The Impact of the Leverage Ratio on Client Clearing*

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Abstract

As part of the post-crisis regulatory reform, many interest-rate derivative transactions are required to be centrally cleared. Nevertheless, the treatment of this type of transaction under the leverage ratio (LR) requirement does not allow for the use of initial margin to reduce the exposure, thereby increasing capital costs. As a result, LR affected clearing member banks may be more reluctant to provide central clearing services to clients given this additional cost. This in turn can prevent some real economy firms from hedging their risks. We analyse whether this is the case by exploiting detailed confidential transaction and portfolio level data as well as the introduction and posterior tightening of the LR in the UK in a diff-in-diff framework. Our results suggest that the LR had a disincentivising effect on client clearing, both in terms of daily transactions as well as the number of clients, but this impact seems to be driven by a reduced willingness to take on new clients.

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1 Introduction

The regulatory response to the global financial crisis has been characterised by a shift towards multi-polar regulation (Haldane, A. G., 2012), that is, the imposition of multiple regulatory constraints. This new regulatory framework emphasizes the importance of not only understanding the effects and consequences of the new regulatory tools, but also how they interact with one another. In isolation, some of these reforms might bring strong benefits; however, when considered as part of a package, their efficacy might be lower than expected or they might give rise to unintended consequences.

Two of such reforms are the leverage ratio requirement (LR) on banks, and the push towards central clearing in derivatives markets—in particular, the introduction of mandatory central clearing. The leverage ratio requires banks to have a minimum amount of (Tier 1) capital funding their exposures, and it has been introduced in order to guard against model and gaming risk. [1] On the other hand, G20 leaders pledged to reform over-the-counter (OTC) derivatives markets with the goal of reducing systemic risk. As a result, regulators have introduced mandatory central clearing for the most liquid types of derivative transactions–that is, these derivatives need to be cleared through a central counterparty (CCP). Importantly, only clearing members (mainly dealer banks) can access the CCP directly, and hence any non-clearing member that is subject to the obligation has to seek clearing services from a clearing member.

Centrally-cleared transactions require a substantial amount of collateral—margin—to be exchanged. This margin—both initial and variation margin—is important to reduce counterparty credit risk. In the risk-based capital requirement, this margin exchanged reduces the exposure of the clearing member (the bank) and hence the resulting capital requirement. In the LR framework, however, initial margin cannot be used to reduce the exposure. Therefore, in this type of transactions, the leverage ratio, rather than the risk-weighted capital requirement, is typically the binding constraint. In other words, banks offering clearing services to clients will see their leverage exposure measure—the denominator of the LR—increase, and hence will be required to raise more capital.

Does this additional capital render part of the client clearing business unprofitable? The financial industry seems to think so, and even some banks have withdrawn from client clearing in the last years (Parsons, J., 2017; Cameron, M., and Jaidev, R., 2012; Jaidev, R., 2012; Vaghela, V., 2016). Indeed, due to the presence of debt over-hang costs (Andersen, L., Duffie, D., and Song, Y., 2018), positive net present value activites might not be taken because the margin is too low. This description fits well with client clearing services, since the trades have very small risk thanks to the collateral exchanged and hence the spread tends to me very low. If the leverage ratio has a significant negative impact on client clearing, then regulators should re-assess their cost and benefit

[1] See Behn et al., 2016 for empirical evidence of the limits of risk-based regulation.

analyses to make sure the regulatory framework still delivers net positive benefits.

There are, however, reasons to think that the impact of the leverage ratio on client clearing is not that significant. First, although initial margin cannot be used to reduce the exposure, other risk-mitigation techniques, such as netting, can be used. Moreover, the leverage ratio applies only to a certain level of consolidation, and it is possible that many dealers are actually not constrained by the LR.[2] Finally, banks might provide access to clearing services as part of a serice package to clients, and hence they include other margins, and not only the ones in the actual derivative transactions, in their decision making process.

This is, hence, an empirical question, and the one qe attempt to answer in this paper. We analyse it by using both UK trade repositories and data collected by the Bank of England on OTC interest rate derivatives cleared at LCH, the most important clearing house for interest rate swapts. We analyse two *shocks* to the leverage ratio requirement in the UK: its introduction in January 2016 (before the central clearing obligation), and its tightening in January 2017 (after the central clearing obligation).[3]

Our datasets allow us to comfortably cover over 75% of the European interest rate derivatives market since London is by far the largest clearing market in Europe. The data from the trade repository includes every single interest rate trade that has passed through the United Kingdom (UK), is denominated in Sterling, or involves a UK entity. We are able to identify each individual trade, the clearing member, client and details of the trade. Moreover, the data from the central counterparty LCH provides information at a daily frequency about the number of clients for whom clearing members are providing services (for interest rate derivatives). The use of granular data, coupled with the regulatory shocks, facilitates the identification of the supply effects (Jiménez, G., Ongena, S., Peydró, J. L., and Saurina, J., 2017).

Our results suggest that leverage-affected banks do reduce their willingness to clear derivative transactions on behalf of their clients. Following the introduction of the LR in the UK, UK clearing member banks reduce on average their client cleared transactions by around 5% and operated with around 4-5 fewer clients as compared to non-UK clearing members. Our results show that this is driven by a lower willingness to take on new clients rather than by dropping existing clients. In fact, clients dealing with UK clearing member banks have a *lower* probability of exiting the market than other clients. Following a further change in the UK LR framework, which effectively tightened it, we find similar results for the number of transactions: leverage-affected clearing member banks on average reduce their client cleared transactions by around 4%. However, they do not appear to be servicing fewer clients, which can be driven by the fact that the clearing obligation had just

[2]When the Tier 1 capital required in the risk-based framework is above the Tier 1 capital required in the leverage ratio framework, we follow the regulatory convention of saying that the bank is constrained by the *risk-based* framework.

[3]We take the idea of using the 2017 tightening from Kotidis, A., and van Horen, N., 2018, who use this shock to understand how the LR impact on repo intermediation.

been introduced.

The results found in this paper are consistent with the claims that the leverage ratio might increase the cost of providing clearing services in the OTC derivatives market, pushing some clearing members to reduce these services. However, the magnitudes that we find are not extremely big, with reductions of the number of transactions and clients of around 5-8%, and mostly when the UK LR was introduced rather than in its posterior tightening. Therefore, we document a potentially unintended consequence of the leverage ratio but at the same time we have to admit that if the leverage ratio regulation, as it is, is delivering net social benefits, adding the costs found in this paper will not likely alter this conclusion.

We contribute to several strands of the literature. We add to the growing set of papers that empirically analyse the post-crisis bank regulatory framework (Trebbi, ming, Adrian, T., Boyarchenki, N., Shachar, O., 2017, Acosta-Smith, J., Grill, M., and Lang, J. H.,, 2017, Brei, M., and Gambacorta, L.,, 2016, Bicu, A., Chen, L., and Elliott, D.,, 2017, Kotidis, A., and van Horen, N.,, 2018). We also contribute to the literature on the optimal design and regulation of the OTC derivative market (Culp, C., 2010, Duffie, D., and Zhu, H., 2011, and Ghamami, S., and Glasserman, P., 2017), but to the best of our knowledge this is the first paper assessing the relative importance of capital requirements in firm transactions.

The rest of the paper is organised as follows. Section 2 describes the centrally cleared derivatives market and the LR requirement. Section 3 describes the data. Section 4 discusses the methodology and presents some summary statistics. Second 5 presents our results. Section 6 concludes.

2 Client clearing and the leverage ratio

The costs and infrastructure requirements to be a clearing member of a generic CCP are significant and are, in practice, only justifiable for entities with a substantial derivatives business. For this reason, entities that wish to centrally clear derivative transactions will usually prefer to enter into a client relationship with one or more CCP clearing member. So roughly speaking, client clearing involves a market participant becoming a client of a clearing member in order to access a CCP to clear its derivative transactions.

Client clearing has become more important since the introduction of mandatory central clearing because to continue transacting in the most liquid derivatives *eligible counterparties*[4] must ensure they have access to authorized (EEA) or recognized (non-EEA) central counterparties (CCPs). Examples of EEA authorised CCPs include LCH.Clearnet.

[4]The definition of eligible counterparty applies to a wide array of market participants such as financial institutions, funds falling under the AIFMD, pension funds and corporates exceeding stipulated thresholds of €3 billion gross notional value. In addition, EMIR has extra-territorial reach. Overseas market participants which would be Eligible Counterparties if they were established in the EU are potentially caught as are overseas market participants whose derivatives contracts have a "direct, substantial and foreseeable effect" within the EU or which have been entered into to evade EMIR's provisions.

A CCP authorised or recognised under EMIR (European Market Infrastructure Regulation) imposes stringent membership costs and operational requirements on its clearing members. Membership is restricted to large institutions because any losses of the CCP arising from the default of a clearing member will be mutualised among all members.[5] For this reason, each clearing member considers the financial strength of all other members before joining a CCP. An eligible counterparty that only engages in limited derivatives trading will find it impractical or undesirable to become a clearing member, preferring instead to obtain access to the CCP by way of a clearing broker which guarantees the performance of the client vis-à-vis the CCP. That is, it will become a client of an existing clearing member of the CCP. In summary, the client enters into a client transaction with its clearing member, who then simultaneously enters into another transaction with the CCP. Across our sample period, LCH.Clearnet Swapclear had between 40 and 46 (out of 103/105) clearing members offer clearing services to their clients.

This interacts with the LR in the following way. According to the Basel III LR framework (Basel Committee on Banking Supervision, 2014), a clearing broker must "calculate its related leverage ratio exposure resulting from the guarantee [of its client's cleared derivative trade] as a derivative exposure ... [i.e.] as if it had entered directly into the transaction with the client." As a result, the LR framework effectively treats a clearing member bank as a direct party to the cleared derivative trade with its client. Hence the clearing firm's exposure is greater than it otherwise would be as an intermediary and financial guarantor for that trade. By treating the clearing broker as its client's counterparty, the LR framework precludes the clearing firm from reducing its derivatives exposure by the collateral (or performance bond) posted by the client. This is the case even if such collateral is held by the relevant CCP (which is effectively the client's true counterparty) and is legally and operationally segregated, thus not available for the clearing firm to use as leverage.[6]

As a consequence, clearing member banks affected by the LR may deleverage since they may be short of capital and raising it externally could be difficult (in the short-term). Faced with higher capital charges, clearing member banks may as a result drop some of their smaller clients because they do not generate the same level of profit as larger ones.[7] These clients in turn may then temporarily lose access to the derivative market, precluding them from hedging part of their risks. Overall, this reduced availability of clearing services may run counter to the globally endorsed goal of promoting clearing to address systemic risk.

[5] This would occur if the CCP is holding insufficient collateral.

[6] In addition, the clearing member also incurs a default fund exposure capital charge. This component is based on the risk that the clearing member's contribution to the CCP's default fund would be tapped in the event of the failure of other clearing members. This exposure however does not count towards the leverage exposure measure to avoid double-counting.

[7] Clearing members usually provide larger clients with clearing services as part of a package, therefore they may be reluctant to withdraw services that they can use as a loss leader.

3 Data

In September 2009, in response to the global financial crisis, G20 leaders agreed that OTC derivatives transactions should be reported to trade repositories by the end of the following business day so that they could be collected and analysed by the respective regulatory authorities. The post-trade disclosure of derivatives transactions opened up a whole new range of possibilities for policy analysis and research. The ability to observe trading activity allows one to identify the reaction of market participants to the implementation of reforms so as to assess their efficacy. This is particularly useful for policy makers who use derivatives data to extract information about market expectations before a market event (e.g., default of an institution) or a policy event (e.g., short term interest rate expectations).

The Bank of England's access to trade reports is as per the conditions stated in EMIR under Article 2 of Commission Delegated Regulation (EU) No 151/2013. This means that we can access reports related to client clearing activities in the interest rate derivatives markets between clearing members and their clients on: a) trades cleared by a CCP supervised by the Bank of England; b) trades where one of the counterparties is a UK entity; c) trades where one of the counterparties is supervised by the Bank of England; and d) aggregated position data for all derivative contracts referencing Sterling.

We analyse the interest rate derivatives markets data in the EU as it is one of the largest segments of the derivatives market. Moreover, it is an important market for hedging purposes for a large number of institutions. We focus our analysis on 2 years of OTC interest rate daily transactions data between May 2015 and April 2017, provided by DTCC trade repository. The data contains only reports related to client activities of LCH.Clearnet Swapclear's clearing members for interest rate trades including all the most liquid interest rate products. On a daily basis Swapclear clears an average of $3 trillion in interest-rate derivatives, including 75% of all the centrally cleared contracts on euro-denominated interest rate derivatives. However, we focus our analysis only on the client activities, which amount to an average of $900 billion.

To enrich our dataset we also use proprietary data relative to LCH.Clearnet Swapclear, which includes information on the identity of the clients and on the portfolio value of all house and client portfolios between May 2015 and April 2017. We clean the data in a number of ways. Since the focus of the paper is client clearing, we remove all *house* portfolios, i.e., those portfolios that clearing members hold on their own behalf. By doing this we get 6,206,758 observations of clearing member-client portfolios. Each observation corresponds to a clearing member - client - currency - date portfolio. In other words, we know, for each day, the market value of the cleared portfolio.

It should be noted that although Swapclear is the biggest clearing house covering interest rate derivatives, there are 59 other CCPs included in the UK trade repository data that can be used to make these trades. However, Swapclear's clearing members tend to concentrate their activity

through one CCP in order to benefit from netting effects. For this reason, trades between Swapclear and its clearing members, and uncleared trades among those clearing members, account for 90% of the total gross notional outstanding in our dataset.

We match the proprietary and the trade repository data with institutions' balance-sheet data so that we have bank level information for each clearing member that offers client clearing services. The banks' balance-sheet data, at a semi-annual frequency starting in 2015, is publicly available from each institution's official website.[8]

4 Methodology and Descriptive statistics

4.1 Methodology

We want to see how an LR requirement affects clearing member banks' willingness to clear derivative transactions on behalf of their clients. To do so, we exploit the fact that the LR was introduced in a disjointed fashion - hitting some banks, but not all. We take those clearing member banks that have a binding regulatory LR requirement as *affected/treated* banks. In our dataset, this corresponds to the biggest seven UK banks since the Bank of England acted in advance of the Basel III implementation timeline (cf. Bank of England, 2015).[9] All other clearing members are part of the control group.

This split between *treated* and *untreated* clearing members is then combined with two distinct events that enable us to compare before and after effects. In particular, we use the following events in a difference-in-difference approach.

1. The introduction of the LR requirement as a mandatory requirement for the biggest seven UK banks in January 2016.

2. The regulatory change in reporting requirement for UK banks in January 2017.[10]

These two events marked important milestones in the UK implementation of the LR requirement and operated in isolation to the global Basel III implementation timeline. In response to the global financial crisis, the BCBS decided to introduce a non-risk based LR requirement to the capital framework. This marked a step change in the design of capital regulation, and was scheduled to begin as a mandatory requirement in January 2018. The Bank of England however, decided to act in advance of the Basel III implementation timeline, and instead introduced the LR as a mandatory

[8] In calculating the LR, in case there is no LR information for a bank, we compute the LR measure as a ratio between tier 1 capital and total assets.

[9] Since the LR requirement applies at a group level, we consider treated all subsidiaries whose parent is a UK big seven bank.

[10] This is as in Kotidis, A., and van Horen, N., 2018 who use this shock in the context of the LR impact on repo intermediation.

requirement two years earlier in January 2016. This mandatory requirement applied to the biggest seven UK banks.[11] As a result, it created differences between these UK LR *affected* banks, and all others who did not have a LR mandatory requirement.

Specifically in respect to client clearing, the LR introduction in January 2016 marked the first point in which leverage *affected* clearing member banks were no longer allowed to offset initial margin from their capital requirement. This was a step-change in their calculations, and of particular use for our identification strategy, it only affected UK banks.

The second event: the change in the regulatory reporting requirements, came the year after. The policy related to how UK regulated banks had to report their LRs (Bank of England, 2015). This was important because it effectively acted as a tightening of the LR requirement, but as before, again only affected UK clearing member banks—all others were unaffected. During the first 12 months of the UK LR framework, reporting banks could measure their on-balance sheet assets on the last day of each month and take the average over the quarter ("monthly averaging"). From January 2017 onwards however, this ceased to be possible, the on-balance sheet assets had to be measured on each day ("daily averaging"). This switch from monthly to daily average reporting, although at first sight seems minor, reduced the ability of banks to window-dress their balance sheet at period ends and so effectively made the LR requirement more binding. Since the change in reporting requirement only hit those banks that had a mandatory LR requirement to begin with, we can use this policy shock as a way to identify the impact of the LR on client clearing activity.

The second shock also coincides with the post-clearing mandate era, which the January 2016 shock does not. The clearing obligation under Article 4 of EMIR requires that all OTC interest rate derivatives contracts denominated in G4 Currencies are subject to mandatory clearing. These types of products include fixed-to-float interest rate swaps (IRS), basis swaps, forward rate agreements, and overnight index swaps. This obligation for firms whose group's aggregate month-end average of outstanding notional amount of OTC derivatives is above €8 billion took effect in the UK from 21st December 2016. However, the requirements included also a frontloading obligation starting from 21 May 2016 for all the financial counterparties. The frontloading obligation required all financial counterparties (FCs) to clear relevant OTC derivative contracts entered into or novated on or after the given frontloading start date by the time the clearing obligation was in place. There was no frontloading requirement for non-financials counterparties (NFCs), but the clearing obligation applied also to contracts between any combination of FCs and NFCs who exceed the clearing threshold of €3 billion gross notional value.

We combine these policy shocks in the following way. We explore the window around the policy shocks to see how *treated* clearing members reacted to the introduction of the LR and its effective tightening after the reporting change (similar to Jiménez, G., Ongena, S., Peydró, J. L., and Saurina, J.,, 2017). We are able to compare behaviour after the shock to how clearing members

[11] HSBC, RBS, Lloyds, Santander UK, Barclays, Standard Chartered, and Nationwide.

were acting previously, and against control group clearing members that did not face these shocks. This difference-in-differences approach, in which due to our granular dataset we are also able to see both dealer and client entities, allows us to identify the impact of the LR both on the willingness of clearing members to clear transactions in terms of volume, but also in terms of the clients they drop or take on.

We run several specifications making use of the different datasets. For the TR data, we run regressions along the following lines:

$$m_{i,j,t} = \beta_1 post_t * dLR_i + \beta_2 X_i post_t + \alpha_i + \alpha_j + \alpha_t + \epsilon_{i,j,t} \tag{1}$$

where $m_{i,j,t}$ is the number of transactions of clearing member i with client j at day t; $post_t$ is a dummy variable equal to 1 if the date is after the policy shock (0 otherwise); dLR_i is a dummy variable equal to 1 if the clearing member bank is affected by the LR requirement; X_i is a matrix with other bank-level controls; α_i are clearing member fixed-effects; α_j are client fixed effects, and α_t are time fixed-effects.[12]

Using transaction-level data in which we are able to see both dealer and client combined with the clear cut-off dates gives us the ability to identify changes in client clearing activity. We have the advantage of being able to easily exploit this at the dealer-client level by dropping all dealer-client transactions in which the client is another dealer bank (interdealer transactions).

With the data on (active) cleared client portfolios from LCH, we run the folowing specifications:

$$NumClients_{i,t} = \beta_1 post_t * dLR_i + \beta_2 X_i post_t + \alpha_i + \alpha_t + \epsilon_{i,t} \tag{2}$$

Where $\text{NumClients}_{i,t}$ is the number of clients serviced by clearing member i at time (week) t, and as before $post_t$ is a dummy marking the policy shock (from January 2016 / 2017 onwards) and X_i is a matrix with bank characteristics. This specification is informative to understand whether banks affected by the leverage ratio change reduce the number of clients that they service. However, it cannot control for credit demand. In order to do so, we also run the following specification:

$$Relation_{i,j,t} = \beta_1 post_t * dLR_i + \beta_2 X_i post_t + \alpha_i + \alpha_j + \alpha_t + \epsilon_{i,j,t} \tag{3}$$

Where $Relation_{i,j,t}$ is a dummy variable equal to 1 if clearing member i is servicing client j at week t, and 0 otherwise. We define this variable only for clearing member - client pairs that are matched at least once in the period under study. This specification allows us to control for client fixed effects (α_j) but also for client x week fixed effects ($\alpha_{j,t}$).

Even if clearing members affected by the leverage ratio reduce the provision of clearing services, this might not have an impact on clients if they are able to easily substitute the clearing member.

[12] In our specifications, we also run regressions with client*time fixed effects in addition to control for demand.

For instance, clients might have "back-up" clearing members to whom they could turn if the current clearing member does not renew their transactions. In order to test this question, we run a cross-section specification at the client level by analysing whether clients that deal with *treated* clearing members before the shock are more likely to exit the market:

$$ClientExit_j = \beta_1 dLR_j + \beta_2 X_j + \epsilon_j \tag{4}$$

Similarly, we look at whether new clients that appear after the shock are less likely to access clearing services through the *treated* clearing members:

$$ClientEnter_j = \beta_1 dLR_j + \beta_2 X_j + \epsilon_j \tag{5}$$

4.2 Descriptive statistics

Our dataset focuses on the number of daily transactions and the number of clearing member clients over a period characterised by low and stable interest rates. This allows us to focus specifically on the link between changes in the regulation, and activity in the derivatives market over the period of our dataset.

Table 1 shows the summary statistics of portfolio-level data from LCH. We divide the data into two panels isolating the two LR events. In Panel A (October 2015 to March 2016), which isolates the UK LR requirement introduction, the average number of clients per clearing member is 62.4; treated clearing members – i.e. those with headquarters in the UK – have on average 53 clients, while untreated clearing members have almost 64. When looking at the client level, we see that the unconditional probability that a client present before the shock disappears from the market (DummyDrop) is 13%. If the client is clearing through a UK clearing member, however, this probability is only 9%. The probability is slightly higher for clients clearing through untreated banks: 14%.

Number CM (pre) shows the number of clearing members with whom clients have clearing services before the shock. Clients have on average 1.2 clearing members, although the vast majority (75%) only have one. Finally, the probability that a new client appears after the shock is 17%. The probability that this new client deals with a treated clearing member however, is only 10%. It is significantly higher for untreated clearing member banks at 18%.

Turning to Panel B (October 2016 to March 2017), which isolates the period around the change in reporting requirement for UK banks, it is clear that the clearing obligation is in place: clearing members have on average 86 clients, 24 more than in the first period. Not only that, but the probability of a client disappearing from the market is lower, at 9%, with the same differentiation between treated (6%) and untreated (10%). We also see that clients seem to be dealing with a similar number of clearing members (most of them just 1) as before. Finally, the probability of

new clients entering is much higher at 32%, with again a similar differentiation between untreated (33%) and treated (25%). In other words, treated clearing members are less likely to accept new clients.

Table 2 shows the summary statistics of transaction-level data deriving from the UK trade data repository. We divide the data into two panels isolating the two LR events. In Panel A (October 2015 to March 2016), which isolates the UK LR requirement introduction, the average number of clearing member operating in each day is 45.2; treated clearing members – i.e. those with headquarters in the UK – have a daily average of 118.6 clients clearing through them, while untreated clearing members have a daily average of 229.7 clients. Turning to Panel B (October 2016 to March 2017), which isolates the period around the change in reporting requirement for UK banks, it is clear that the clearing obligation is in place: clearing members clear in behalf of an daily average of 444.8 clients, almost 326 more than in the first period. We also see that number of clients that we can see in portfolio-level data are 35% than in the UK trade repository. The reason is that the granularity of the portfolio-level data includes also the clients of several non-UK institutions that are not supposed to be reported in the trade data repository. It should be noted that, differently from the portfolio-level data, we do not use the transaction-level data to determine the number of clients managed by each clearing member since the lack of transactions does not necessarily mean the drop of a specific client. In fact, it might happen that clients do not clear because of their own strategies.

Figure 1 presents the frequency distribution of original maturities from the UK trade repository data. The figure is split as follows: the left hand upper quadrant presents the distribution for all clients, the right upper quadrant presents the distribution for hedge funds, the lower left hand quadrant presents the distribution for pension funds, and the lower right hand quadrant presents the distribution for insurers. As can be seen from the upper left hand quadrant, the majority of trades are short- and medium-term. These are the most liquid types of contracts with the most common maturities of 2, 5 and 10 years. However, there is also around 40% of interest rate derivative transactions cleared with a maturity greater than 10 years.[13] This means that clients are particularly interested in long term strategies. We use all trades – we do not discard any – since we are interested in all counterparty relations, and even if some contracts are very infrequent relative to the total number of transactions, they nonetheless indicate an important counterparty relationship.

Considering the individual sectors, hedge funds are disproportionably higher users of contracts with shorter maturities (2, 5, and 10 years). It should be noted that around 70% of transactions with a hedge fund have a maturity of less than 10 years. This is compared to the total average of less than 60%. Insurers and pension funds on the other hand have a preference for longer-dated maturities – of their total transactions, 31% and 35.6% respectively have a maturity greater than

[13]This is compared to a global average of less than 25% (Bank for International Settlements, 2017).

20 years. This is compared to the total average of 15.3%. This reflects the long duration of their liabilities. It also means that a possible loss of access to the centrally cleared market may cause difficulties in finding a counterparty that offers such a long-dated pay-float position in interest rate derivatives.

Figure 2 shows the distribution of the number of clearing members that clients use to centrally clear. Most of the clients (almost 80%) use only one clearing member. More than 97% of clients use at most two clearing members. Very few clients use more than two clearing members. This emphasises the importance of understanding any regulation that may drive clearing members to cut their client services since very few clients have alternative means to go through another clearing member.

Figure 3 shows the number of clearing members offering client clearing services through LCH. The number fluctuates from 42 at the beginning of the sample to 46 at the end. Figure 4 shows the number of clients served by those clearing members during the same period. This number has been steadily increasing, especially after the introduction of mandatory central clearing of interest rate swaps in mid-2016 (the frontloading obligation for big clients started on 21st May 2016). From the two charts, one can infer that the average number of clients per clearing member ranges from around 50 at the beginning of the sample to almost 80 at the end of the sample.

Figure 5 shows the evolution of the number of clients for treated and untreated clearing members around the introduction of the UK LR requirement. The difference between treated and untreated clearing members increases slightly after the shock; however, this increase could be due to other factors, and thus it is important to explore this question by using econometric techniques that control for these.

Figure 6 shows the evolution of the number of clients for treated and untreated clearing members around the regulatory change in reporting requirements - an effective tightening of the LR. After this shock, the line for *treated* clearing members is flat, although it increases just before. The line for *untreated* clearing members, however, continues to increase after the shock.

Figure 7 shows the 5-day rolling average per day of the number of transactions clearing members clear on behalf of their clients. The red vertical line represents the introduction of the UK LR requirement.[14] The chart is split by treated and untreated clearing members. What is striking is that the pattern of both groups is broadly similar. Towards the end of the period, the treatment group does seem to be on a downward trend, whereas the untreated group is broadly flat, but of course, this does not take into account any additional factors that may have an effect.

Figure 8 shows the 5-day rolling average per day over December 2016 to January 2017. The red vertical line denotes the UK LR change in regulatory reporting requirements. The chart is split by treated and untreated clearing members. Interestingly, after the regulatory change, the two groups

[14]The dip in transactions around end-December corresponds to the Christmas period when fewer transactions occur.

seem to somewhat diverge, and the average number of transactions cleared by treated banks seems significantly lower than the average number cleared before the regulatory change.

5 Results

The results follow in two stages. First, we analyse reactions around the introduction of the LR in January 2016 as a binding requirement for UK banks. Second, we analyse the reaction to the tightening of the LR requirement that effectively occurred in January 2017 when the regulatory reporting requirement changed.

5.1 Introduction of the UK leverage ratio: January 2016

Table 3 shows the results from the regression around the January 2016 policy shock testing whether the number of transactions was affected by it. The variable $\text{Post}_2016\ \text{Treated}_b$ denotes the impact of the LR. Column (1) isolates the shock with one month either side and the treated dummy variable. We find that leverage *affected* institutions clear on average 1.4 transactions less per day, per client, than they would have if they were not *leverage affected*, which represents around 5% fewer transactions for this period. Column (2) confirms significance with additional control variables and the addition of client*time fixed effects. By adding client*time fixed effects we are able to control for demand, and so column (2) illustrates the result in column (1) is driven by the supply side. Column (3) onwards considers the interaction between between a clearing member's LR and whether it is a treated bank. Taking column (3) first, we can see that although the $\text{Post}_2016\ \text{Treated}_b$ dummy is negative and statistically significant, its interaction with the LR (the second row), is positive and significant. This suggests that although *treated* clearing members have a relatively lower number of daily transactions than *untreated* clearing members, this effect is smaller, the higher the LR it has. So whereas a *treated* clearing member with a 0% LR has on average 14 fewer daily transactions (per client) than an *untreated* clearing member, if it has a 3% LR, this relative reduction declines to -4. This is intuitive, since the higher the LR a clearing member has, the less concern it has for hitting this regulatory binding constraint. Columns (4)-(6) confirm the robustness of this result when we extend the time-window to three months either side, although it becomes insignificant in column (6).

The influence of the LR on client clearing also appears when we start study the number of clients rather than numbers of transactions. The results of running specification 2 are shown in Table 4. In particular, we create a panel at the clearing member–week level and define our dependent variable as the average number of clients serviced by clearing member b at week t. All standard errors are clustered at clearing member level. The first column shows the specification with clearing member fixed effects and only the interaction between the $post_t$ and the $treated_b$ dummies. The coefficient of the interaction is around -4.86 and significant at 10%. This suggests that clearing members affected by the introduction of the leverage ratio *decreased* the number of clients with respect to the non-affected ones. In column (2) we introduce time (week) fixed effects, to account for possible common trends / shocks throughout the period, but the coefficient of the interaction is nearly

identical.

In column (3) we add the variable Client portfolio$_b$ interacted with the $post_t$ dummy. Client portfolio$_b$ is defined as the number of clients clearing member b is servicing at the beginning of the sample. This variable, hence, controls for ex ante market share. The coefficient of the interaction of interest remains negative and significant. In column (4), we further interact the Tier 1 capital ratio, the leverage ratio, and the size (logarithm of the leverage exposure measure) of the clearing member (all evaluated in the first half of 2015). Our coefficient of interest remains broadly unchanged. Furthermore, clearing members with higher leverage ratio seem to take on more clients in the first quarter of 2016 as compared to the last quarter of 2015.

In columns (5) and (6) we restrict the sample to see whether the results are robust. In column (5) we drop clearing members with less than four clients at the beginning of the sample, which corresponds to clearing members below the 25th percentile. The coefficient remains similar (significance drops slightly but driven by an increase in standard errors, which could be the result of dropping the number of clusters). In column (6), we narrow the time window that we study by selecting November 2015 – February 2016 as the period. The coefficient is still significant even if smaller, which is to be expected given the shorter horizon than clearing members would have to adjust.

We further analyse this shock in Table 5 by running the same specifications as in columns (3) and (4) of Table 4 but for different samples. In columns (1) and (2) we concentrate on the 12-week period before the introduction of the leverage ratio, while columns (3) and (4) refer to the 12-week period at the beginning of 2016 ($post_t$ simply cuts the period in half). We use these samples to understand when the adjustment of the number of clients take place. The coefficients of the interaction of interest in these first four columns suggest that most of the adjustment is done before the introduction of the leverage ratio, although the coefficients in columns (3) and (4) are also large (but not statistically significant in column (4)).

While we cluster the standard errors of all specifications at clearing member level, Bertrand, M., Duflo, E., Mullainathan, S. [2004] show that even doing this might not solve the bias of the difference-in-differences estimates. In order to eliminate this bias, we run the same specifications in columns (5) and (6) but only including the first and the last weeks of the sample. This means that each clearing member has two observations, one before and one after the shock. We still use clearing member and time fixed effects. The coefficients of the interaction of interest not only remain negative and significant, but also increase in size significantly: it is close to -9 clients less for treated clearing members. The fact that the magnitude is higher is not surprising given that banks partially adjust during the pre as well as the post periods.

While Table 4 and Table 5 show that the number of clients served by treated clearing members relatively declines after the introduction of the leverage ratio, one caveat of these specifications is that the type of clients served by treatment and control clearing members might be different, and

hence the results could be driven by the demand, rather than the supply, of clearing services.

In order to reduce this concern, we do the following. We take each clearing member-client pair in the sample, and create a dummy variable equal to 1. As with many similar datasets, whenever a clearing member is not dealing with a client, there is no observation. Hence, we create these "missing" observations for every pair that exists in the dataset, and set the dummy variable equal to 0. Therefore, the resulting dataset is a perfectly-balanced panel at the pair-week level, with a dummy variable equal to 1 if the clearing member provides services to the client in that particular week, and 0 otherwise. We do not create any observation for clearing member-client pairs that never have any relation. We then run specification Table 3. The interesting characteristic of this specification is that it allows the use of client x time fixed effects, thus controlling for the demand for clearing services. The downside is that doing so restricts the regression to clients with two or more clearing members, which are a minority.

The results are shown in Table 6. Columns (1) to (5) run the same specification but saturating with more fixed effects each time. In column (1) we do not use any fixed effect. The coefficient of the interaction suggests that treated banks are 6 percentage points more likely to drop a client relationship (or less likely to acquire a new one). In fact, given the coefficient of $post_b$, a more precise interpretation would be the following: on average, the control group increases the probability of acquiring new clients by 4.6 percentage points after the introduction of the leverage ratio in the UK; for the treatment group, this number is reduced by 6.2 percentage points (the two coefficients together are not statistically different from zero).

Similar coefficients are found when including time FE (2), clearing member FE (3), client FE (4), and even client x time FE (5). In column (6) we repeat the exercise of only focusing in the first and last weeks of the sample, thus reducing the potential bias. The coefficient is higher (-0.102) albeit only marginally statistically significant at 13%. This specification is quite demanding, since it has client x time FE as well as clustering at clearing member level. All in all, the results from the previous tables are confirmed: we do observe a reduction of clearing services from banks affected by the introduction of the leverage ratio in the UK.

Even if clearing members affected by the leverage ratio reduce the provision of clearing services, this might not have an impact on clients if they are able to easily substitute the clearing member. For instance, clients might have "back-up" clearing members to whom they could turn if the current clearing member does not renew their transactions. In order to test this question, we run a cross-section specification at the client level. The dependent variable is a dummy that equals 1 if the client i is present at the beginning of the sample (week 1) but not at the end (week 24), and 0 if it is present in both periods. The variable of interest is $treated_i$, which equals to 1 if the client deals with a clearing member affected by the leverage ratio introduction, and 0 otherwise. The results are shown in Table 7.

The coefficient in column (1) is at first counterintuitive and seems to contradict all the previous

results: clients dealing with treated clearing members are less, not more, likely to disappear from the market after the introduction of the leverage ratio. There is an overall positive probability of exiting the market: the coefficient of the constant is 14%. However, this probability is 5.4 percentage points lower if the client is dealing with a treated clearing member.

In column (2), we introduce the variable $Number\ of\ CMs_i$, which equals the number of clearing members that client i deals with at the beginning of the sample. As one could expect, clients dealing with more clearing members are less likely to disappear from the market. The coefficient of interest, however, stays broadly similar.

In column (3) and (4) we split the sample: in column (3) we only include clients dealing with one clearing member at the beginning of the sample, while in column (4) we only include clients dealing with more than one clearing member. While the coefficient is still significant in both cases, only in column (4) is statistically significant: the lower likelihood of abandoning the market for clients dealing with affected clearing members comes from the subset of clients with more than one clearing relationship.

So far, our results suggest that clearing members affected by the introduction of the leverage ratio reduce the provision of client clearing services. Table 7, however, seems to contradict that. We disentangle this apparent contradiction by running a very similar specification but changing the dependent variable. In Table 8, the dependent variable is a dummy variable equal to 1 if the client is present at the end of the sample but not at the beginning (i.e., it is new) and 0 if it is present in both periods. We run the same type of cross-section client-level specification as before.

Results in column (1), Table 8, show that new clients are less likely to deal with affected clearing members. In particular, while the proportion of new clients after the introduction of the leverage ratio is 18% (the coefficient of the constant term), this proportion decreases by more than 8 percentage points if the clearing member has been affected. Column (2) shows that the results are broadly the same when controlling for the number of clearing members that each client has (active) access to. In columns (3) and (4), as before, we split the sample. The coefficient in column (3) shows that the lower likelihood is driven by clients dealing with only one clearing member: affected clearing members are 10 percentage points less likely of taking a new single-relationship client. The coefficient for multi-relationship clients, in column (4), is not significant.

The evidence collected in this section suggests that clearing members affected by the introduction of the UK leverage ratio reduce their willingness to provide clearing services to clients, in particular to service new clients. Nevertheless, one should be careful in drawing strong conclusions from these results. First, while statistically significant, the magnitudes are not economically huge: they correspond at most to around 5% of the clearing services (in terms of number of transactions and clients). Furthermore, this is a period with several regulations being phased-in, with banks still transitioning to new liquidity, solvency and even structural positions, and with some jurisdictions–such as the US–with mandatory central clearing already in place. While we replicate Table HHH

for the 2014Q4–2015Q1 period as a placebo exercise, and we find no significant results in that period, we cannot control for all this changing environment (results available upon request).

5.2 Tightening of the UK leverage ratio: January 2017

Table **??** shows the results from the regression of the number of daily transactions per client, per clearing member around the January 2017 policy shock. The results suggest that a stricter LR disincentivises clearing member banks from engaging in transactions. We find an economically and statistically significant negative coefficient. Leverage *affected* clearing members significantly reduce their willingness to extend client clearing services compared to otherwise. Looking at the one-month window around Dec 2016 to Jan 2017, the results are somewhat weaker than 2016, but still confirm the story. The *treated* dummy is negative and significant in columns (2)-(3) which also include client*time fixed effects to control for demand. Extending the sample period around the shock (columns (4)-(6)) and the results are consistently significant. What is more, as previously, while on average *treated* clearing members clear fewer transactions than *untreated* ones, this difference declines as the clearing member's LR increases. Taking column (6) for example, which includes all control variables and client*time fixed effects, whereas the coefficient suggests a *treated* clearing member with a 0% LR would clear around 13 fewer transactions than otherwise, if it had a 3% LR, then this number would be 5 fewer.

We replicate all the previous regressions for the tightening of the UK leverage ratio in January 2017. Tables 10 and 11 show the results for the number of clients. As we can observe in column (1), on average clearing members service almost 13 clients more after the policy shock than before (the coefficient of $post_t$ is 12.7). The coefficient of the interaction of interest, however, is not significant in any of the regressions. In fact, it even becomes positive (but very close to 0) once we introduced time FE and a variable controlling for the number of clients that clearing members serve at the beginning of the sample (column (3)). Adding more bank controls interacted (column (4)), restricting the sample to clearing members above the 25th percentile (5) and shortening the time window (6) delivers the same message: we do not find a significant change in the number of clients for treated clearing members.

We consider two potential explanations for this result. The first one is that, in a regime with mandatory central clearing, leverage ratio constraints do not play any role since banks cannot keep client transactions in the bilateral market anymore. According to this view, then, the benefits of providing clearing services as strong enough to compensate any cost derived from the leverage ratio. Importantly, this view would be consistent with the results found for the introduction of the UK leverage ratio (Tables 4 8) but would qualify the policy implications: clients are still being served, but in the bilateral sector.

The other explanation concerns the particular timing of the clearing obligation for category 2 firms-the obligation that concerns clients. As previously mentioned, the actual clearing obligation

started in 21st of December 2016 but the frontloading requirements were in place seven months earlier (21st May 2016). Transactions entered after the frontloading requirement would have to be cleared by the date of the clearing obligation, which usually means that they would be centrally cleared from the beginning to avoid the re-pricing later on (the pricing of bilateral OTC derivatives differs substantially from the one for centrally-cleared transactions). But some clearing members, especially those more constrained by the leverage ratio, might wait until later to build up their capital positions. Considering that our treated group was already legally subject to the leverage ratio, this is a plausible explanation.

Moreover, there is some evidence on that front. In both Figures 6 and 8 we see a spike in the number of transactions and the number of clients until around the 21st of December 2016, which suggests that clearing members were bringing their client portfolio towards the cleared segment. Some further evidence of this can be found in Table 11, where we perform the same regressions as in Table 5 but for the 2017 policy shock. The first two columns focus on the 12 weeks before the policy change, i.e., from October to December 2016. The end of this period coincides precisely with the introduction of the clearing obligation for Category 2 firms. Although they are not significant, the coefficients of the interaction appear to be positive and quite large. During this period, hence, treated clearing members do increase the number of clients that they serve in the cleared segment, which is consistent with them bringing clients in from the bilateral segment.

In columns (3) and (4), the focus is now the 12-week period after the tightening of the UK leverage ratio. This is already after the clearing obligation. Although again not significant, we find large and negative coefficients, similar to those found in the same columns in Table 5. Finally, in the last two columns, we take the first and last week of the period, and consistent with the previous table, we do not find any statistically significant relationship.

As mentioned before, these specifications cannot control for client demand. We use a more disaggregated panel at clearing member client week and create a dependent variable that equals one if the clearing member client relationship is active in week t, 0 otherwise. This variable is defined only for pairs that transact at some point during 2016Q4 and 2017Q1, the period of interest in this section. The results, shown in Table 12, confirm the previous findings: we cannot find a significant coefficient to suggest that treated clearing members were less likely to engage in client clearing after the tightening of the UK leverage ratio.

As before, we also study whether a client dealing with a treated clearing member nefore the tightening of the UK leverage ratio is more likely to exit the market after the policy has been implemented. The results are reported in Table 13. Maybe surprisingly, we find the opposite: these clients are less likely to exit the market. In particular, between 2.5 3.5 percentage points less likely. As shown in column (3), this relationship is present mainly for clients only actively dealing with one clearing member. For clients dealing with two or more, the relationship is not significant.

And what about new clients? We again run a cross-sectional regression with all clients present

at the end of the time window and define a dummy variable tat equals 1 if they were not present at the beginning of the period (i.e., if they are new) and 0 otherwise. As one can see in column (1) in Table 14, the probability of finding a new client is over 30%, consistent with the fact that the clearing obligation is already in place—and consistent with clearing members bringing a lot of clients into the cleared segment just before the clearing obligation. Treated clearing members, however, have a lower probability of taking on new clients, similar to the case of the introduction of the UK leverage ratio. Comparing the coefficient of the constant and of the $treated_i$ variable, however, treated clearing members still took around 24% of new clients.

5.3 Pension funds

Table 15 attempts to understand these results further by isolating the client sample to pension funds. The dependent variable is the number of transactions per day, per clearing member-client pair. One might be particularly concerned for pension funds, since client clearing underlies much of their hedging activity. Also, intuitively, pension funds might be the first to come under pressure from a reduction in client clearing activity. This is because, firstly their trades are usually unidirectional, and secondly this is often the only service the clearing member bank is providing. So clearing members cannot use this service as a a loss leader.

Considering the results for 2017 first. Table 15 illustrates this hypothesis seems to be borne out in the data. *Treated* clearing member banks clear on average around 2-4 fewer transactions per day, per client, than they would if they were not *treated*. Table 15 also tests whether there is an additional impact for smaller pension funds.[15] There does not seem to be a significantly different treatment for smaller versus larger pension funds in 2017. Column (2) illustrates that the results holds once control variables are included, and columns (3)-(4) confirm robustness once client*time fixed are included to control for demand.

For 2016, results are slightly different. When client*time fixed effects are excluded (columns (5)-(6)), results suggest *treated* clearing members clear on average 2-4 more transactions than otherwise, but for smaller pension funds, the opposite is true. *Treated* clearing members clear significantly fewer transactions for smaller pension fund clients than otherwise, around 7 fewer. Thus perhaps, because in 2016, the clearing mandate had yet entered into force, clearing member banks were able to concentrate their reduction on smaller pension funds that are less profitable. Then once in 2017, there was a more general effect across all pension funds. Column (7) illustrates the result with client*time fixed effects to control for demand. The interaction with smaller pension funds cannot be performed due to the low number of observations. It confirms the general negative coefficient seen across the columns.

[15]Smaller pension funds are defined as those that transact less than the median pension fund - defined in the 12 months prior to the sample period.

6 Conclusions

This paper investigates the impact of the LR on client clearing activity in the interest rate derivatives markets. We exploit a unique transaction level dataset that captures the relationship between clearing members and their clients in combination with regulatory changes in the LR. Studying adjustments within client clearing activity, we find that clearing members affected by the LR reduce the volume of client transactions they are willing to clear, as well as the number of clients, compared to unaffected ones. The paper thus indicates that the LR can disincentivise client clearing intermediation.

If some institutions lose access to the cleared market, this may have negative implications for their daily activity. If they find it more difficult to implement hedging strategies, they might seek alternative riskier or more expensive hedging strategies. Or if they are able to use the non-centrally cleared market, it will be necessary to post higher levels of collateral to novate their contracts (International Swaps and Derivatives Association, 2013).

Importantly, our paper does not attempt to quantify the net-benefits of the LR. We instead analyse a particular segment, and a full cost-benefit analysis would entail a broader study of the financial system and the economy as a whole. Since the LR is independent of risk, it provides a guardrail against model risk and measurement error which can affect the risk-based capital ratio.[16] While quantifying the net-benefit of the LR is beyond the scope of this paper, our results indicate that the LR can affect client clearing in the interest rate derivatives markets. As such, policy measures to improve access for end users may be warranted.

[16] By increasing the capitalisation of banks, the LR mitigates the risk of insufficient loss absorbing capacity (cf. Acosta-Smith, J., Grill, M., and Lang, J. H.,, 2017).

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7 Tables and Figures

Table 1: Summary statistics from the portfolio-level data

Panel A: January 2016 shock

	All			Treated			Untreated		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Num clients$_{b,t}$	62.43	125.67	5,425	53.14	69.43	791	63.70	132.88	4,634
DummyDrop$_i$	0.13	0.34	2,089	0.09	0.29	340	0.14	0.35	1,749
Number CM$_i$ (pre)	1.22	0.52	2,089	1.39	0.76	340	1.18	0.45	1,749
DummyNEW$_i$	0.17	0.38	2,184	0.10	0.30	332	0.18	0.39	1,852
Number CM$_i$ (post)	1.25	0.55	2,184	1.39	0.84	332	1.22	0.47	1,852

Panel B: January 2017 shock

	All			Treated			Untreated		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Num clients$_{b,t}$	85.71	144.32	5,641	78.01	66.24	774	86.92	153.08	4,867
DummyDrop$_i$	0.09	0.29	2,634	0.06	0.25	389	0.10	0.30	2,245
Number CM$_i$ (pre)	1.22	0.53	2,634	1.37	0.82	389	1.19	0.46	2,245
DummyNEW$_i$	0.32	0.47	3,507	0.25	0.43	501	0.33	0.47	3,006
Number CM$_i$ (post)	1.17	0.48	3,507	1.38	0.81	501	1.14	0.39	3,006

Notes: This table presents the key variables of interest used in tables **??**, **??** (Panel A) and **??**, **??** (Panel B). "Num clients$_{b,t}$" is the number of clients that bank b is clearing for at day t. "DummyDrop$_i$" is a dummy variable equal to 1 if client i is present at the beginning of the period but disappears at the end, 0 otherwise. "Number CM$_i$ (pre)" is the number of clearing members that client i deals with at the beginning of the period. "DummyNEW$_i$" is a dummy variable equal to 1 if client i is present at the end of the period but not at the beginning, 0 otherwise. "Number CM$_i$ (post)" is the number of clearing members that client i deals with at the end of the period. The period for Panel A is from the 1st of October 2015 until the 31st of March 2016. The period for Panel B goes from the 1st of October 2016 until the 31st of March 2017.

Table 2: Summary statistics from the trade repository data

Panel A: January 2016 shock

	All			Treated			Untreated		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Num clients	314.58	85.25	4,411	118.69	30.28	2,376	229.78	76.14	3,258
Number CMs	45.24	5.32	80	8.03	0.51	10	37.24	4.86	70
Number trans	7,626.67	2,972.90	1,029,601	2,268.70	1,160.20	290,394	5,457.70	2,161.51	736,790

Panel B: January 2017 shock

	All			Treated			Untreated		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Num clients	444.8	98.07	4,677	169.46	31.54	2,494	335.86	88.88	3,589
Number CM	50.34	3.75	84	8	0.29	10	41.48	6.58	73
Number trans	10,603.57	4,123.88	1,452,689	2,670.14	751.47	349,789	7,795.2	3,032.47	1,060,157

Notes: This table presents the key variables of interest used in tables 3, 9 (Panel A), 3, 9 (Panel B), 15. "Num clients" is the number of clients observed during the period under analysis. "Number CM" is the number of clearing members that clients deal with during that period. The period for Panel A is from the 1st of October 2015 until the 31st of March 2016. The period for Panel B goes from the 1st of October 2016 until the 31st of March 2017. "Num trans" is the number of transactions reported during the period under analysis.

Table 3: Number of daily transactions per client - January 2016 shock

	(1)	(2)	(3)	(4)	(5)	(6)
Post_{2016} Treated_b	-1.3989*	-4.6548**	-14.328*	-14.703*	-14.1658*	-32.571
	(0.743)	(1.965)	(8.095)	(7.679)	(7.696)	(31.056)
Post_{2016} Treated_b * LR			3.515*	3.833*	3.721*	7.994
			(1.777)	(2.133)	(2.126)	(6.790)
Leverage Ratio			-1.201		0.582*	2.214*
			(3.034)		(0.2888)	(1.227)
RWA/TA		-20.001	18.505	14.968	15.924	12.042
		(24.422)	(25.866)	(15.702)	(16.097)	(33.690)
Size		-4.725	-0.912	-5.095	-4.750	-2.574
		(8.670)	(8.501)	(3.482)	(3.345)	(9.666)
Clearing member & day FE	Yes	Yes	Yes	Yes	Yes	Yes
Client FE	Yes	-	Yes	Yes	Yes	-
Client-day FE	No	Yes	No	No	No	Yes
Sample	Dec-Jan	Dec-Jan	Dec-Jan	Oct-Mar	Oct-Mar	Oct-Mar
Observations	1,845	302	1,845	6,403	6,403	1,015
R squared	0.2874	0.6908	0.3101	0.395	0.3951	0.4176

Notes: The dependent variable is the number of transactions per client that a clearing member has at day t. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post_t' is a dummy equal to 1 if the date is after the date specified in t, 0 otherwise. Robust standard errors clustered at clearing member, week level in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Number of clients - January 2016 shock

	(1)	(2)	(3)	(4)	(5)	(6)
Post_t	3.133					
	(1.905)					
$\text{Post}_t \times \text{Treated}_b$	-4.860*	-4.870*	-5.091**	-4.519**	-4.675*	-2.789*
	(2.825)	(2.865)	(2.448)	(2.186)	(2.624)	(1.446)
$\text{Post}_t \times$ Client portfolio$_b$			-0.011	-0.013	-0.013	-0.001
			(0.026)	(0.021)	(0.022)	(0.007)
$\text{Post}_t \times$ Capital Ratio$_b$				0.160	0.314	-0.0613
				(0.445)	(0.647)	(0.235)
$\text{Post}_t \times$ Leverage Ratio$_b$				4.141***	4.264**	2.583**
				(1.447)	(1.554)	(0.996)
$\text{Post}_t \times \text{Size}_b$				-0.053	-0.298	-0.259
				(1.762)	(2.115)	(1.087)
Observations	858	858	858	834	720	556
Adjusted R-squared	-	-	-	-	-	-
Within adj. R-squared	-	-	-	-	-	-
Clearing member FE	Y	Y	Y	Y	Y	Y
Time (week) FE	N	Y	Y	Y	Y	Y
Sample	Base	Base	Base	Base	More than 4 clients	Nov15 - Feb16

Notes: The dependent variable is 'Num of clients$_{b,t}$', which is the number of clients that clearing member b has at week t. 'Treated$_b$' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post$_t$' is a dummy equal to 1 if week t is after the 1st of January 2016, 0 otherwise. The "base" sample spans from the 28th of September 2015 to the 24th of March 2016, and includes clearing members with more than one client at the beginning of the sample. In column 5, the analysis is restricted to those client members with at least 4 clients at the beginning of the sample (25th percentile). In column 6, we shorten the time window and drop four weeks in both extremes. Client portfolio$_b$ is the (log of) $Num\,clients_{b,t}$ at the beginning of the "base" sample. Capital Ratio$_b$, Leverage Ratio$_b$, and Size$_b$ are all defined at the level of the clearing member's parent. Capital Ratio$_b$ is Tier 1 capital over risk-weighted assets in 2015H1. Leverage Ratio$_b$ is Tier 1 capital over the leverage exposure measure in 2015H1. Size$_b$ is the logarithm of the leverage exposure measure in 2015H1. Fixed effects are either included ('Y') or not included ('N'). All regressions are estimated using ordinary least squares. Robust standard errors clustered at clearing member level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Number of clients (robustness) - January 2016 shock

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Post}_t \times \text{Treated}_b$	-3.893*	-3.309*	-2.199*	-2.340	-9.717**	-8.747*
	(2.071)	(1.678)	(1.262)	(1.545)	(4.657)	(4.001)
$\text{Post}_t \times$ Client portfolio$_b$	0.017	0.014	-0.030	-0.031	-0.033	-0.039
	(0.025)	(0.022)	(0.015)	(0.011)	(0.069)	(0.062)
$\text{Post}_t \times$ Capital Ratio$_b$		0.590		-0.318		0.743
		(0.459)		(0.316)		(1.143)
$\text{Post}_t \times$ Leverage Ratio$_b$		2.393**		2.480***		8.598***
		(1.026)		(0.902)		(3.091)
$\text{Post}_t \times \text{Size}_b$		0.213		0.159		0.560
		(1.332)		(1.061)		(3.910)
Observations	427	415	467	454	70	68
Adjusted R-squared	-	-	-	-	-	-
Within adj. R-squared	-	-	-	-	-	-
Clearing member FE	Y	Y	Y	Y	Y	Y
Time (week) FE	Y	Y	Y	Y	Y	Y
Sample	Oct15 - Dec15	Oct15 - Dec15	Jan16 - Mar16	Jan16 - Mar16	2 weeks	2 weeks

Notes: The dependent variable is 'Num of clients$_{b,t}$', which is the number of clients that clearing member b has at week t. 'Treated$_b$' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. Treated$_b$' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. The sample in columns (1) and (2) spans from the 28th of September 2015 to the 18th of December 2015; in columns (3) and (4), it spans from the 7th of January 2016 to the 24th of March 2016. Columns (5) and (6) focus on the first week (28th Sep - 2nd Oct 2015) and last week (20th Mar - 24th Mar 2016) of the sample. In all columns, 'Post$_t$' is a dummy equal to 1 in the second half of the sample, 0 in otherwise. Client portfolio$_b$ is the (log of) $Num\,clients_{b,t}$ at the beginning of the "base" sample. Capital Ratio$_b$, Leverage Ratio$_b$, and Size$_b$ are all defined at the level of the clearing member's parent. Capital Ratio$_b$ is Tier 1 capital over risk-weighted assets in 2015H1. Leverage Ratio$_b$ is Tier 1 capital over the leverage exposure measure in 2015H1. Size$_b$ is the logarithm of the leverage exposure measure in 2015H1. Fixed effects are either included ('Y') or not included ('N'). All regressions are estimated using ordinary least squares. Robust standard errors clustered at clearing member level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Clearing member - client relations - January 2016 shock

	(1)	(2)	(3)	(4)	(5)	(6)
Post_t	0.046**					
	(0.022)					
Treated_b	0.069	0.069				
	(0.049)	(0.049)				
$\text{Post}_t \times \text{Treated}_b$	-0.062**	-0.062**	-0.062**	-0.062**	-0.085*	-0.102
	(0.030)	(0.030)	(0.030)	(0.030)	(0.048)	(0.068)
Observations	76,584	76,584	76,584	76,584	33,696	2,808
Adjusted R-squared	0.004	0.008	0.061	0.500	0.225	0.181
Within adj. R-squared	0.004	0.001	0.001	0.001	0.001	0.001
Time (week) FE	N	Y	Y	Y	-	-
Clearing member FE	N	N	Y	Y	Y	Y
Client FE	N	N	N	Y	-	-
Client * time FE	N	N	N	N	Y	Y
Sample	Base	Base	Base	Base	Base	Two weeks

Notes: The dependent variable is $Relation_{b,i,t}$, which is a dummy variable equal to 1 if the clearing member b is servicing client i in week t, 0 otherwise. We only have clearing member - client pairs that are active at some point during the sample. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post_t' is a dummy equal to 1 if week t is after the 1st of January 2016, 0 otherwise. The sample spans from the 28th of September 2015 to the 24th of March 2016, and includes clearing members with more than one client at the beginning of the sample. Column (6) focuses on the first week (28th Sep - 2nd Oct 2015) and last week (20th Mar - 24th Mar 2016) of the sample. Fixed effects are either included ('Y') or not included ('N'). All regressions are estimated using ordinary least squares. Robust standard errors clustered at clearing member level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Clients exiting - January 2016 shock

	(1)	(2)	(3)	(4)
Treated_i	-0.054***	-0.046***	-0.0324	-0.094***
	(0.017)	(0.018)	(0.023)	(0.019)
Number of CMs_i		-0.042***		0.049
		(0.012)		(0.024)
Constant	0.140***	0.189***	0.150***	-0.022
	(0.008)	(0.017)	(0.009)	(0.049)
Observations	2,088	2,088	1,717	371
Adjusted R-squared	0.004	0.008	0.001	0.036
Sample	Base	Base	One CM	> One CM

Notes: The dependent variable is Client exiting_i, a dummy equal to 1 if client i is present during the first week of the sample (28th Sep - 2nd Oct 2015) but has disappeared in the last week of the sample (20th - 24th March 2016), zero if it is still in the sample. Treated_i is a dummy equal to 1 if the client deals with treated clearing members before the shock. Column 3 restricts the sample to clients dealing with only one clearing member; column 4 restricts the sample to clients dealing with two or more clearing members. Number of CMs_i is the number of clearing members client i deals with. All regressions are estimated using ordinary least squares. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 8: Clients entering - January 2016 shock

	(1)	(2)	(3)	(4)
Treated_i	-0.085***	-0.067***	-0.101***	0.013
	(0.019)	(0.019)	(0.023)	(0.027)
Number of CMs_i		-0.099***		-0.026***
		(0.012)		(0.008)
Constant	0.181***	0.302***	0.214***	0.103***
	(0.009)	(0.020)	(0.011)	(0.024)
Observations	2,181	2,181	1,714	467
Adjusted R-squared	0.007	0.028	0.008	0.005
Sample	Base	Base	One CM	> One CM

Notes: The dependent variable is Client entering_i, a dummy equal to 1 if client i is present in the last week of the sample (20th - 24th March 2016) but not at the beginning of the period under study (28th Sep - 2nd Oct 2015), zero if present in both cases. Treated_i is a dummy equal to 1 if the client deals with treated clearing members after the shock. Column 3 restricts the sample to clients dealing with only one clearing member; column 4 restricts the sample to clients dealing with two or more clearing members. Number of CMs_i is the number of clearing members client i deals with. All regressions are estimated using ordinary least squares. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 9: Number of daily transactions per client - January 2017 shock

	(1)	(2)	(3)	(4)	(5)	(6)
Post_{2017} Treated_b	-1.53459	-5.439*	-8.6467*	-2.924**	-8.185*	-13.604*
	(4.103)	(2.449)	(4.304)	(1.414)	(4.772)	(7.332)
Post_{2017} Treated_b * LR	0.195	1.153	1.7218	0.636*	1.661	2.726*
	(0.829)	(0.687)	0.9340	(0.353)	(1.006)	(1.466)
Leverage Ratio			0.36734**		0.349*	0.4761
			(0.1227)		(0.194)	(0.3876)
RWA/TA	-10.882					-7.724
	(8.394)					(10.239)
Size	-4.982*	1.138	-3.3006***	-3.893***	-5.383***	-2.792
	(2.450)	(1.373)	(0.6416)	(1.053)	(0.315)	(3.588)
Clearing member & day FE	Yes	Yes	Yes	Yes	Yes	Yes
Client FE	Yes	-	-	Yes	Yes	-
Client-time FE	No	Yes	Yes	No	No	Yes
Sample	Dec-Jan	Dec-Jan	Dec-Jan	Oct-Mar	Oct-Mar	Oct-Mar
N	8,238	3,943	3,943	27,932	27,932	11,251
R squared	0.134	0.325	0.224	0.1409	0.1409	0.167

Notes: The dependent variable is the number of transactions per client that a clearing member has at day t. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post_t' is a dummy equal to 1 if the date is after the date specified in t, 0 otherwise. Robust standard errors clustered at the clearing member, week level in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 10: Number of clients - January 2017 shock

	(1)	(2)	(3)	(4)	(5)	(6)
Post_t	12.740***					
	(4.054)					
$\text{Post}_t \times \text{Treated}_b$	-2.422	-2.535	0.248	-0.041	-2.423	-0.625
	(4.785)	(4.848)	(5.833)	(6.529)	(7.036)	(5.416)
$\text{Post}_t \times \text{Client portfolio}_b$			0.128***	0.120**	0.118**	0.106
			(0.039)	(0.045)	(0.047)	(0.042)
$\text{Post}_t \times \text{Capital Ratio}_b$				0.743	1.115	0.332
				(0.973)	(1.688)	(0.720)
$\text{Post}_t \times \text{Leverage Ratio}_b$				0.941	0.993	-0.179
				(2.695)	(3.010)	(2.118)
$\text{Post}_t \times \text{Size}_b$				1.384	0.930	0.913
				(2.765)	(4.494)	(2.136)
Observations	967	967	936	888	720	592
Adjusted R-squared	0.991	0.991	0.995	0.995	0.995	0.996
Within adj. R-squared	0.186	0.001	0.420	0.420	0.412	0.396
Clearing member FE	Y	Y	Y	Y	Y	Y
Time (week) FE	N	Y	Y	Y	Y	Y
Sample	Base	Base	Base	Base	More than 4 clients	Nov15 - Feb16

Notes: The dependent variable is 'Num of $\text{clients}_{b,t}$', which is the number of clients that clearing member b has at week t. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post_t' is a dummy equal to 1 if week t is after the 1st of January 2017, 0 otherwise. The "base" sample spans from the 3rd of October 2016 to the 31st of March 2017, and includes clearing members with more than one client at the beginning of the sample. In column 5, the analysis is restricted to those client members with at least 6 clients at the beginning of the sample (25th percentile). In column 6, we shorten the time window and drop four weeks in both extremes. '$\text{Client portfolio}_b$' is the 'Num of $\text{clients}_{b,t}$' at the beginning of the "base" sample. 'Capital Ratio_b', 'Leverage Ratio_b', and 'Size_b' are all defined at the level of the clearing member's parent. 'Capital Ratio_b' is Tier 1 capital over risk-weighted assets in 2016H1. 'Leverage Ratio_b' is Tier 1 capital over the leverage exposure measure in 2016H1. 'Size_b' is the logarithm of the leverage exposure measure in 2016H1. Fixed effects are either included ('Y') or not included ('N'). All regressions are estimated using ordinary least squares. Robust standard errors clustered at clearing member level in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 11: Number of clients (robustness) - January 2017 shock

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Post}_t \times \text{Treated}_b$	3.634	3.238	-3.834	-3.196	1.677	1.601
	(4.419)	(4.057)	(3.318)	(4.179)	(7.928)	(9.004)
$\text{Post}_t \times \text{Client portfolio}_b$	0.019	0.007	0.101**	0.103**	0.154***	0.134***
	(0.014)	(0.011)	(0.038)	(0.041)	(0.031)	(0.040)
$\text{Post}_t \times \text{Capital Ratio}_b$		0.781		0.295		1.485
		(0.628)		(0.494)		(1.449)
$\text{Post}_t \times \text{Leverage Ratio}_b$		2.189		-0.556		4.015
		(1.318)		(1.947)		(4.076)
$\text{Post}_t \times \text{Size}_b$		1.978		-0.761		2.483
		(1.301)		(1.943)		(4.358)
Observations	468	444	507	481	78	74
Adjusted R-squared	-	-	-	-	-	-
Within adj. R-squared	-	-	-	-	-	-
Clearing member FE	Y	Y	Y	Y	Y	Y
Time (week) FE	Y	Y	Y	Y	Y	Y
Sample	Oct16 - Dec16	Oct16 - Dec16	Jan17 - Mar17	Jan17 - Mar17	2 weeks	2 weeks

Notes: The dependent variable is '$\text{Num of clients}_{b,t}$', which is the number of clients that clearing member b has at week t. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. The sample in columns (1) and (2) spans from the 3rd of October 2016 to the 23rd of December 2016; in columns (3) and (4), it spans from the 9th of January 2017 to the 31st of March 2017. Columns (5) and (6) focus on the first week (3rd Oct - 7th Oct 2016) and last week (27th Mar - 31st Mar 2017) of the sample. In all columns, 'Post_t' is a dummy equal to 1 in the second half of the sample, 0 in otherwise. '$\text{Client portfolio}_b$' is the '$\text{Num of clients}_{b,t}$' at the beginning of the "base" sample. 'Capital Ratio_b', 'Leverage Ratio_b', and 'Size_b' are all defined at the level of the clearing member's parent. 'Capital Ratio_b' is Tier 1 capital over risk-weighted assets in 2016H1. 'Leverage Ratio_b' is Tier 1 capital over the leverage exposure measure in 2016H1. 'Size_b' is the logarithm of the leverage exposure measure in 2016H1. Fixed effects are either included ('Y') or not included ('N'). All regressions are estimated using ordinary least squares. Robust standard errors clustered at clearing member level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 12: Clearing member - client relations - January 2017 shock

	(1)	(2)	(3)	(4)	(5)	(6)
Post_t	0.110***					
	(0.019)					
Treated_b	0.057	0.057				
	(0.046)	(0.046)				
$\text{Post}_t \times \text{Treated}_b$	0.015	0.015	0.015	0.015	-0.005	0.051
	(0.067)	(0.067)	(0.067)	(0.068)	(0.055)	(0.094)
Observations	106,536	106,536	106,536	106,536	35,064	2,922
Adjusted R-squared	0.020	0.025	0.040	0.499	0.173	0.157
Within adj. R-squared	0.020	0.003	0.000	0.000	0.000	0.000
Time (week) FE	N	Y	Y	Y	-	-
Clearing member FE	N	N	Y	Y	Y	Y
Client FE	N	N	N	Y	-	-
Client * time FE	N	N	N	N	Y	Y
Sample	Base	Base	Base	Base	Base	Two weeks

Notes: The dependent variable is $Relation_{b,i,t}$, which is a dummy variable equal to 1 if the clearing member b is servicing client i in week t, 0 otherwise. We only have clearing member - client pairs that are active at some point during the sample. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post_t' is a dummy equal to 1 if week t is after the 1st of January 2017, 0 otherwise. The sample spans from the 3rd of October 2016 to the 31st of March 2017, and includes clearing members with more than one client at the beginning of the sample. Column (6) focuses on the first week (3rd Oct - 7th Oct 2016) and last week (27th Mar - 31st Mar 2017) of the sample. Fixed effects are either included ('Y') or not included ('N'). All regressions are estimated using ordinary least squares. Robust standard errors clustered at clearing member level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 13: Clients exiting - January 2017 shock

	(1)	(2)	(3)	(4)
Treated_i	-0.035**	-0.026*	-0.047***	0.035
	(0.014)	(0.014)	(0.016)	(0.024)
Number of CMs_i		-0.052***		-0.013
		(0.007)		(0.008)
Constant	0.097***	0.158***	0.113***	0.046**
	(0.006)	(0.012)	(0.007)	(0.019)
Observations	2,634	2,634	2,154	480
Adjusted R-squared	0.002	0.011	0.003	0.009
Sample	Base	Base	One CM	> One CM

Notes: The dependent variable is Client exiting_i, a dummy equal to 1 if client i is present during the first week of the sample (3rd - 7th October 2016) but has disappeared in the last week of the sample (27th - 31st March 2017), zero if it is still in the sample. Treated_i is a dummy equal to 1 if the client deals with treated clearing members before the shock. Column 3 restricts the sample to clients dealing with only one clearing member; column 4 restricts the sample to clients dealing with two or more clearing members. Number of CMs_i is the number of clearing members client i deals with. All regressions are estimated using ordinary least squares. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 14: Clients entering - January 2017 shock

	(1)	(2)	(3)	(4)
Treated_i	-0.087***	-0.047**	-0.049*	-0.057**
	(0.021)	(0.021)	(0.026)	(0.025)
Number of CMs_i		-0.171***		-0.050***
		(0.014)		(0.013)
Constant	0.327***	0.522***	0.358***	0.226***
	(0.009)	(0.019)	(0.009)	(0.036)
Observations	3,491	3,491	2,975	516
Adjusted R-squared	0.004	0.035	0.001	0.020
Sample	Base	Base	One CM	> One CM

Notes: The dependent variable is Client entering_i, a dummy equal to 1 if client i is present in the last week of the sample (27th - 31st March 2017) but not at the beginning of the period under study (3rd - 7th October 2016), zero if present in both cases. Treated_i is a dummy equal to 1 if the client deals with treated clearing members after the shock. Column 3 restricts the sample to clients dealing with only one clearing member; column 4 restricts the sample to clients dealing with two or more clearing members. Number of CMs_i is the number of clearing members client i deals with. All regressions are estimated using ordinary least squares. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 15: Number of daily transactions - Pension funds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	2017				2016		
Post_{2017} Treated_b	-0.894*	-1.582***	-2.124**	-1.902**	2.575***	4.462***	-1.167*
	(0.454)	(0.456)	(0.933)	(0.855)	(0.668)	(1.078)	(0.603)
Post_{2017} Treated_b Small_j	0.594	0.416	0.282		-6.640***	-7.520**	
	(1.436)	(1.631)	(0.814)		(1.475)	(2.648)	
Leverage Ratio		0.682				2.223	
		(0.444)				(2.305)	
Size		-16.948				-8.426**	
		(9.996)				(2.666)	
Observations	2,847	2,657	306	306	1,416	1,416	44
Clearing member & day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Client FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Client-time FE	No	No	Yes	Yes	No	No	Yes
R-squared	0.3675	0.3789	0.1745	0.1801	0.744	0.745	0.512

Notes: The sample period for 2017 is Oct 2016 to Mar 2017. The sample period for 2016 is Oct 2015 to Mar 2016. The dependent variable is the number of transactions that a clearing member has at day t. 'Treated_b' is a dummy variable that equals 1 if the parent company of the clearing member is headquartered in the UK, and 0 otherwise. 'Post_t' is a dummy equal to 1 if the date is after the date specified in t, 0 otherwise. Small_j is a dummy that equals 1 if the pension fund client j transacts less than the median pension fund (defined in the 12 months prior to the sample period). Robust standard errors clustered at the clearing member, week level in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Number of transactions by maturity year within the client clearing.

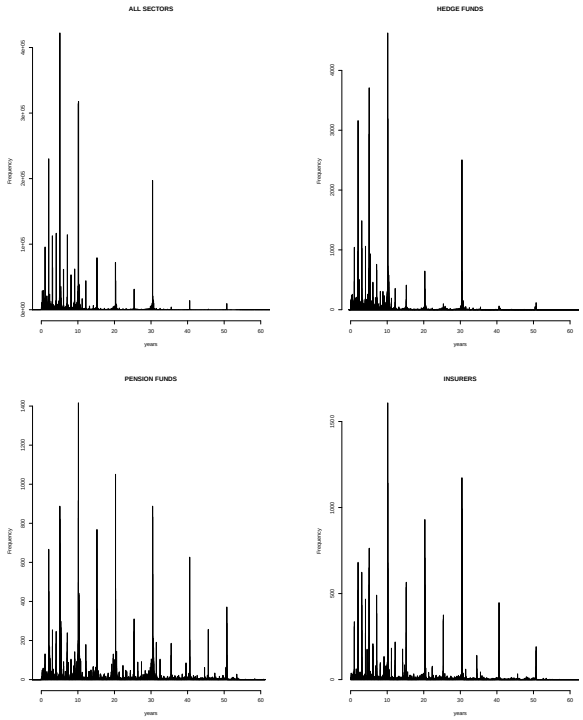


Figure 2: Number of clearing members per client

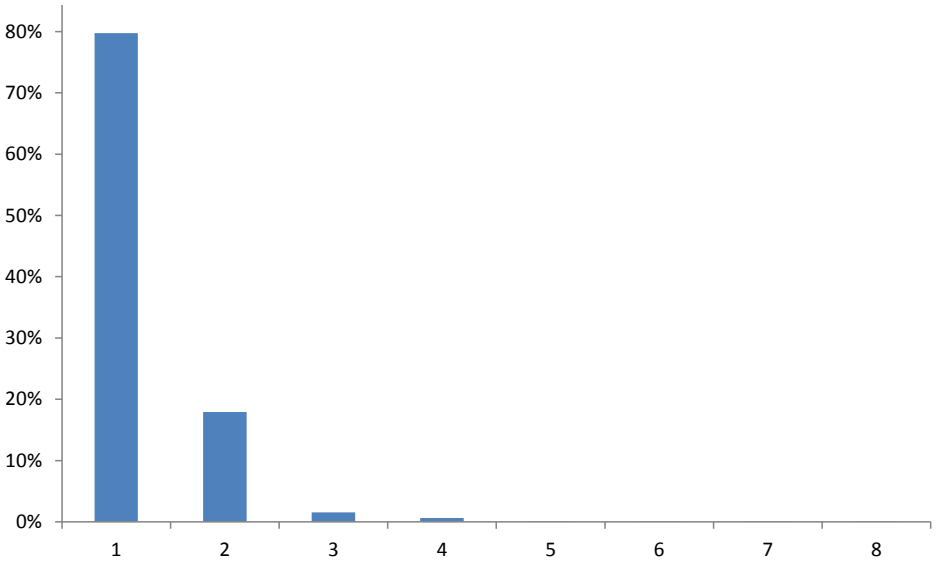


Figure 3: Number of clearing members offering clearing services in LCH

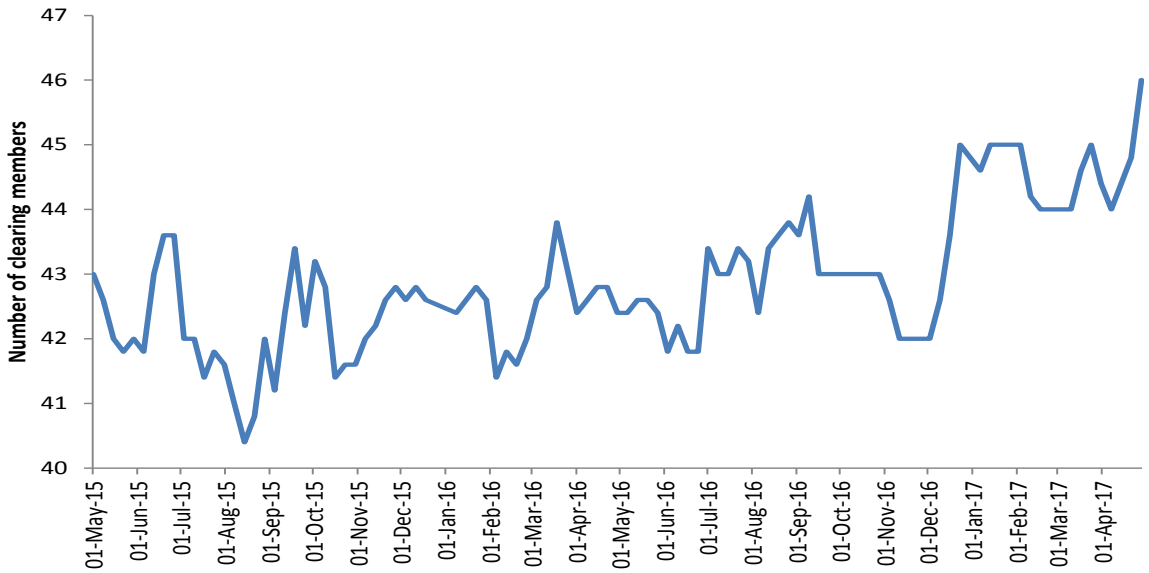
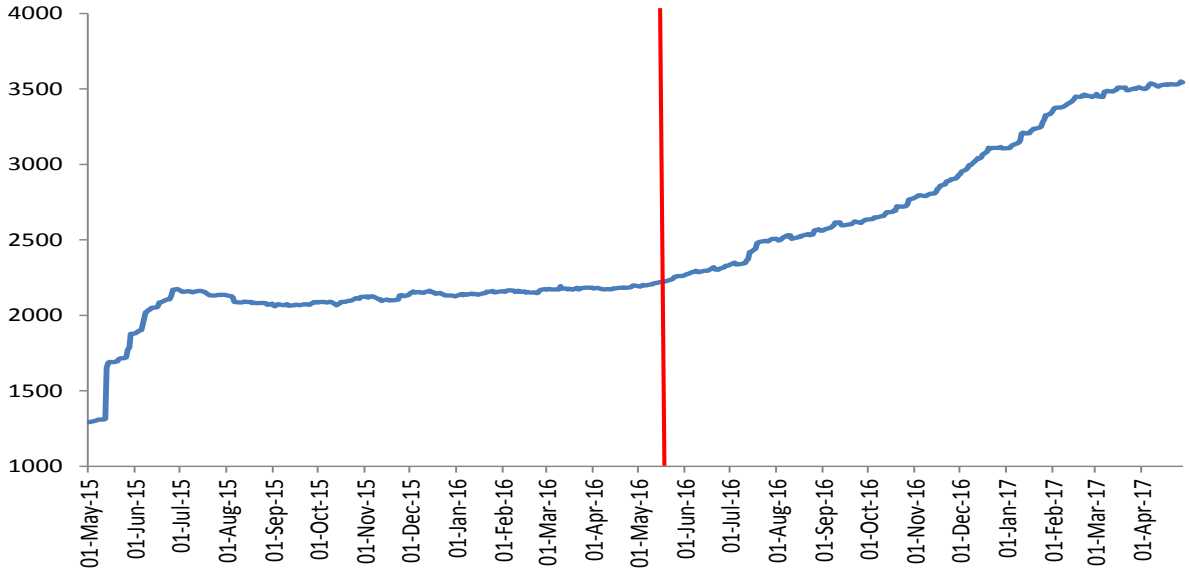
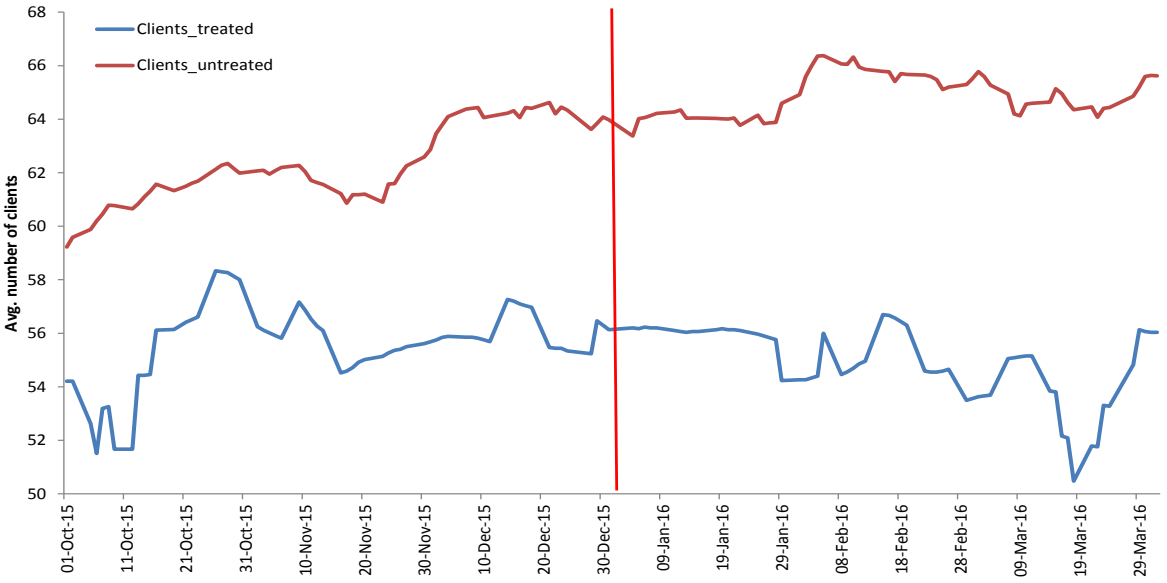


Figure 4: Number of clients using Swapclear data



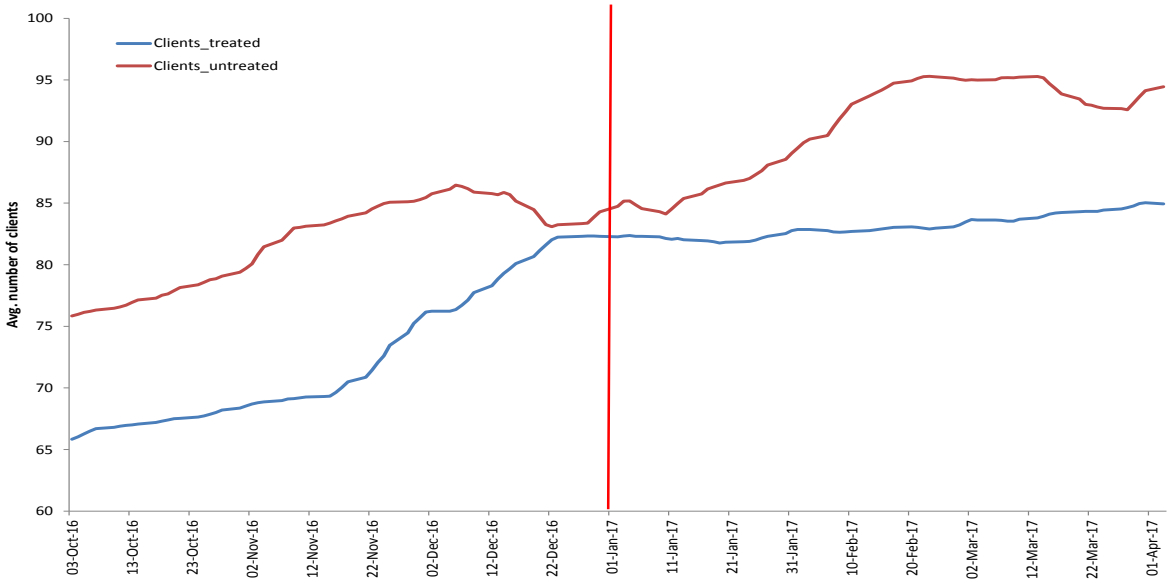
Notes: The chart shows the number of clients over time using data from LCH.Clearnet Swapclear. The vertical red line denotes the introduction of the frontloading mandatory central clearing requirement for the category 2 firms.

Figure 5: Average number of clients serviced by clearing members



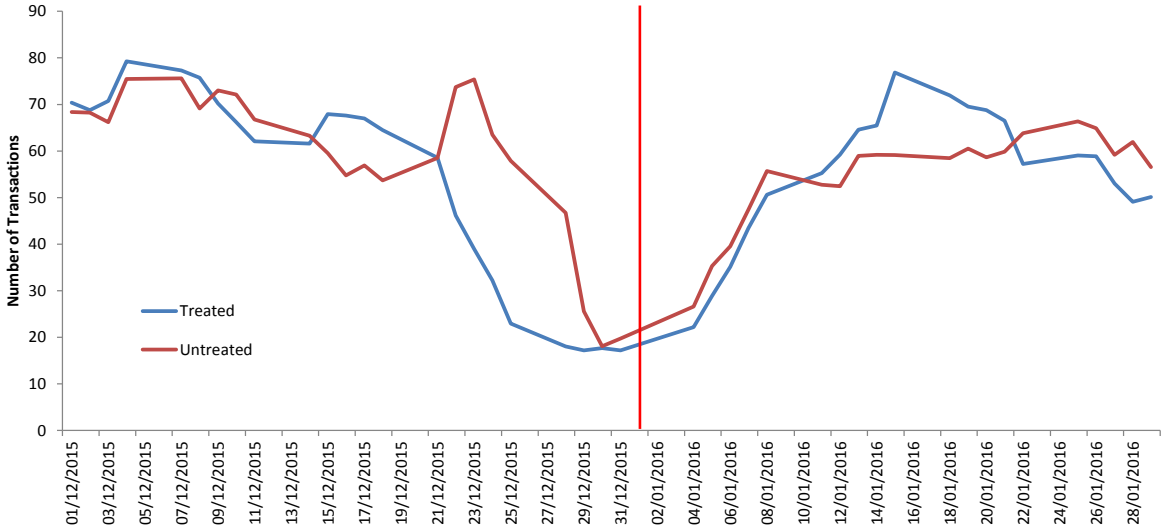
Notes: The chart shows the average number of clients serviced by clearing members three months before and after the January 2016 shock. This is split by treated and untreated clearing members. The vertical red line denotes the introduction of the UK leverage ratio requirement.

Figure 6: Average number of clients serviced by clearing members



Notes: The chart shows the average number of clients serviced by clearing members three months before and after the January 2017 shock. This is split by treated and untreated clearing members. The vertical red line denotes the UK leverage ratio change in regulatory reporting requirements.

Figure 7: Average number of transactions by clearing members per day: Dec 2015 - Jan 2016



Notes: The chart shows the average number of transactions cleared on behalf of clients per day. This excludes all intra-dealer transactions one month before and after the January 2016 shock. The numbers are 5-day rolling averages. The vertical red line denotes the introduction of the UK leverage ratio requirement.

Figure 8: Average number of transactions by clearing members per day: Dec 2016 - Jan 2017

Notes: The chart shows the average number of transactions cleared on behalf of clients per day one month before and after the January 2017 shock. This excludes all intra-dealer transactions. The numbers are 5-day rolling averages. The vertical red line denotes the UK leverage ratio change in regulatory reporting requirements.