] Breedon (1996) studies the differences between the two contracts in details and their likely impact on prices.

became clear that much would depend on whether German banks would really be willing to trade on DTB even if it were less liquid. By mid-1991, leading German banks with a stake in DTB signed a Gentlemen's agreement whereby they committed to support liquidity on DTB by acting as market makers for the Bund. The Gentlemen's agreement was effective and DTB's market share climbed to almost 20% by mid-July. The commitment by the German banks was strengthened in November when they committed to specific volume targets.

Competition in the product space. The battleground between LIFFE and DTB quickly moved to the product space. While the Bund was clearly the key product, each exchange tried to reinforce the contract by offering complementary products and services. Thus, DTB launched an option on the Bund in August 1991, and it started a Bobl contract, a future on the medium-term German government bond in October 1991. In January 1993, LIFFE launched its own version of the Bobl and DTB launched an option on the Bobl. Finally, DTB launched the Schatz contract, a future on the short-term German government bond in March 1997. Each of these product launches was accompanied by statements by the exchanges suggesting that Bund traders would be interested in these products. DTB's Bobl turned out to be a hit in its own right (LIFFE's version was a failure). However, the Bund remained the dominant contract and it is not clear to what extent these products attracted new traders on the exchanges, instead of simply benefitting from the positive spillovers from the Bund contract.

New services were also offered to boost trading in the Bund. LIFFE launched a basis-trade facility where traders could trade simultaneously the Bund future and its cash equivalent in July 1995, followed by DTB in October of the same year. LIFFE launched a spread facility where traders could buy a Bobl and sell a Bund (or the other way round) simultaneously in February 1994, followed by DTB in May 1997.

Access. DTB's electronic market did not in principle require members to be based in Germany. However, futures traders and exchanges were regulated by their national supervisory authorities (e.g. the Securities and Futures Authority in the UK or the Commodity Futures Trading Commission in the US). DTB had to be recognized as an exchange in other countries for the trading firms in these countries to be allowed to trade on DTB, and likewise, these firms had to be recognized as investment firms in Germany to be able to trade on a German exchange. Thus, initially, only firms with an office in Germany could trade on DTB.

DTB seemed to have realized early on that access was critical.[5] In December 1993, it signed an agreement with the French derivatives exchange MATIF whereby MATIF members would be able to trade the Bund and Bobl on DTB. The agreement came into force in September 1994, at the same time as Dutch regulatory authorities authorized proprietary traders based in the Netherlands to trade on DTB. DTB also actively lobbied US and British regulatory authorities to allow remote access from

[5] "DTB may put screens outside Germany", Financial Times, 23 January 1991.

the US and the UK, two important sources of trading volumes. Those efforts resulted in a no-action letter issued on 29 February 1996 by the CFTC allowing US-based traders to trade on DTB. DTB's efforts with the British authorities were unsuccessful. In the meantime, the European Union approved the Investment Services Directive. The Directive, which came into force in January 1996, implied that any exchange and investment firm authorized and regulated in one of the European Union countries would be recognized and authorized in all the other countries. From then on, EU-based trading firms could have remote access to DTB.

As an open outcry exchange for most of 1990s, LIFFE members were essentially forced to have staff in London making access and regulatory approval a lower priority for LIFFE. Yet, financial regulations in other countries did also affect trading on LIFFE because trading in the Bund took place on an electronic platform after-hours until August 1998 and was entirely electronic after that.

Electronic trading versus open outcry. There was a fair amount of discussion in the industry at the time on the relative advantages of open outcry versus electronic trading. It was argued that open outcry markets were better at aggregating information in periods of high volatility and that they allowed for more complex strategies than electronic markets. Electronic trading, it was argued, was significantly cheaper: a single broker could be in contact with clients and input orders in the market whereas open outcry required a floor-broker on top of the broker in contact with clients, transactions were automatically processed through clearing, and so on.

Breedon and Holland (1998) summarize the evidence on the relative quality of the Bund market at both exchanges. Using different measures of spreads (the difference between the buy price and the sell price) and transaction prices, they find that "realized" liquidity was similar in both markets around 1995. However, transaction sizes on LIFFE were more than double the size of transactions at DTB, suggesting DTB might have been less liquid, had transaction sizes been as large as on LIFFE. They also found that volumes tended to migrate to LIFFE in periods of high volatility.

Macroeconomic developments. Trading volumes of the Bund grew fifteen-fold during the 1990s. Several factors contributed to this. First, German reunification in 1990 increased Germany's borrowing needs. The resulting increase in the public debt fueled interest in the future contract. Second, interest rates in the eurozone progressively converged as monetary union took shape (the euro - which fixed exchange rates among participating countries - was introduced on 1 January 1999). As a result, the Bund contract, which was the biggest future on a government bond in Europe progressively attracted traders from other government bond futures. Third, futures went from exotic financial instruments to common investment and hedging instruments used routinely by banks, asset management funds and corporations. The ensuing pool of liquidity attracted speculators and arbitrageurs of all kinds. Increased volumes may have played in favor of DTB by decreasing the relative difference in liquidity between the two markets.

Mergers. Both exchanges underwent mergers during the 1990s. LIFFE merged with the London

Traded Options Market (LTOM), an equity option exchange, in 1992. It merged with the London Commodity Exchange in 1996. DTB became part of Deutsche Börse, the Frankfurt-based stock exchange, in August 1994. It merged with the Swiss derivatives exchange SOFFEX in September 1998. The SOFFEX merger, which was announced at the end of 1997, brought about 40 new members instantaneously to DTB. The new entity took the name of Eurex.

The loss of the Bund. Between 1992 and 1996, DTB's share of the Bund trading remained virtually unchanged at 30% (Figure 1). Things started to change at the end of 1996. The Investment Services Directive had come into force and, during 1996, DTB installed access points in Amsterdam, Chicago and Zurich for easy access to its market. In August 1997, DTB extended its trading hours to match those of LIFFE and in September 1997, a price war broke out with both exchanges waiving transaction fees on the Bund. A sixth of DTB's members were now based in London and DTB opened an office there to facilitate contacts and new traders training.

The exchanges were head-to-head by the last quarter of 1997: LIFFE was still ahead in September, but DTB took the lead and they finished the year with an almost equal market share. Things went very fast afterwards. LIFFE completely restructured its fee structure in March 1998 in the hope to boost its appeal. During that time, DTB maintained the pressure: it wrote a letter to LIFFE's members offering a computer and DTB's trading software to any members willing to trade on DTB. DTB also ran an advertising campaign in all major newspapers offering its trading system to LIFFE for free. By mid-July, it was clear that LIFFE had lost the Bund. Late 1998, LIFFE unveiled a new contract, the DM-denominated Libor-Financed-Bond aimed at challenging the Bund's dominance of the long term part of the yield curve. The new contract never took off. LIFFE underwent a complete restructuring following the loss of the Bund. It demutualized in February 1999 and became an all-electronic exchange.

3 Four stories

Traders incur several costs on each contract traded: transaction fees, margins and price impact costs. First, they pay a transaction fee to the exchange. Second, for each new open position a trader has, margins must be deposited at the clearing house to guarantee the trade. LIFFE's clearing house paid an interest on these margins but DTB's clearing house did not. Moreover, even when margins accrue interests, this return may be much lower than what a trader could generate elsewhere. Thus, margins generate an opportunity cost. Third, a trader may influence the price of the future when trying to buy or sell large quantities. The impact cost of a transaction is defined as the difference between the theoretical "equilibrium price" for the contract at the time of the transaction and the realized price for the transaction. Impact costs are related to the liquidity of a market. The more liquid a market is, the less specific orders affect prices.

Everything else equal, traders prefer to trade in more liquid markets: liquidity - essentially a corollary to trading volumes - implies lower impact costs and thus ultimately lower trading costs. This creates a tendency for trading to concentrate on a single exchange and gives an advantage to any incumbent exchange. Yet, everything else is rarely equal. Traders differ in their liquidity needs, opportunity cost of money, trading behavior, value for the other products traded by each exchange and adoption costs. These sources of trader heterogeneity create an opportunity for an entrant exchange to attract trades. This suggests four possible (and non exclusive) stories for the observed pattern.

Story 1: Vertical differentiation. According to this story, the main source of differentiation between the two exchanges was liquidity. LIFFE, being the incumbent, offered a larger liquidity pool to traders. However, it was also intrinsically more expensive, both due to its fee structure and its market organization. When selecting an exchange, traders traded off the higher liquidity of LIFFE with DTB's lower costs as in Pagano (1989). Traders with low liquidity needs - essentially traders with smaller transactions - were predominently attracted to DTB. The fact that traded volumes also grew during that period further contributed to a decrease in the difference of liquidity between the two exchanges - even holding market shares constant. The resulting increase of DTB's liquidity eventually triggered a snowball effect, leading to the complete reversal in market share.

A variant on this story is that traders' cost of margins was the main source of differentiation and that DTB had lower margins requirements. Thus traders with high costs of margins - either because they had high opportunity costs of money or because they tended to keep positions open during longer periods - migrated to DTB. Further decreases in DTB margins attracted more traders, until DTB offered a lower cost of trading for all types of traders. This variant is easily ruled out on the basis of our data: on average, margins were higher on DTB than on LIFFE.

Story 2: Horizontal differentiation I. According to this story, the main source of differentiation between the two exchanges was their product portfolio and DTB was more dynamic and successful than LIFFE in trading products that also attracted Bund traders. Section 2 suggests that both exchanges attempted strategies motivated by this story.

Story 3: Horizontal differentiation II. According to this story, the main source of differentiation between the two exchanges was their geographically determined access costs. Access deregulation in the EU combined with the fact that DTB was an electronic exchange lowered the cost of access to DTB and increased the size of market for exchange members. Traders who originally used brokers to trade the Bund could now afford a membership at DTB. This increased trading volumes on DTB. Bessler, Book and Preuß (2006) make an argument along these lines. They argue that scalability of electronic trading, enhanced by access deregulation, is what gave DTB a definite advantage in the Battle of the Bund.

Story 4: Non economic factors. Several industry participants suggested that political forces rather

than economic forces led to the market share reversal. In the words of one of them: "German banks had a gun on their heads to trade on DTB."

Note that none of the stories assumes that exchanges acted optimally as the dynamics played out. In fact, it is likely that some stories require some level of non optimal behavior by the incumbent exchange (this is the case for story 2, and for story 1 if the cost differential between the two exchanges is not too big).

The four stories also differ in the role of switchers (traders who were initially members of LIFFE and who switched to DTB) and newcomers (traders who were not members of any exchange). Stories 2 and 4 are essentially stories of switchers, whereas story 3 is a story about newcomers driving the observed phenomenon. Story 1 is consistent with both switchers and newcomers.

Finally, the four stories are non exclusive. In fact, except for story 2, some elements of story 1 (liquidity matters) must also hold to explain the complete tipping in the Bund trading.

4 Data

This section describes the dataset we collected and provides preliminary evidence on the sources of variation in our analysis.

4.1 Exchange data

For both exchanges and for the period between 1 January 1990 until 31 December 1999, we collected the following monthly data: (1) admission fee to the exchange, (2) annual membership fee, (3) transaction and clearing fee per contract, (4) initial and maintenance margins,[6] (5) membership, (6) product launches and delisting, and (7) traded volume in the Bund contract. Fees, margins and product launches and delisting were collected from exchange notices to members, membership was computed on the basis of the information provided to us by both exchanges, and volume data come from Datastream.

In addition, we combined internal sources of information (press releases, notices and circulars to members, records of changes in the rules of the market) and external sources of information (search on Factiva) to identify events of potential consequences for Bund traders. Specifically, we tracked the following events: (1) regulatory changes concerning access and recognition in other countries, (2) marketing campaigns not reflected in the fee structure such as free hardware or free installation, (3) technological changes such as the opening of access points.

The conversion to the euro takes place during our sample period (1 January 1999) and both exchanges introduced a Euro-denominated Bund contract towards the end of 1998. We use the Deutsche

[6] Initial margins are those margins required at the opening of the position. As time passes, the clearing house credits or debits the initial margin depending on the evolution of the future contract. If margins go below the level of maintenance margins, the clearing house calls on the trader to deposit additional margins.

Mark as the currency for all the data. Fees are converted into DM using the monthly average exchange rate for the Pound/DM, and the fixed conversion rate for the euro/DM. The size of the Bund contract was slightly changed following the conversion to the euro, from 250,000 DM to 100,000 euros (195,583 DM equivalent). Trade volumes and transaction fees were all scaled accordingly. Maturities for the Bund are quarterly and generate three-month cycles in trading volumes. We smooth out these cycles by considering three-month averages for volumes instead of monthly volumes.

Table 1 provides descriptive statistics for our exchange variables for the period between 1 November 1990 and 1 March 1999 which corresponds to the period during which competition between the two exchanges was effective. The number of month observations is 101.

Table 1: Descriptive statistics for the exchange dataset

	LIFFE				DTB			
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
admission fee	0	0	0	0	87000	36303.18	0	102000
fixed fee	9246.34	941.06	7707	10839.15	29000	12101.06	0	34000
transaction fee	0.94	0.30	0	1.30	0.52	0.36	0	1.50
margins	2983.34	858.13	1500	6250	3579.33	929.84	2000	5000
volume	$2.11\ 10^6$	$1.24\ 10^6$	0	$4.11\ 10^6$	$1.97\ 10^6$	$2.55\ 10^6$	0	$10.6\ 10^6$
log(vol)	5.98	1.21	0	6.70	5.93	0.83	0	7.03
members[7]	147.94	3.79	141	156	122.38	64.15	62	309
group members[8]	125.97	2.93	121	135	106.02	45.64	60	232

In practice, neither exchange seemed to have used admission and fixed fees to lure new members. LIFFE did not charge an admission fee (but members had to buy a share in the exchange) and annual fees were constant during the entire sample period. DTB charged a 102,000 DM admission fee and a 34,000 DM fixed fee until December 1997, after which both fees were waived. There was more activity on the transaction fee front with several price wars at the end of 1997 and in 1998.

Table 1 also suggests that, if anything, the costs of margins favored LIFFE rather than DTB: margins were on average higher on DTB than on LIFFE. Moreover, LIFFE paid an interest on the deposited margins. Thus, this variant of story 1 can safely be discarded. Table 1 distinguishes between individual memberships and memberships held by establishments under the same ownership, which is actually the data we used in our econometric analysis (see next section). Both numbers display the same pattern. They confirm that LIFFE was an established exchange by the early 1990s, with a stable membership, unlike the newly established DTB.

[7] LIFFE membership numbers are restricted to those allowed to trade interest rate instruments.

[8] Group membership corrects for memberships held by individual establishments under the same ownership. See section 4.2 below.

4.2 Firm data

We have obtained from each exchange a list of past and current members, with their names, mnemonic code, and start and end dates of membership. In addition, the DTB data contain the country and city location of these members and the LIFFE data contain the instrument class (equities, commodities or financials) that the member can trade. For current members, we also have the address of the establishment.

The original data from DTB contain information on 493 individual establishments that held a membership any time during the 1 January 1990 - 31 December 1999 period. The original data from LIFFE contain information on 305 individual establishments that held a membership allowing them to trade interest rate instruments (including the Bund) any time during the 1 January 1990 - 31 December 1999 period. Sixty-six individual establishments appear in both datasets. This means that our data cover 732 individual establishments.

For each member (establishment), we have collected additional information on (1) their (historical) group affiliation including mergers and acquisitions, (2) the establishment inception date and, if applicable, its closing date, (3) the group inception date and, if applicable, its bankruptcy date, (4) the activities of the establishment, and (5) whether the establishment trades the Bund or any other long-term government bond derivatives. This information was collected manually following the procedure described in Appendix A.

This process allowed us to track the needed information on most but not all establishments. Inception dates are missing for 110 (15.0%) of the individual establishments and 59 groups (10.15%). We could establish whether individual establishments traded the Bund contract or any other long-term government bond future in 78.3% of the cases. We assign the month prior to joining any of the two exchanges as the default establishment and group inception dates when these are missing, and we consider that the establishment trades the Bund when we do not know. We consider different default values when we do our robustness checks.

Groups versus individual establishments. We face three issues when defining the proper unit of observation in our environment. First, establishments can be endogenous to the decision to join an exchange. Prior to September 1994, traders had to have an office in Germany to be able to trade on DTB. Similarly, traders had to have a presence in London to trade on LIFFE before August 1998. Second, membership decisions of individual establishments that belong to the same group are not independent, and largely depend on the group's internal organization. Some groups are organized along geographical lines, with trading desks in each country. Others are organized along business lines with a single trading division. In the first case, all geographical trading divisions could, in principle, be members of a given exchange. In the second case, we would observe only one membership for that group. Third and relatedly, mergers and acquisitions can lead to membership resignations because the resulting entity rationalizes its membership and not because the resigning establishment no longer

values the membership. We address all three issues by defining the group as the proper unit of observation and use the collected information on group ownership and mergers and acquisitions to match establishments to groups. With this convention, our dataset covers 578 groups. On average, 362.64 groups are present in any given month (min = 315, max = 433, std deviation = 32.66).

Business models. We partitioned the establishments and the groups in our dataset into seven business model categories: universal bank, investment bank, retail bank, specialized trading firm, asset management, brokerage and proprietary trading firm. We distinguished banks by the type of customers they serve. Retail banks serve primarily individual customers as well as small and medium enterprises. Investment banks serve corporate clients as well as, often, wealthy individuals. Universal banks serve all types of customers.

For most of their activities, investment banks compete with more focused financial firms. Table 2 summarizes the main activities of an investment bank (IB): underwriting and mergers & acquisitions, market making, brokerage services, asset management and proprietary trading. Specialized trading firms compete with investment banks by making markets, offering execution and/or clearing for institutional clients, and trading on their own account. Asset management firms sometimes offer brokerage services to a retail clientele and trade on their own account on top of their core asset management activity. Brokerages offer execution services and sometimes also offer some funds. Proprietary trading firms are firms that focus on trading on their own account. Table 2 compares the activities covered by these firms. In categorizing our firms, we have assigned the smallest encompassing category for each group. Thus a group active in market making, proprietary trading and asset management would be classified as an IB, but a group active in asset management and proprietary trading would be classified as an asset management firm and a group active in proprietary trading and market making would be classified as a specialized trading firm.

Table 2: Investment banks and their competitors

Activities \ Business types	IB	Specialized	Asset Mgt	Brokerage	Proprietary
Underwriting, M&A	√				
Market making	√	√			
Retail brokerage	√			√	
Institutional brokerage	√	√		√	
Asset Management	√		√	(√)	
Proprietary trading	√	√	(√)		√

Business types proxy for three things in our dataset. They proxy for size because universal banks tend to be larger than retail banks and investment banks on average, and investment banks tend to be bigger than more specialized financial firms. Some proprietary trading firms are one or two people operations. Business types also proxy for trading motives and sources of revenue, and thus eventually

for traders' value for liquidity and margins. Brokerages trade on behalf of third parties and are paid on the basis of a fee in return. Their value added lies in providing access to exchanges and they will thus be interested in exchanges that organize markets in the instruments their clients need. At the other extreme, proprietary trading firms are only interested that the exchange offers the product(s) they speculate on. Relatedly, business types proxy for the scope of products traded. Finally, business types are likely to proxy for traders' transaction sizes and thus value for liquidity.

Evaluated at the time a group first appears in our dataset, our data contain 64 universal banks, 28 retail banks, 102 investment banks, 48 asset management firms, 95 specialized trading firms, 110 brokerages and 131 proprietary trading firms.

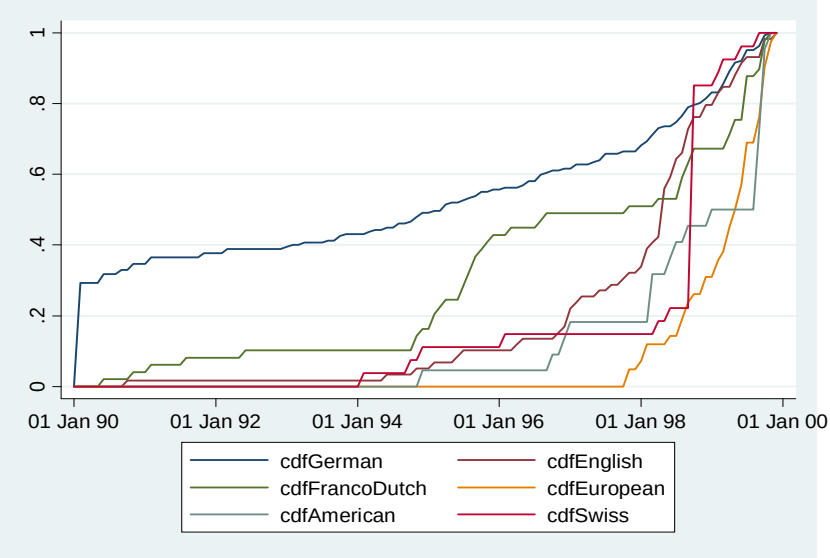
Geographical presence. Geographical presence affected adoption costs depending on the state of access deregulation. In our sample, 127 groups have their headquarters (HQ) in Germany, 37 have their HQ in Switzerland, 116 in the UK, 149 in the rest of Europe, 108 in the US and 41 in the rest of the world. We have also constructed a variable that records a group's geographical presence in any given month based on the locations of its headquarters and its known subsidiaries in that month. This variable underestimates the geographical presence of the group because it is mainly based on the group's establishments that were members of one or the other exchange at some point during 1990-2000 (there are few exceptions when tracking a specific establishment, we learned about the opening or the existence of an establishment in another country). However, we believe our geographical presence accurately records the useful information because a group eventually joins an exchange from the most convenient location and these establishments are in our dataset.

4.3 Evidence on the sources of trader heterogeneity

Section 3 suggested four sources of trader heterogeneity in our environment: different traders have different adoption costs, different traders trade different sets of products and thus value the exchanges' product portfolios differently, different traders care about margins costs differently because they have different trading behaviors, and some traders care more about liquidity than others.

In practice, our measures of groups' characteristics are their headquarter location, their geographical presence and their business type. Because of the way deregulation worked, geographical presence clearly captures differential adoption costs. Figure 1 plots the cumulative distribution function of the time at which groups joined DTB as a function of their "closest" geographical presence three months before joining.[9] In defining "closest" geographical presence, we considered that Germany was closest, followed by France and the Netherlands, followed by Switzerland, followed by the UK, followed by other EU countries, followed by the US and finally by the rest of the world. Thus, for example, the closest geographical presence of a group with establishments in the UK, France and the rest of the world will be France.

[9] We consider their geographical presence three months before joining to ensure it is exogenous to the decision to join.

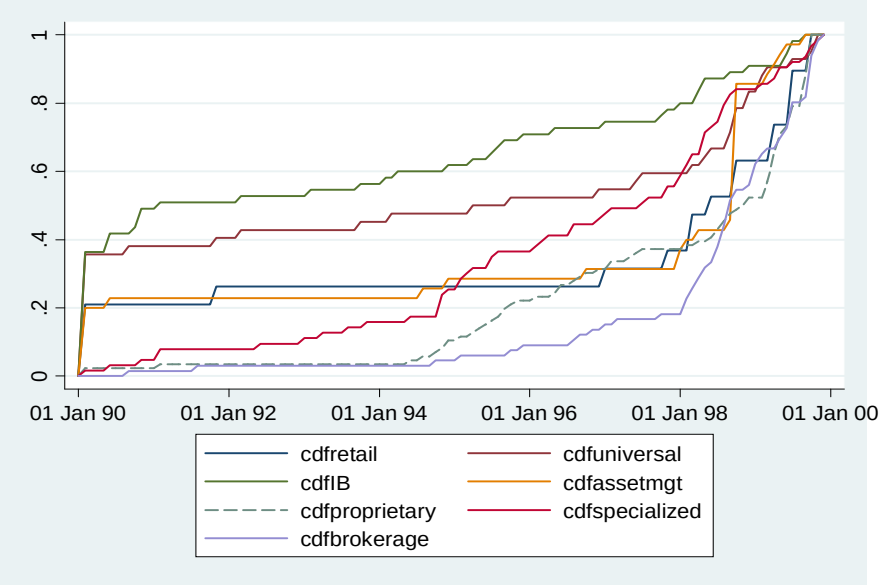


: Figure 1: DTB joining time according to closest geographical presence

Figure 1 shows that geographical presence captures one important aspect by which groups differ. Geographical presence affects both the volume of early DTB members (30% of groups with a German presence had joined by January 1990 whereas it took a year for groups without an initial German presence to join DTB) as well as the dynamics of the timing of adoption (many groups with a French or Dutch join after the deregulation of access from the Netherlands and France in September 1994; likewise, membership from groups based in Switserland jumps around the time of the merger with SOFFEX). Yet, it is also clear that geographical presence does not entirely capture the timing of adoption. Figure 1 shows that groups with an English presence but no German, French or Dutch presence came in earlier than groups with a European presence outside of Germany, France, Holland and the UK despite the fact that those groups were in principle affected equally by deregulation.

Figure 2 plots the cumulative distribution function of the time at which groups joined DTB, by business category. Again the figure suggests differences in the timing of DTB membership. There seem to be two types of retail banks and asset management firms: those that joined DTB at the very beginning, and those that joined at the end of the decade. Very few joined in-between. By contrast, most of the new members circa 1995-1996 were specialized trading firms and proprietary trading firms. Brokerages followed suit but later.

Table 3 describes the relationship between closest geographical presence and business types. It shows that the two variables capture different sources of heterogeneity. For example, the fact that proprietary firms came in later than specialized trading firms cannot be explained by geography alone.



: Figure 2: DTB joining times according to business type

Table 3: Relationship between closest geographical presence and business types

Closest geo presence	Universal	Retail	IB	Specialized	Asset Mgt	Propr	Brokerage
Germany	31	12	42	18	16	53	19
France or NL	3	0	6	26	2	14	13
Switzerland	3	2	1	2	20	1	2
UK	19	7	48	45	1	48	50
Rest of EU	8	7	6	1	8	3	18
US	0	0	0	3	1	12	8
ROW	0	0	0	0	0	0	0
Total	64	28	102	95	48	131	110

4.4 Switchers versus newcomers, and evidence of lock-in

Table 1 already suggested that DTB experienced an increase in membership whereas membership at LIFFE remained almost constant during the 1990s. A first question we can answer on the basis of our data (since we have tracked group ownership) is to what extent the increase in DTB membership was driven by traders switching from DTB to LIFFE (or, more plausibly given Table 1, joining DTB on top of LIFFE), rather than by newcomers choosing predominantly DTB. To answer this question, we build a panel data of groups' membership status over the 120 month period between 1 January

1990 till 31 December 99.[10] Thus an observation is a group-month observation. For each group-month observation, we record the group's membership status in the previous month and the current membership status.

Figure 3 summarizes the resulting transition matrix. DTB's success seems largely due to newcomers. Newcomers predominantly chose DTB at a ratio of almost 4 to 1: Out of the 364 groups that were not members of either exchange at the beginning of the sample, 285 chose DTB.[11] There were at most 11 "switchers" from LIFFE to DTB (a switcher would have first joined DTB generating a LIFFE-Both transition, and then resigned from LIFFE, generating a Both-DTB transition). If we also consider those groups that added a DTB membership to their LIFFE membership, the number of "switchers" is 75 maximum. This is to be compared to the 285 newcomers who joined DTB.

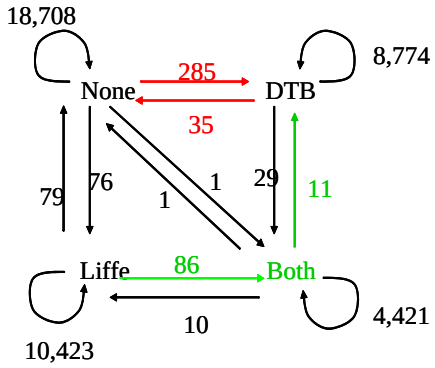


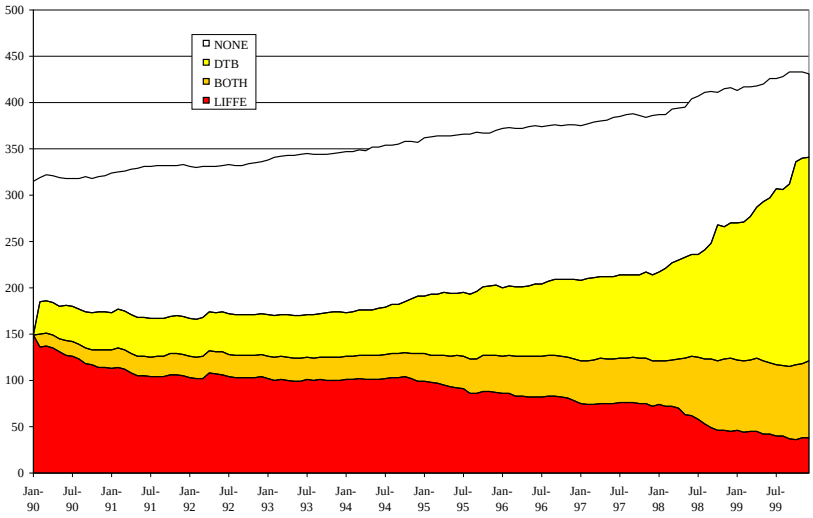
Figure 3: Transitions in full dataset
(1/99 - 12/99)

The total number of transitions is 589. Given that our dataset controls for group ownership and group entries and exits, these transitions can be attributed to changes in the value that the firms assign to the exchanges.[12] Among the 578 groups present in our data, 97 never change membership status over the entire period during which they are present, 372 change status once, 92 change status twice and 11 change status three times and 6 change status four times. Approximately 18 % of groups undergo at least two changes of status. This is not a trivial number. It motivates our empirical model where firms decide to join or quit exchanges at all times.

[10] A group is present in the data from its inception date until its exit date (acquisition, merger or bankruptcy). A group is a member of an exchange as soon as one establishment belonging to the group is a member

[11] This number is somewhat exaggerated because we consider the period 1/90 till 9/99 and DTB was set up in January 1990. This boosts the number of newcomers by about 50 right there independently of the Bund.

[12] Put differently, membership resignations due to bankruptcies or membership rationalization following a merger are not counted in this number. Likewise, decisions by groups to add another membership from another location in addition to their existing membership are also not counted. As a benchmark, the number of transitions would be equal to 1,019 if we did not correct for those and took establishment memberships as our unit of observation.



: Figure 4: Exchange members and non-members over time

As an additional perspective on newcomers, Figure 4 plots the number of groups that were members of LIFFE, BOTH, DTB or no exchange over time. The area at the bottom represents the group membership at LIFFE only. The second area from the bottom represents membership at both exchanges. The third area corresponds to DTB-only members. The top area corresponds to those groups that are not members of any exchange.

Figure 4 shows both the increase in the size of the market for exchange members and the increase in the proportion of these groups that are members of an exchange. Depending on the adopted definition, the time window in which tipping occured was from May 1997 till May 1998, or if we take a narrower definition, September 1997 to December 1997. Figure 4 shows an acceleration in the number of new members for DTB just *after* tipping occured or in the last phase of tipping if we take the broader definition. Interestingly, a significant fraction of these new members are LIFFE members who add a DTB membership to their existing membership. An interpretation of this pattern is that trading firms were more reactive in their choice of an exchange than forward-looking.

5 Benchmark model

This section introduces our benchmark empirical model, discusses its microfoundations, and how we address the econometric issues that the model and the data raise.

5.1 Model

We assume that trading firms reconsider every month which exchange(s) they want to be a member of, based on their expected period profit from membership. Traders can be members of one or both exchanges, or not be a member of any exchange.

Formally, let i denote a trading firm, $s \in \mathcal{S} = \{$universal bank, retail bank, IB, specialized trading firm, proprietary trading firm, asset management, brokerage$\}$ denote the type of business it does, and t denote time. The state variable ω_{it} describes the membership status of firm i at time t, where $\omega_{it} \in \{D, L, B, 0\}$ stands for DTB, LIFFE, BOTH and NONE respectively. Firm i's profit from membership at exchange k at time t can be decomposed into a fixed component, a component that varies with trading volumes in the Bund, and an adoption cost (in case firm i was not a member of exchange k in the previous period). Thus we let firm i's expected profit from being a member of exchange k at time t be:

$$\pi_{it}(k, \omega_{it-1}) = F_{it}(k) + VAR_{it}(k) - A_{it}(k, \omega_{it-1}) \tag{1}$$

where $F_{it}(k)$ and $VAR_{it}(k)$ are firm i's fixed and variable components of profit due to its membership at exchange k and $A_{it}(k, \omega_{it-1})$ stands for firm i's adoption cost for exchange k given that it was a member of exchange ω_{it-1} in the previous period. We normalize $\pi_{it}(0, \omega_{it-1}) = 0$.

Fixed profits. The fixed component of profits is made of the exchanges' fixed fee, a specific term for each exchange, business-type and HQ location, an exchange specific time trend, and a random shock to the value of exchange membership:

$$F_{it}(k) = \alpha_1 \text{FIXED}_{kt} + \alpha_{2skHQ} + \alpha_{3k}\text{TIME} + \varepsilon_{ikt} \tag{2}$$

Note that whereas FIXED clearly captures a cost component, the other variables in (2) capture both cost and revenue components to exchange membership. The term α_{2skHQ} captures any time-invariant match quality between a firm and exchange k. It may be due to exchange k's product portfolio or reporting practice or any other unobservable cost or revenue component specific to that exchange. We impose that all firms with the same headquarter location and business types have the same match quality. This yields 126 coefficients. Controlling for headquarter location, rather than geographical presence, will allow us to identify any nationalistic bias if it exists. The coefficients on the time trend vary with the exchange because technological progress, labor costs, and the evolution of real estate affected exchanges differently.

Variable profits. The variable component of profits is a function the ability of trader i to turn trades in the Bund contract into revenue, trader i's opportunity cost of margins and the exchange's transaction fee and liquidity (through the impact cost). Because these variables impact a trading firm's profit differently depending on its trading behavior (see appendix B for details, and the next

subsection for some microfoundations), we assume it takes the following form:

$$\text{VAR}_{it}(k) = \beta_{1i}\text{FEE}_{kt} + \beta_{2i}\text{MARGINS}_{kt} + \beta_{3i}\text{LIQUIDITY}_{kt} + \eta_{it} \qquad k = D, L \tag{3}$$

where FEE_{kt} stands for transaction fees, MARGINS_{kt} stands for the initial margins requested to secure trades, and LIQUIDITY_{kt} captures a measure of impact costs. For $k = B$,

$$\begin{aligned} \text{VAR}_{it}(B) \quad = \quad & \beta_{1i}(\text{FEE}_{Dt} + \text{FEE}_{Lt}) + \beta_{2i}(\text{MARGINS}_{Dt} + \text{MARGINS}_{Lt}) \\ & + \beta_{4i}\text{LIQUIDITY}_{Bt} + \eta_{it} \end{aligned} \tag{4}$$

Adoption costs. Adoption costs depend on the admission fee charged by the exchange and on the time and geography-varying adoption costs borne by traders to prepare for membership (opening of an office, organization of the back office, traders' training and so on).

$$A_{it}(k, \omega_{it-1}) = (\gamma_1 \text{ADM}_{kt} + D(i\text{'s most favorable location given } k \text{ and } t))\, 1_{\{i \text{ must bear adoption cost}\}} \tag{5}$$

where D is a dummy variable constructed for each location and time period during which a relevant access regulation regime was in place. For traders with multiple locations, we take the a priori most favorable location and check ex-post that the estimation results are consistent with that assumption (See appendix A for details). To avoid an endogeneity bias due to the possibility that firms open an establishment at the same time as they join an exchange, we consider the geographical presence of firms at $t-3$ to construct D.

At time $t-1$, trading firms decide on their membership status for period t. We observe

$$\omega_{it} = k \text{ if } k = \arg \max_{k' \in \{D,L,B,0\}} \pi_{it}(k', \omega_{it-1}) \tag{6}$$

Firms are myopic and they take time $t-1$ values into account to evaluate their expected payoff from each option. In other words, they play a best response to the previous period observed payoff and do not account for the possibility that the environment might be changing, either following exogenous events or following membership decisions by other firms.[13] An alternative interpretation is that firms are forward-looking but that current values for the independent variables capture entirely their expectations about the future. The coefficients should interpreted accordingly.

5.2 Microfoundations

Our application has two distinctive features relative to standard models of technology adoption and competition between networks. The first distinctive feature is that exchange membership is not necessary to trade on a market: a trader can always use a broker to access an exchange. The second

[13] This "best-response" approach is in the spirit of Arthur (1989) and Auriol and Benaim (2000) for environments of technology adoption with network externalities, and more generally with the literature in evolutionary economics. Cabral (1990) argues that "best response"-type behavior converges to the lowest coordination equilibrium in a similar environment with a continuum of agents.

distinctive feature is that traders can (and do) become members of both exchanges. We now discuss the microfoundations of (1)-(5) and interpretation of the model's coefficients.

We first consider the feature that consists in exchange membership not being necessary for trading. Why and how should liquidity matter then? If a trader trades exactly the same amount whether he is a member or not, the only difference membership makes is that the trader avoids the broker's commission but must pay the exchange's fixed fee. A trader trading large volumes will choose membership, whereas occasional traders will opt for the broker. With our normalization of the payoff to NONE to zero, this would imply $VAR_{it}(k) = \text{vol}_{it}\text{BROKERFEE}_t$ where vol_{it} is trader i's exogenous trading volume at time t.[14] Liquidity would not matter. Margins and fees would not matter either.

In practice, exchange members trade more than non members because they can take advantage of arbitrage or speculation opportunities that would be unprofitable with a brokerage fee. Even exchange members who earn a profit from commission rather than trading profits are likely to trade more than non members because they can price their services more competitively. When trading volumes differ, liquidity (and margins and fees) affect a trader's variable profit even after normalization. Formally, let vol_{it} be trader i's trading volume if he is not a member of an exchange at time t and let vol_{ikt} be his trading volume if he is a member of exchange k. Suppose trader i generates an average revenue of ρ_i on each contract traded. Then, trader i's variable profits from membership at exchange k are (after normalization): $(\text{vol}_{ikt} - \text{vol}_{it})(\rho_i - \text{FEE}_{kt} - \text{COST\_MARGINS}_{kt} - \text{IMPACT\_COST}_{kt}) + \text{vol}_{it}\text{BROKERFEE}_t$. Suppose $(\text{vol}_{ikt} - \text{vol}_{it})$ is only a function of i. Then $\text{VAR}_{it}(k)$ takes the form of (3) and the interpretation for η_{it} is that it collects the extra revenue from exchange membership and the broker fee term: $\eta_{it} = (\text{vol}_{ikt} - \text{vol}_{it})\rho_i + \text{vol}_{it}\text{BROKERFEE}_t$. The α coefficients incorporate $(\text{vol}_{ikt} - \text{vol}_{it})$, the extra volume generated from being an exchange member. In other words, our model assumes that traded volumes depend on a trader's membership status, and that the additional volume does not vary across time or exchange.[15]

We now consider the value for dual membership. Suppose a trader trades sufficient volumes that the cost of membership at one exchange is justified. Our model allows for two reasons why such a trader may want to be a member of both exchanges. First, dual membership allows a trader to send his trades where total transaction costs are cheapest at any given time. This explains our functional form for variable profits from dual membership (4) where we allow for a different coefficient on liquidity than in (3). Second, dual members benefit from all the products traded on both exchanges without

[14] Indeed, the variable costs from being a member of exchange k are given by $\text{vol}_{it}(\text{FEE}_{kt} + \text{COST\_MARGINS}_{kt} + \text{IMPACT\_COST}_{kt})$. The variable costs incurred if trader i is not a member of any exchange is $\text{vol}_{it}(\text{FEE}_{kt} + \text{COST\_MARGINS}_{kt} + \text{IMPACT\_COST}_{kt} + \text{BROKERFEE}_t)$. Thus, after normalization, $\text{VAR}_{it}(k) = \text{vol}_{it}\text{BROKERFEE}_t$.

[15] This discussion also suggests one constraint on our measure of impact costs. Because $\text{vol}_{ikt} - \text{vol}_{it} = 0$ when an exchange does not trade the Bund, we need a measure of impact cost that converges to zero when trading on an exchange converges to zero.

the intermediation of a broker. This will be all the more valuable that there is little overlap between the exchanges' other products and that the trader is interested in those. This effect is captured by allowing β_{2sBHQ} to be different from $\beta_{2sDHQ} + \beta_{2sLHQ}$ and a distinct time trend coefficient.

5.3 Estimation

We can rewrite traders' profit function as follows:

$$\begin{aligned} \pi_{it}(k, w_{it-1}) &= \theta_i X_{ikt} + \varepsilon_{ikt} + \eta_{it}, \quad k \in \{D, L, B\} \\ \pi_{it}(0, w_{it-1}) &= 0 \end{aligned} \tag{7}$$

Expression (7) raises two issues for estimation. First, without further restriction, η_{it} is not separately identified from the coefficients on other time-varying variables. In other words, if we estimated η_{it} as a fixed effect we would need to drop all other time-varying variables from the estimation. Recall that the time-varying part of η_{it} is equal to $\text{vol}_{it}\text{BROKERFEE}_t$ and that the time-invariant part is proportional to the extra volume of trading generated by membership. As a first step in our empirical analysis, we consider that these aspects are captured by the time trend and the business-type-HQ-exchange fixed effects, and thus ignore η_{it} in the estimation.

The second issue concerns the trader-specific coefficients θ_i. As a first step we constrain them to be equal across business types. In that case, if we assume that ε_{ikt} are i.i.d. extreme value, we have a standard multinomial logit. Estimation is done using Maximum Likelihood Estimation.

In a future version, we plan to implement Revelt and Train (1998)'s mixed logit estimator for panel data. This estimator adds an extra level of flexibility by assuming a functional form for the distribution of θ_i and estimating the parameters of this distribution. This seems justified given that business types proxy for many things and are thus likely to be poor proxies for traders' trading behavior.

6 Results

Before presenting the results, we summarize the sources of time and exchange variation in our data. Our empirical model includes six sources of variation across exchanges and time. The first source of variation is access deregulation. It is location specific and affects all trading firms with a geographical presence in a given country equally. The second source of variation is liquidity. This source of variation affects all traders irrespective of geography, but it potentially affects different business types differentially. Likewise, transactions fees and margins are allowed to affect traders of different business types differently. The last two sources of time and exchange variation are the time trend and the fixed fees. They affect all traders equally.

The next tables report our results for the benchmark model. For the estimation, we dropped the 25 groups for which we could not get any information and the 36 group-month observations for which

we could establish that they did not trade the Bund during that period. DTB traded the Bund from November 1990 onwards, whereas no more Bund trades took place on LIFFE after 1 January 1999. For the periods where exchanges do not trade the Bund, all components of variable profits are set equal to zero (given that our discussion of the microfoundation suggests the coefficients should be equal to zero in this case). This leaves us with 40,140 group-month observations covering the period of January 1990 to December 1999 and 518 groups.

The first specification in Table 5 constrains the coefficients of the variable profits to be equal for all business types. In specifications (2) and (3), we estimated business-type-specific coefficients for liquidity (thus imposing that $\beta_{3i} = \beta_{3s}$ and $\beta_{4i} = \beta_{4s}$ for all i of business type s).. Liquidity at exchange k and time t (liquidity_{kt}) is defined as the 3-month average of traded volume at exchange k over periods $t-3$ to $t-1$ in 100,000s of contracts. To help with the estimation, transaction fees are expressed in Pfennig and margins are expressed in thousands of DM.

Adoption costs, implicit adoption costs and access deregulation. The top part of Table 5 reports the coefficients for adoption costs. Admissions fees were statistically significant in all three specifications and negative as expected. Given that LIFFE never charged an admission fee during the sample period and that DTB charged 102,000 DM until 1 January 1998 and then zero afterwards, we will be using this coefficient to give a DM interpretation to the other coefficients. The next set of estimates, from DTBaccessG through LIFFEaccessUS2, are the regulation and geography related dummy variables for adoption costs. They capture the implicit costs of adoption, i.e. those costs incurred by a new member beyond the admission fee charged by the exchanges. All of these estimates are statistically significant and negative as expected, indicating that explicit admission costs were only one part of the costs borne by new members. The coefficients are stable across specifications. If we use the explicit admission fee coefficient as a benchmark, taking into account that admission fees were equal to 102,000 DM, we get that implicit adoption costs were of the order of 3 times larger than explicit admission fees.

Within a geography, access costs evolve as expected. Implicit adoption costs at DTB for a EU-based trader or a Swiss-based trader declined overall as deregulation progressed. Whereas the change in the law that allowed EU-based firms to become clearing members did not have much affect, access from a EU country was clearly cheaper after the ISD. Access from Switzerland became significantly easier after the merger with SOFFEX. For the DTBaccessUS series, the rise in magnitude of DTBaccessUS3 relative to the other US coefficients is expected, since this event was a reversal or previous regulations that allowed more US access to DTB. Implicit adoption costs for LIFFE and for firms with a EU presence but no presence in the UK was not affected much by the ISD. This is expected because the APT was not technically accessible from outside the UK and full migration to electronic (on Liffe.connect) only happenned in May 1999.

Table 5: Conditional Logit Estimates for Traders' choice of exchange: Access

Coefficient (variable)	Estimate	st. err.	Estimate	st. err	Estimate	st. err.
Specification	(1)		(2)		(3)	
ADM (γ_1)	2.78 10^{-5**}	3.77 10^{-6}	2.88 10^{-5**}	3.78 10^{-6}	2.90 10^{-5**}	3.86 10^{-6}
DTBaccessG	-7.57**	0.24	-7.45**	0.24	-7.26**	0.26
DTBaccessEU1	-11.74**	0.49	-11.64**	0.49	-11.41**	0.52
DTBaccessEU2	-10.76**	0.51	-10.69**	0.51	-10.45**	0.53
DTBaccessEU3	-8.75**	0.22	-8.71**	0.22	-8.35**	0.25
DTBaccessFrench	-6.85**	0.37	-6.79**	0.37	-7.11**	0.41
DTBaccessSwiss1	-10.45**	0.63	-10.34**	0.64	-10.33**	0.91
DTBaccessSwiss2	-10.42**	1.02	-10.54**	1.02	-10.81**	1.21
DTBaccessSwiss3	-6.50**	0.33	-6.83**	0.39	-7.19**	0.72
DTBaccessUS1	-10.50**	1.03	-10.38**	1.03	-10.25**	1.15
DTBaccessUS2	-7.17**	0.42	-7.03**	0.43	-6.67**	0.50
DTBaccessUS3	-9.03**	1.03	-8.85**	1.04	-8.48**	1.06
DTBaccessUS4	-6.16**	0.53	-6.01**	0.55	-5.64**	0.61
LIFFEaccessUK	-9.65**	0.16	-9.64**	0.16	-9.53**	0.17
LIFFEaccessEU1	-13.29**	0.59	-12.68**	0.60	-13.34**	0.64
LIFFEaccessEU2	-12.70**	0.60	-12.60**	0.64	-12.65**	0.65
LIFFEaccessEU3	-12.05**	0.61	-11.93**	0.61	-12.05**	0.71
LIFFEaccessUS1	-12.06**	1.00	-12.08**	1.01	-11.83**	1.03
LIFFEaccessUS2	-9.67**	1.03	-9.99**	1.04	-10.06**	1.09
FIXED	4.87 10^{-5**}	1.25 10^{-5}	5.16 10^{-5**}	1.24 10^{-5}	5.2 10^{-5**}	1.27 10^{-5}
FEE (β_1)	-0.0039**	0.0015	-0.0038**	0.0016	-0.0033**	0.0017
MARGINS (β_2)	-0.096**	0.049	-0.096**	0.049	-0.064	0.050
LIQUIDITY (β_3)	0.0173**	0.0033	See Table 6		See Table 6	
LIQUIDITYBOTH (β_4)	0.0251**	0.0084	See Table 6		See Table 6	
exchange time trend	yes		yes		yes	
exchange dummies	yes		yes		no	
exchange-type-HQ dummies	no		no		yes	
Loglikelihood	-2,739.55		-2,717.43		-2,577.31	
Pseudo R^2	0.9508		0.9512		0.9537	
N	40,140		40,140		40,140	

** indicates significance at 5%, * indicates significance at 10%

Across geographies and for DTB, access costs compare as we expect and are broadly consistent with the way we constructed the dummies for groups with several geographical presences. Access costs

from Switzerland were lower than from the EU, and except when remote access was authorized from the US, access from the US was more expensive than from Europe. For the first part of the decade, access for firms with a presence in Germany was cheapest. Adoption costs later from Switzerland and the US (DTBaccessSwiss3 and DTBaccessUS4) are lower than from Germany. This suggests that costs may have declined over time for other reasons than regulation, and that the estimate for adoption costs from Germany (DTBaccessG) may be an underestimate of costs at the beginning of the period and an overestimate of costs later in the decade. Across geographies and for LIFFE, our estimates confirm that traders with a presence in the UK did incur lower set-up costs than traders without a UK presence.

Finally, we can compare access costs across exchanges. The coefficient magnitudes indicate that access to LIFFE was more difficult than access to DTB.

Table 6: Coefficients on liquidity in specifications (2) and (3)

	(2)		(3)	
	β_3	β_4	β_2	β_3
universal bank	0.022**	0.032**	0.026**	0.034**
	(0.004)	(0.009)	(0.006)	(0.011)
retail bank	0.019**	0.019	0.028**	0.071**
	(0.005)	(0.013)	(0.006)	(0.033)
IB	0.019**	0.020**	0.022**	0.019
	(0.004)	(0.009)	(0.006)	(0.010)
specialized	0.014**	0.032**	0.010**	0.018
	(0.004)	(0.009)	(0.005)	(0.011)
brokerage	0.017**	0.030**	0.022**	0.064**
	(0.004)	(0.009)	(0.005)	(0.014)
assetmgt	0.023**	1.56	0.026**	-0.42
	(0.005)	(111.68)	(0.007)	(32.67)
proprietary	0.017**	0.015	0.016**	0.016
	(0.004)	(0.009)	(0.004)	(0.016)

Standard deviation in parenthesis **indicates significance at 5%

Variable costs coefficients. The second half of Table 5 reports the coefficients on the variable costs. All variables have significant coefficients with the expected sign. In specifications (2) and (3) we let the coefficients on liquidity vary with business types. These are reported in Table 6.

Liquidity has a positive impact on profits as expected. The coefficients on β_3 are all significant in both specifications whereas only three coefficients on β_4 are significant in specification (3). This may be due to the combination of the small number of trading firms that are members of both exchanges

and the presence business-type-HQ–location-exchange fixed effects in specification (3). The coefficients vary with business types but those differences are generally not significant. This may be due to the fact that business types are a poor proxy for these firms' value for liquidity or because trading firms are actually fairly similar on this dimension. A future version will introduce random coefficients for these variables to investigate the first possibility in more detail.

Exchange-business-types-HQ-location fixed effects. Specification (3) includes 126 exchange-business-types-HQ-location dummies (the headquarter locations were US, UK, Germany, Switzerland, EU except for Germany and UK, ROW). The omitted categories are for the "none" choice, thus the interpretation for each of these variables should be relative to the preference of a given trader for an exchange relative to not being a member of any exchange. Many of these dummies are significant suggesting that trader-exchange unobservable may be important. Table 7 reports a subset of these coefficients. (n/a indicates that the dummy is not identified).

Table 7: Evidence of HQ location - business type effects

		DTB	LIFFE	BOTH
UK HQ	Universal	n/a	5.30**	11.44**
			(0.87)	(1.20)
	IB	4.14**	5.89**	11.58**
		(0.88)	(0.60)	(0.82)
	Brokerage	1.44*	5.32**	7.24**
		(0.78)	(0.43)	(1.36)
German HQ	Universal	6.48**	3.82**	12.26**
		(0.51)	(1.32)	(1.03)
	IB	7.26**	7.21**	12.52**
		(0.47)	(0.80)	(0.85)
	Brokerage	5.19**	n/a	n/a
		(0.57)		
US HQ	Universal	4.45**	5.01**	8.92**
		(0.97)	(0.72)	(1.33)
	IB	7.04**	5.77**	12.79**
		(0.69)	(0.49)	(0.72)
	Brokerage	5.03**	5.12**	7.63**
		(0.65)	(0.48)	(1.35)

Across locations and business types, the value for the fixed effect for "BOTH" is larger than the fixed effects for the individual exchanges. This suggests that the two exchanges were far from being substitutes from the point of view of traders even if they were substitutes if we only consider the Bund.

Table 7 also allows us to assess the theory according to which German traders were biased towards DTB. We use the US-headquartered firms as a benchmark for unbiasedness and compare the fixed effects for investment banks (the only category for which all fixed effects are available). UK-headquartered investment banks valued LIFFE 1.75 points higher than DTB. This is to be compared with -1.27 for US-headquartered investment banks and -0.05 for German-headquartered banks. This is hardly evidence of nationalistic bias. If anything, British and German investment banks were biased towards LIFFE.

7 Conclusions

Liquidity matters in financial markets. This creates a tendency for trading to concentrate on a single exchange and gives incumbent exchanges a first-mover advantage. However, exchanges differ in other dimensions than liquidity. National regulation, product portfolio, user convenience all provide scope for differentiation. Competition and coexistence will be possible when these other dimensions of exchange differentiation can counterbalance the incumbent's liquidity advantage.

This paper is a first attempt at evaluating the contribution of these dimensions of differentiation to the attractiveness of exchanges. Understanding the sources of exchange differentiation has implications for exchange strategies, for competition policy, and, more generally, for the normative evaluation of market structure in the exchange industry.

The current version of this paper describes the dataset we have collected, lays out a very simple model for traders' choice, and reports the estimates from this model. The advantage of our dataset is that we matched the members from both exchanges and tracked their group affiliation, histories, and geographical presence. As a result, two features of the competition between LIFFE and DTB stand out by simply looking at descriptive statistics. First, the Battle of the Bund is a story of newcomers rather than switchers. These newcomers result from an increase in the size of the market for exchange membership and an increase in the proportion of these firms that are effectively members of an exchange. Second, geographical presence is a key determinant of adoption time for DTB and it is clearly connected to the timing of access deregulation.

The econometric results confirm this and provide further insights into the way the Battle of the Bund played out. Geographically-determined access costs are highly significant and explain most of the variation in the data. Access costs decreased over time as access deregulation spread and explain the increase in the number of DTB members.

We also found evidence of heterogeneity in the match between traders and exchanges suggesting that other dimensions of horizontal differentiation beyond geography played a role. By contrast, we did not find evidence that German-headquartered groups were more likely to join DTB over LIFFE, once we controlled for geographical presence. Thus, if it is likely that nationality played a role in

explaining the early membership by some German institutions, it does not explain why DTB continued to attract some many new members, including German ones. Another interesting result from the econometric analysis is that LIFFE and DTB memberships were far from being substitutes in traders' payoff function: a dual membership creates as much value as the sum of the values from individual memberships. This reinforces the idea that exchanges - and LIFFE and DTB in particular - are differentiated competitors.

Finally, while we found that liquidity mattered, we did not find much evidence of trader heterogeneity in the value of liquidity, suggesting that vertical differentiation did not play an important role in the observed dynamics. However, the current results seem sensitive to the specification. They warrant further analysis.

To summarize, the story the data tells is one of horizontal differentiation induced artificially by national access barriers that came down following the European Investment Services Directive and access deregulation in the US, with secondary roles played by liquidity and product portfolio effects. DTB won the Battle of the Bund because it won a membership war.

We intend to push our results in two directions. First, we intend to estimate alternative specifications to control for trader heterogeneity and cross-product effects, alternative timing for traders' decision making and specification testing. Second, while the fact that we do not impose that DTB and LIFFE behaved optimally limits what we can do in terms of counter-factuals, we can already investigate the following questions:

1. How much was access deregulation worth for DTB? (by considering the alternative admission fee DTB should have charged to maintain adoption constant, absent deregulation)

2. Is there evidence that the exchanges optimized their fee structure? (by considering the costs of alternative fee structure that would have generated the same adoption behavior).

3. Holding the behavior of DTB fixed, what would it have taken LIFFE to keep the Bund?

[bibliography is incomplete]

References

[1] Arthur, W. Brian (1989), Competing Technologies, Increasing Returns, and Lock-In by Historical Events, *The Economic Journal*, 99, 116-131

[2] Auriol, Emmanuelle and Michel Benaim (2000), Standardization in Decentralized Economies, *American Economic Review,* 90(3), 550-570.

[3] Breedon, Francis and Allison Holland (1998), Electronic versus Open Outcry Markets: the Case of the Bund Future Contract, Bank of England Working Paper 76.

[4] Bessler, Wolfgang, Thomas Book and Andreas Preuß (2006), Elektronischer Handel versus Parketthandel: Der Wechsel in der Marktführung im Bund-Future-Handel von der LIFFE zur DTB/Eurex, in Wolfgang Bessler (Ed.): Börsen, Banken und Kapitalmärkte, Duncker & Humblot, Berlin.

[5] Bower, Joseph and C. Christensen (1996), Customer Power, Strategic Investment, and the Failure of Leading Firms, *Strategic Management Journal,* 17(3), 197-218.

[6] Brock, William and Steven Durlauf (2001), Discrete Choice with Social Interactions, *Review of Economic Studies,* 68, 235-260.

[7] Chamberlain, Gary (1980), Analysis of Covariance with Qualitative Data, *Review of Economic Studies*, 47, 225-238.

[8] Christensen, Clayton (1997), The Innovator's Dilemna: When New Technologies Cause Great Firms to Fail, *Harvard Business School Press.*

[9] Christensen, Clayton and R. Rosenbloom (1995), Explaining the Attacker's Advantage: Technological Paradigms, Organizational Dynamics, and the Value Network, *Research Policy,* 24(2), 233-257.

[10] De Palma, André and Luc Leruth (1993), Equilibrium in Competing Networks with Differentiated Products, *Transportation Science*, 27, 73-80.

[11] Economides, Nicholas and A. Siow (1988), The division of markets is limited by the extent of lliquidity (spatial competition with externalities), *American Economic Review*, 78(1), 108-121.

[12] Farrell, Joseph and Garth Saloner (1986), Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation, *American Economic Review,* 76(5), 940-955.

[13] Farrell, Joseph and Paul Klemperer (2004), Coordination and Lock-in: Competition with Switching Costs and Network Effects, preliminary draft for the *Handbook of Industrial Organization.*

[14] Geweke, John, Michael Keane and David Runkle (1997), Statistical Inference in the Multinomial Multiperiod probit model, *Journal of Econometrics*, 80, 125-165.

[15] Hull, John C. (2003), Options, Futures, and Other Derivatives, Fifth Edition, Prentice Hall

[16] Kim, David (1997), Treasury Bond futures Mechanics and Basis Valuation, Chapter 58, in: Fabozzi (Ed), *The Handbook of Fixed Income Securities,* 5^{th} Edition, McGraw Hill

[17] Kynaston, David (1997), LIFFE: A Market and its Makers, Granta Editions, London

[18] Krailo, M and M. Pike (1984), Conditional Multivariate Logistic Analysis of Stratified Case-Control Studies, *Applied Statistics*, 44(1), 95-103.

[19] Madhavan, Ananth (2001), Market Microstructure: A Survey, *Journal of Financial Economics,* XXXXX

[20] Pagano, Marco (1989), Trading Volume and Asset Liquidity, *Quarterly Journal of Economics,* 104, 255-274.

[21] Pirrong, Craig (2003), Bund for Glory, or It's a Long Way to Tip a Market, mimeo

[22] Revelt, David and Kenneth Train (1998), Mixed Logit with Repeated Choices: Households Choice of Appliances Efficiency Level, *Review of Economics and Statistics,* 80(4), 647-657.

8 Appendix A: Description of data and variable construction

This appendix complements the main text. It describes how the firm dataset was constructed and provides definitions for the geography and time contingent adoption costs and for the exchange period dummies.

8.1 Firm dataset

The main text reports that, for each individual establishment, we collected information on (1) its (historical) group affiliation including mergers and acquisitions, (2) the establishment inception date and, if applicable, its closing date, (3) the group inception date and, if applicable, its bankruptcy date, (4) the activities of the establishment, and (5) whether the establishment trades the Bund or any other long-term government bond derivatives. This information was collected manually using the following procedure:

1. *Group and establishment inception dates and exit dates. I*nception dates for existing companies were taken from ORBIS, UKdata.com or by contacting the establishment directly.[16] For bankrupt establishments located in Germany and Switzerland, we used the Dufa-Index and the Dun&Bradstreet (Swtizerland)'s records (both available through Factiva).[17] Factiva was used to track any available information for other bankrupt firms (e.g. reports of bankruptcy filing, trading license being upheld). Some establishments still exist legally but are no longer active. Those appear in ORBIS with the mention "inactive" and we took the date of the last financial accounts as the exit date.

2. *Information on group ownership structure including mergers and acquisitions* was gathered from company websites, ORBIS, UKdata.com, Dufa-Index, Dun & Bradstreet and press articles (Factiva). We consider that an establishment belongs to a group when it is owned 100% by this group or when it is clearly managed as a wholly-owned subsidiary (for example, a common ownership structure for specialized trading firms is that the local partners own a small fraction - of the order of 5% - of the capital of the local subsidiary. In these case, we considered that the establishment belonged to the group).

[16] ORBIS is a database of about 15 million listed and non listed companies worlwide that aggregates legal (such as legal status, inception date, structure of ownership), financial (balance sheets) and business information (www.bvdep.com/ORBIS.html). UKdata.com has the same kind of information but is limited to UK companies (www.ukdata.com).

[17] The Dufa Index is published by Dumrath & Fassnacht. It contains registration information of German companies, as published in the official daily Bundesanzeiger. It includes information on legal status, change of ownership, management, liquidation, settlement and mergers & acquistions. The information is available from 8 June 1994. Dun & Bradstreet (Switzerland)'s records contain all company-related publications by the Swiss official gazette of commerce (SHAB). The information is available from 20 August 1996.

3. *Information on establishments' business activities* was taken from self-descriptions of the business on company websites, ORBIS, and press articles during the relevant period, as well as direct phone or email contract with the company when possible. We recorded the following business activities: retail banking, investment banking, private banking,[18] asset management, proprietary trading, market making, brokerage for institutional or professional traders, brokerage for retail clients, arcade[19] and universal banking.

4. *Information on the products traded* was taken from company websites, LIFFE's product licenses, LIFFE's and DTB's notices to members, press articles during the relevant period, and phone calls to the establishment when possible.

8.2 Regulation-driven adoption costs

8.2.1 DTB

Initially, a trader had to have an office in Germany to be a member of DTB and only German firms could be clearing members. On 28 July 1993, there was a change in the law and EU trading firms with a German office could become clearing members. In September 1994, MATIF members could become members of DTB and the Dutch authorities recognized DTB and authorized Dutch-based firms to trade on DTB for their own account. The EU Investment Services Directive came into force in January 1996. Switzerland is not part of the EU and thus access from Switzerland followed its own timetable. Acess points were installed in Zurich in January 1996 and SOFFEX members became members of Eurex when SOFFEX and DTB merged in September 1998. Finally, the US Commodities Futures Trading Commission granted a no-action letter to DTB on 28 February 1996 which authorized US-based traders to trade on DTB. The authorization was frozen in October 1998, forbidding any new membership from the US. It was reinstated in August 1999.

A single geography-time adoption dummy is turned out for each group that is not a member. For groups with geographical presence in several locations, we considered the "closest" geographical location according to the following a-priori order: Germany $\succ$ France and the Netherlands between 9/94 and 12/95 $\succ$ Switzerland $\succ$ EU except France and the Netherlands between 9/94 and 12/95 $\succ$ US. We confirm ex-post that this order is the correct one on the basis of our estimation results. Locations included in the construction are those prevailing at $t-3$. The following table summarizes the value for the $D(i$'s most favorable location given k and $t)$ variable.

[18] Private banks, essentially a German-Swiss concept, offer financial advice and asset management to wealthy individuals. They also offer some corporate banking services.

[19] An arcade is a firm ofering services to independent traders, such as access to exchanges, back office support or office space.

Name	Events	Location	t between ...
DTBaccessG		Germany	1/90-12/99
DTBaccessSwiss1		Switzerland	1/90-12/95
DTBaccessSwiss2	Access points in Zurich	Switzerland	1/96-8/98
DTBaccessSwiss3	Merger with SOFFEX	Switzerland	9/98-12/99
DTBaccessEU1		EU	1/90-7/93
DTBaccessEU2	EU-based institutions can be clearing members	EU	8/93-12/95
DTBaccessEU3	Investment Service Directive	EU	1/96-12/99
DTBaccessFrench	Dutch regulatory approval + link with MATIF	France and NL	9/94-12/95
DTBaccessUS1		US	1/90-2/96
DTBaccessUS2	CFTC no-action letter	US	3/96-9/98
DTBaccessUS3	CFTC no-action letter upheld	US	10/98-7/99
DTBaccessUS4	CFTC no-action letter reinstated	US	8/99-12/99

8.2.2 LIFFE

Until August 1998, LIFFE was an open-outcry exchange, requiring LIFFE members to have staff based in London. We distinguished between groups that had a presence in the UK and those that did not have a presence in the UK before they joined the exchange. For those without a UK presence but a European presence, we distinguished three periods: before the European Investment Service Directive, after the ISD but before LIFFE moved the Bund to electronic trading in August 1998, and after August 1998. For firms with a US presence only, we distinguished between two periods, before July 1999 when the CFTC issued a no action letter for Liffe.connect, and after. The next table summarizes the resulting variables.

Name	Events	Location	t between ...
LIFFEaccessUK		UK	1/90-12/99
LIFFEaccessEU1		EU	1/90-12/95
LIFFEaccessEU2	Investment Service Directive	EU	1/95-7/98
LIFFEaccessEU3	Bund moved to electronic trading	EU	8/98-12/99
LIFFEaccessUS1		US	1/90-8/99
LIFFEaccessUS2	CFTC no-action letter	US	9/99-12/99

8.3 Other events affecting the attractiveness of DTB and LIFFE

The next table records the events that affect the attractiveness of DTB and LIFFE, beyond those already controlled for in the base specification. A dummy switch on in the specified period. Launches of complementary products or of trading facilities fostering trades with a complementary products are

captured by the trading volume in these complementary products in the base specification.

Other vents affecting the attractiveness of DTB	Type	t between ....
Cut in one-time connection charges for German-based customers	adoption cost	4/95-12/99
DTB offers free computers to LIFFE members	adoption cost	4/98-10/98
Other events affecting the attractiveness of LIFFE	**Type**	**t between ...**
Launch of new Automated Trading Platform (APT)	market rules	12/93-12/99
LIFFE-CBOT link	extra trading opportunities	5/97-12/97
Top step initiative	market rules	6/97-12/99
Bund trading moved entirely to APT stations	market rules	8-98-12/99
Bund only traded on Liffe.connect,demutualization voted	market rules, corp. gov.	5/99-12/99

9 Appendix B: Economics of futures trading

This section provides a concise overview of the basics of futures trading for the purpose of determining the relevant factors we will need to take into account in our analysis.

A future (contract) is a promise to sell or to buy a specific instrument at a future date and at a given price. At the time of the agreement, the price and maturity are decided, but typically no payment is made. Delivery and payment take place at maturity.

Because economic conditions may have changed between the time of the agreement and the maturity date, the ex-ante beneficial contract is usually no longer beneficial ex-post for one of the parties. This creates an incentive to default. Futures have been used at all times and places, and various mechanisms have been used to mitigate this default risk. One of them is the use of exchanges and clearing.

9.1 Exchange-traded futures

Two key features characterize exchange-mediated futures trading. First, future contracts traded on exchanges are standardized. The exchange defines the product (size of the contract, delivery date, product that can be delivered) and its trading rules (hours, minimum tick size, ...). Standardization pools liquidity around a limited set of contracts and makes it easier for traders to find a counterpart at the best price. Second, exchange-traded contracts are cleared by a clearing house. Clearing is the process by which a trade—initially an agreement between two traders—is transformed into a commitment by each trader vis-à-vis the clearing house. In return for acting as a central counterparty, the clearing house requires each trader to put up margins as collateral. Margins are updated daily in a way that eliminates traders' incentives to default. Thus clearing removes counterparty (default) risk.

Market rules vary across exchanges and instruments. Broadly speaking, there are two cate-

gories of market organization: floor-based trading (also known as open outcry) and electronic trading. In floor-based trading, traders meet in a single physical venue and shout the price at which they are willing to buy or sell. All orders are channeled through traders on the floor. In electronic trading, traders can, in principle, be located anywhere in the world. They sit behind a computer connected to the exchange and input orders into the market through their computers. Orders are matched on the basis of price and some time priority rule. For most of the 1990s, LIFFE was an open outcry exchange and DTB was an electronic exchange.

Participation in futures exchanges is restricted to members. Futures exchanges impose conditions on new members to ensure the well functioning of their markets. New members must prove their financial stability and clearing arrangements must be in place (i.e. the new member must be "approved" by the exchange's clearing house, or must have an agreement with a member of the clearing house). New members must take an exam confirming their knowledge of basic finance and of the exchange's market rules and code of conduct.

Corporate governance. Traditionally, exchanges were set up as member-owned and member-managed organizations. Members owned a seat and/or shares in the exchange. Recently, there has been a worldwide move towards demutualization and thus decoupling between ownership and membership. In particular, LIFFE demutualized in May 1999. Members of DTB were not shareholders.

9.2 Market participants and trading motives

Broadly speaking, we can distinguish between three trading motives: hedging, speculation and arbitrage. Futures trading was initially set up to hedge risk. A firm or individual with a commitment to deliver or buy a product or money in the future would be able to lock in the cost of this transaction today by buying or selling a future contract. Speculators trade on the basis of their forecasts about the future movement of prices: they take positions, hoping that prices will move in a direction favorable to them. Finally, arbitrageurs are traders who speculate on the basis of price co-movements between similar securities. For example, an arbitrageur might simultaneously buy a future on a 2-year bond and sell a future on a 5-year bond, hoping to derive a profit from the variation in relative interest rates.

Today and in most futures markets, pure hedgers are in the minority. Speculators and arbitrageurs dominate. The reason has to do with the way future contracts are traded. At the time of the trade, no money is transferred. Only margins, often representing less than 2-3% of the value of the contract, must be deposited with the clearing house to guarantee the trade. Thus, very large positions can be taken, without having to commit significant financial resources. This leverage is unique to derivatives markets and explains their success with asset managers, investment banks and hedge funds.

9.3 Cost of trading

The costs of trading on an exchange fall into three categories: adoption costs, fixed costs, and variable costs incurred when trading.

Adoption costs. Traders must be members of an exchange to be able to trade on it without using a broker. New members bear the cost of training their traders to use the exchange and the cost of satisfying all the financial requirements for being a member. In addition, some exchanges charge an admission fee or require that the new member buys a seat or shares in the exchange. Finally, a new member would need to organize his back office to keep track of trade orders, current open positions, commissions and margins. Together, these adoption costs are far from trivial. A March 1996 article estimated those set-up costs for a US-based trading firm wanting to join DTB at one million dollars.[20]

Fixed costs. Fixed costs include the annual fees members pay to the exchanges, as well as a series of fees in return for some service, independently of the amount traded. Those service fees are typically priced at cost and are not a source of profit for exchanges.

Variable costs. Variable costs of trading are made of three components: transaction fees, margins, and price impact costs. First, on each contract traded, a trader pays a transaction fee to the exchange and a clearing fee to the clearing house. Second, for each new open position a trader has, margins must be deposited at the clearing house.[21] Some clearing houses pay interests on margins but many do not. In particular, LIFFE's clearing house did remunerate margins but DTB's clearing house did not. However, even when margins accrue interests, this return may be much lower than what a trader could generate elsewhere. Thus, margins generate an opportunity cost. Third, a trader may influence the price of the future when trying to buy or sell large quantities. The impact cost of a transaction is defined as the difference between the theoretical "equilibrium price" for the contract at the time of the transaction and the realized price for the transaction. Impact costs are related to the liquidity of a market. The more liquid a market is, the less specific orders affect prices. Figure 8 represents the impact cost of a ten-unit transaction in a liquid and less liquid market. The state of the market at a particular time is captured by the unmet demand and supply (this would correspond to the order book in an electronic order-driven market). These are closer to one another in a liquid market. The equilibrium price is defined as the average of the lowest unmet ask price and the highest unmet bid

[20] "DTB receives CFTC approval to install trading screens in U.S.", Securities Week, vol. 23, No. 10, 11 March 1996.

[21] A new position is opened when a trade does not cancel an earlier open position. For example, suppose that a trader buys a future contract at time t, and sells the same future contract at time $t+1$. From the clearing house's perspective, these two transactions cancel out and there is no residual default risk after $t+1$. In this case, margins will be required only for one day.

price. The figure illustrates that impact costs are higher in less liquid markets.

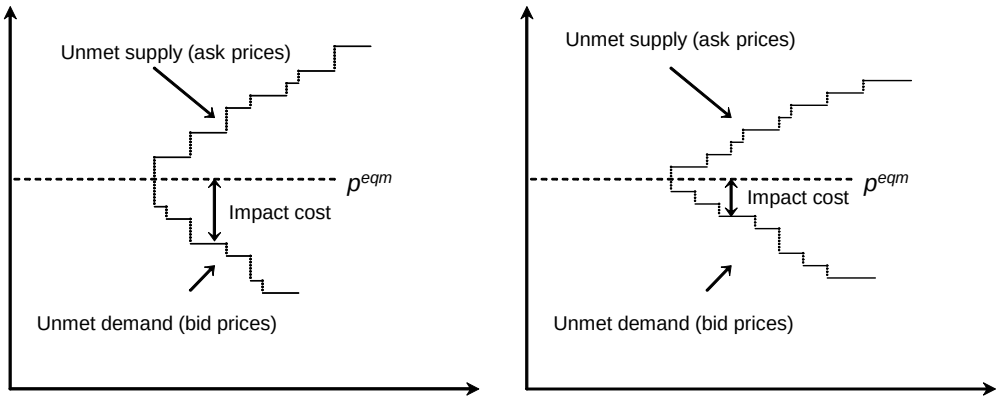


Figure 8: Impact costs in a less liquid (left panel) and liquid market (right panel)

The variable costs that a trader incurs depend on his trading behavior. First, some exchanges have different transaction fees for different classes of traders. For much of the 1990s, LIFFE had a reduced "scratch trade" transaction fee for traders trading on their own account, when they liquidated positions at the same price as the price at which they opened them, within the same day. The scratch trade fee was meant to encourage those traders to provide liquidity by reducing the penalty they bore in case they made no trading profit. Second, the opportunity cost of margins depends on the average length during which a trader keeps his position open. Day-traders for example are speculators who speculate on within day price movements. They close their positions every night, thereby foregoing margins completely. At the other extreme, hedgers will typically keep their positions open until maturity, and thus bear the opportunity cost of margins until then. Finally, impact costs depend on the size of trades a trader executes. The larger the transactions, the higher the impact costs, everything else equal.

Transaction fees, opportunity cost of margins and price impact costs were of comparable size for the Bund contract in the 1990's. Moreover, two different traders could rank the two exchanges differently on the basis of these variable costs as the following back-of-the-envelope calculation illustrates. Consider an average trader trading 10,000 contracts a month in April 1995. At that time, transaction fees were 0.45 £ on LIFFE (that is, the equivalent of 1 DM) and 0.50 DM on DTB. Initial margins were 3,500 DM on LIFFE and 5,000 DM on DTB. We consider two scenarios for the opportunity cost of margins. In the first scenario, the trader is a day trader who closes all his positions at the end of the day. He does not need to deposit any margins. At the other extreme, the trader keeps on average a position open for 15 days. We assume a 3% opportunity cost of capital. Under this assumption, the opportunity cost of margin deposits for this trader were equal to $(1.03^{\frac{1}{24}} - 1) * 3500 = 4.3$ DM per contract on LIFFE and 6.2 DM on DTB. Finally, consider the impact cost. Suppose that Eurex was less liquid in April 1995, meaning that 3% of the contracts were traded at one tick higher (or lower) than the best bid or ask, and that this number was only 2% on LIFFE. Given a tick size of 25 DM,

this adds 0.75 DM to costs for DTB versus 0.50 DM for LIFFE. From a day-trader's perspective, the total average variable costs of trading were lower on DTB (1.25 DM per contract versus 1.5 DM). From the "long term" trader on the other hand, the cost comparison favored LIFFE (5.8DM versus 7.45 DM).

This example illustrates that the different components of variable costs are roughly in the same ball park: none dominates the others. It also illustrates that different traders may rank the exchanges differently on the basis of their trading costs. A similar example can be generated where the preference for one or the other exchange depends of traders' average transaction sizes and thus impact costs.