Introducing ENNs: A Measure of the Size of Interest Rate Swap Markets

by

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Executive Summary

Notional amount is not a good measure of the size of the interest rate swap (IRS) market, that is, of the magnitude of risk transfer through IRS. First, since a significant volume of IRS swaps are short term, notional amount exaggerates the extent of risk transfer in this market. Second, since trading conventions leave pairs of counterparties holding risk-offsetting long and short positions, notional amount—which adds longs and shorts—significantly overstates risk transfer between pairs of counterparties.

This paper introduces Entity-Netted Notionals (ENNs) as a better measure of market size. ENNs for a market are computed as follows: convert the long and short notional amounts of each entity to 5-year risk equivalents; net longs against shorts in a given currency within pairs of legal entities; and sum the resulting net longs (or net shorts) across entities. While any individual entity can easily calculate its own ENNs, the CFTC is uniquely positioned to calculate market ENNs using the detailed data it receives from Swap Data Repositories (SDRs).

To describe ENNs intuitively, imagine that each pair of swap counterparties established its net interest rate risk position with bonds instead of swaps. More precisely, within each pair of counterparties, the counterparty that is net long has purchased a 5-year equivalent risk position in bonds from the counterparty that is net short. Then, the sum of those hypothetical bond positions across all pairs of counterparties is a measure of the size of the market and is equal to ENNs as defined in this paper.

For all U.S. reporting entities as of December 15, 2017, notional amount across the dominant IRS products, namely, fixed-for-floating swaps, FRAs, OIS, and swaptions, is $179 trillion. Expressed in 5-year risk equivalents, that notional amount falls to $109 trillion. ENNs, however, are only $15 trillion, or just over 8% of notional amount. Therefore, measured with ENNs, the size of the interest rate swap market is comparable to the sizes of other fixed income markets, like corporate bonds at $12 trillion, mortgages at $15 trillion, or U.S. Treasuries at $16 trillion.[2]

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[2] Financial Accounts of the United States, Board of Governors of the Federal Reserve System, Second Quarter 2017.

In conclusion, the great empirical difference between notional amount and ENNs in the IRS market argues strongly for moving away from notional amount as a metric of market size and risk transfer.

I. WANTED: A Measure of the Size of Interest Rate Swap Markets

The financial community has found it more difficult to measure the sizes of derivatives markets, like the interest rate swap (IRS) market, than to measure the sizes of bond markets.

With respect to bond markets, principal amount outstanding is the commonly accepted measure of size because, in rough terms, principal amount translates directly into several quantities of interest. For example, the fact that the principal amount outstanding of corporate bonds in the United States is about $12 trillion[3] has several useful implications:

- *Funds raised*: Investors loaned about $12 trillion to corporate issuers to finance their business activities.
- *Market risk*: Assuming an average bond price of 100 and an average bond duration of 5 years, then, roughly speaking, a 100-basis point increase in interest rates would result in a mark-to-market loss to investors of about $12 trillion x 5% or $600 billion.
- *Credit risk*: Assuming a default rate of 5% and a recovery rate of 40%, then annual corporate defaults would cost investors $12 trillion x 5% x (1 – 40%), or $360 billion of principal.

Unlike principal amount in bond markets, however, the notional amount of outstanding IRS cannot be interpreted as easily.

Funds raised, for instance, has no meaning in IRS markets. Unlike the issuance of a bond, the initiation of an IRS raises no funds. When a bond issuer sells $100 million principal amount at par, investors pay the issuer $100 million. But when one counterparty enters into a $100 million notional IRS with another counterparty, there is no payment of this $100 million. The $100 million is called a "notional amount" precisely because that amount is used solely to calculate the future interest payments due on the IRS transaction.

As for market risk, the notional amount of IRS is not a good metric of market size, that is, of the amount of risk transferred from one set of entities to their swap counterparties. First, since many swaps are of short maturity, which have little risk, adding the notional amount of these short maturity swaps together with long maturity swaps is misleading.

Second, as explained later in this paper, trading conventions leave many swap market participants holding offsetting long and short positions with each other.[4] But the notional amount of an IRS position is calculated by adding together the notional amount of the long and short positions.

To be more concrete, as a result of trading conventions and the calculation of notional amount, a counterparty's $500 million IRS notional with another counterparty might represent either a long

[3] Financial Accounts of the United States, Board of Governors of the Federal Reserve System, Second Quarter 2017. Note that this $12 trillion includes bonds issued by foreign corporations and held by U.S. entities.
[4] In IRS markets, "receiving fixed" indicates a long position, which suffers when interest rates rise, while "paying fixed" indicates a short position, which profits when interest rates rise. Section II explains this in more detail.

notional position of $500 million or offsetting long and short notional positions of $250 million each. Clearly then, notional amount is not a reasonable measure of size in the sense of how much market risk one counterparty transfers to another.

Lastly, with respect to credit risk, notional amount again fails as a suitable metric. While a bond issuer may default on its principal amount, neither counterparty to an IRS ever promises to pay the IRS notional amount. Therefore, in a $100 million notional swap, neither counterparty is ever at risk of losing that $100 million. It follows directly that notional amount is not a reasonable measure of size with respect to credit risk. To set terminology, note that the risk that a counterparty defaults on a derivatives transaction is often referred to as "counterparty credit risk" or simply, "counterparty risk."

Despite these conceptual problems, notional amounts are often used to describe the size and risks of IRS markets. Recent examples include "EU Derivatives Market Worth €453T, ESMA Analysis Reveals,"[5] and "the notional value of OTC derivatives contracts outstanding was $630 trillion… which was eight times greater than global output and 6.5 times larger than outstanding debt securities."[6] Quotations like these are misleading because notional amount is not a measure of "worth" or "output," and notional amount is not comparable to the outstanding principal amounts of debt securities.

The purpose of this paper is to introduce ENNs—Entity-Netted Notionals—as a measure of the size of the IRS market *with respect to the transfer of market risk*. It is sensible to define the size of the IRS market in this way because risk transfer is, after all, the primary purpose of IRS.

The first step in computing ENNs is to convert all notional amounts into 5-year risk equivalents. Since 10-year swaps are riskier than 5-year swaps, for example, $100 million notional of 10-year swaps might equal $191 million 5-year equivalents. By contrast, since 2-year swaps have less risk than 5-year swaps, $100 million notional of 2-year swaps might equal only $39 million 5-year equivalents. See Appendix 2 for details.

ENNs work in 5-year equivalents so as to capture the biggest component of interest rate risk, namely "outright risk" or "level risk," in which rates of all terms are assumed to move up or down together. By construction, therefore, ENNs ignore smaller components of interest rate risk, like "curve risk," or "curvature risk," in which rates of different terms are not perfectly correlated.[7]

There is no overwhelming reason to choose 5-year equivalents as a benchmark, but any reasonable choice would reflect the maturity distribution of the broader bond market. Along these lines, note that one broad U.S. investment grade bond index currently has an effective duration of about 5.8 years and a weighted average maturity of about 8.2 years.[8] These statistics point toward using either 5-year or 10-year equivalents, and ENNs use the 5-year standard.

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[5] Law360, October 19, 2017, accessed from www.Law360.com on December 27, 2017. ESMA is the European Securities and Markets Authority.

[6] BIS Statistical Bulletin, December 2017, p. 252.

[7] While working in 5-year equivalents is certainly a simplification, ENNs so constructed nevertheless improve on metrics like bond market principal amounts, which add principal amounts of different maturities, that is, of different first-order interest rate risk. In any case, some implications of ENNs' focus on outright risk will be pointed out later in the paper.

[8] iShares Core U.S. Aggregate Bond ETF. Accessed from www.ishares.com/us/products/239458/ishares-core-total-us-bond-market-etf on January 2, 2018.

In any case, after converting all notional amounts to 5-year equivalents, the next step in computing ENNs is to sum all net long (or net short) 5-year equivalent notional amounts, where netting occurs only across swaps denominated in the same currency and only across swaps between a single pair of legal entities, or counterparties.

Consider a simple example, with all notional amounts expressed in 5-year equivalents. A pension fund is long $300 million notional and short $200 million notional against a swap dealer, while an asset manager is long $400 million notional and short $500 million notional against that same dealer. (Section III will explain how market trading conventions result in simultaneous long and short positions between a single pair of counterparties.)

Adding the notional amounts of all positions in this example, the notional amount of this market is $1.4 trillion: $300 million + $200 million + $400 million + $500 million. But, by ignoring the fact that long and short positions offset, this $1.4 trillion vastly overstates the risk transfer in this hypothetical market.

By contrast, netting within pairs of counterparties gives a more realistic picture of the market. The pension fund is net long $100 million notional against the swap dealer; the swap dealer is net short $100 million against the pension fund and net long $100 million against the asset manager; and the asset manager is net short $100 million against the swap dealer.[9]

The ENNs of this market, therefore, are the sum of the net longs across all counterparties: the $100 million net long of the pension fund against the swap dealer plus the $100 million net long of the investment bank against the asset manager, for a total of $200 million.

Equivalently, since net longs have to equal net shorts across the market, ENNs also equal the sum of the net shorts across all counterparties: the $100 million net short of the swap dealer against the pension fund and the $100 million net short of the asset manger against the swap dealer.

In terms of risk transfer, the $200 million of ENNs can be described as the sum of two risk transfers: the pension fund transfers the risk of $100 million notional to the swap dealer, and the swap dealer transfers the risk of $100 million notional to the asset manager.

The CFTC has computed ENNs for the IRS market as of December 15, 2017. For this purpose, the market was defined as the four dominant categories of IRS, namely, fixed-for-floating swaps, floating rate agreements (FRAs), overnight index swaps (OIS), and swaptions. The data were collected by the Swap Data Repositories (SDRs) from all U.S. reporting entities and then reported to the CFTC.

Total notional amount across the covered products and reporting entities on this date was $179 trillion. In terms of 5-year equivalents, the notional amount was $109 trillion. ENNs, by contrast, were only $15 trillion. Hence, the size of this IRS market with respect to market risk transfer, as measured by

[9] These 5-year equivalent net notional amounts, by construction, capture the outright or level risk between each pair of counterparties, but not higher orders of risk, like curve risk. Say, for example, that the pension fund is long $300 million 5-year equivalents in 10-year swaps and short $200 million 5-year equivalents in 2-year swaps. Then, stated most accurately, the pension fund has a $100 million 5-year equivalent outright exposure and a $200 million 5-year equivalent curve exposure. ENNs ignore the latter.

ENNs, is of the same order of magnitude as other fixed income markets, like the Treasury market at $16 trillion, the mortgage market at $15 trillion, or the corporate bond market at $12 trillion.[10]

It is also crucial, of course, to measure the amount of counterparty risk in the IRS market, and, as discussed earlier, this cannot sensibly be done with notional amount. Appendix 1 discusses more appropriate, existing measures of counterparty risk.

It is also crucial to measure operational risk, for which, in fact, notional amount is a good proxy. This point will be explained in greater detail below.

In short, discussions about market size and the transfer of interest rate risk should shift away from notional amounts and to metrics that normalize swaps for risk and account for long-short netting between pairs of counterparties, like ENNs.

The plan of this paper is as follows.

Section II reviews the terms of bonds and IRS to clarify that individual bonds and IRS are very similar with respect to market risk, but very different with respect to credit risk.

Section III describes the calculation of notional amount for portfolios of swaps in greater detail, introduces ENNs, and concludes that ENNs are a good measure of market size with respect to the transfer of market risk. As mentioned earlier, ENNs are not intended to measure counterparty credit risk or operational risk.

Section IV elaborates on the point that ENNs are not intended and do not, in fact, measure counterparty risk or operational risk. As it turns out, under relatively minor assumptions, notional amount is a good proxy for operational risk.

Section V presents IRS notional amounts and ENNs for all U.S. reporting entities, by sector. The analysis reveals not only the size of this IRS market, but also the extent to which each sector transfers market risk to other sectors. Appendix 2 gives details with respect to the data and the calculation of ENNs with these data.

Section VI concludes with potential regulatory implications of the paper and with plans to extend the analysis: to include the few, relatively small remaining interest rate products; to define and compute ENNs for other swaps markets (e.g., credit default swaps, foreign exchange derivatives); and to conduct more detailed analyses of how derivatives are used by entities within particular sectors.

II. Individual Bonds and IRS are Similar with respect to Market Risk, but Different with respect to Credit Risk.

A typical, coupon bond pays interest on principal at some fixed rate, and then, at maturity, returns principal. To fix some numbers, consider a bond with a principal amount of $100, an initial price

[10] Financial Accounts of the United States, Board of Governors of the Federal Reserve System, Second Quarter 2017.

of $100, an interest rate of 6%, and a 10-year maturity. This bond would cost $100, make interim interest payments of $6 per year, and then, 10 years later, make a principal payment of $100.

For comparison with other financial instruments, however, it is useful to take into account the opportunity cost of buying a bond. If one spends $100 on a bond, one cannot spend that $100 on anything else. From this perspective, it is best to think of a bond investment in terms of borrowing the initial bond price and paying some interest rate on that borrowing.

Continuing with the example at the start of this section, the initial bond price of $100 would be borrowed through the short-term repo market, where the bond is posted as collateral[11] and the short-term repo borrowings would be rolled at prevailing repo rates until the bond's maturity.

From this perspective, the cash flows from the bond investment are: $0 today—since the purchase price was borrowed; interim receipts of $6 in coupon interest minus repo interest payments; and no final payment at maturity—since the $100 principal amount received from the bond at maturity would be used to pay off the principal of the repo loan.

Now turn to the cash flows from an IRS. The counterparty that "receives fixed" or "pays floating" receives some fixed rate on the notional amount in exchange for paying some floating rate on the notional amount. The counterparty that "pays fixed" or "receives floating" does the opposite, paying the fixed rate and receiving the floating rate.

With a fixed rate of 6%, a notional amount of $100, and a term of 10 years, the cash flows from receiving fixed in an IRS would be $6 per year minus the floating rate interest payments. There are no initial or final payments: the fixed rate on an IRS is typically set such that both counterparties are willing to enter into the swap without any initial payment, and counterparties to an IRS never promise to pay or receive the notional amount.

Combining the discussions of bonds and swaps reveals that the fixed cash flows from $100 principal amount of 6%, 10-year bonds—financed in the repo market—are the same as the fixed cash flows from receiving fixed at 6% on $100 notional amount of IRS. The total cash flows differ only to the extent that the floating rate indexes differ: bonds would typically be financed at a repo rate, whereas the floating side of swaps are typically indexed to LIBOR.

From a market risk perspective, therefore, buying a bond is the same as receiving fixed on a swap. If interest rates increase, the value of the bond declines in the same way that the value of the swap declines to the fixed receiver.[12] Therefore, with respect to market risk, receiving fixed in IRS is just like being long a bond and, conversely, paying fixed in IRS is just like being short a bond.

While, as just demonstrated, individual bonds and swaps are similar with respect to market risk, they are not at all similar with respect to credit risk.

Continuing with the examples, say that the issuer of the 6%, 10-year bond defaults. An investor in $100 face amount of that bond will not receive any more interest payments and will receive only

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[11] For a more detailed discussion of repo markets see, for example, Fixed Income Securities: *Tools for Today's Markets*, Third Edition, by Bruce Tuckman and Angel Serrat, Wiley, 2011, Chapter 12.
[12] The difference in interest rate risk arising from the difference in floating rate indexes is typically trivial.

some fraction of the bond's principal amount, say $40. But this investor still owes and must pay back the $100 repo loan.[13] The losses from a bond's default, therefore, can be quite large.

By comparison, the consequences of a counterparty default on a swap are quite small. The notional amount of a swap is never paid or received. The value of a swap that is at risk to a counterparty default is limited to the change in the market value of the swap since its initiation.

Say that interest rates have declined since the initiation of the swap in the example. At initiation, the fair market rate on the 10-year swap was 6%, which means, by definition, that the value of the 6%, 10-year swap to the fixed receiver (and the fixed payer) was zero. Since rates subsequently declined over the next year, say, for example, to 4%, the value of the swap to the fixed receiver might increase from $0 to $1.50, just as the value of $100 principal of a 10-year bond might increase by $1.50 for a similar decline in rates.

If the fixed payer on the swap then defaulted, the swap would essentially be canceled and the fixed receiver might lose its $1.50 in swap value. In practice, however, counterparties to most IRS transactions post collateral to ensure performance on swap contracts. In this example, therefore, the fixed receiver is likely to have enough of the fixed payer's collateral available to cover this $1.50 loss.

III. ENNs vs. Notional Amounts as a Measure of Market Size and Risk Transfer

To describe the existing measures of the sizes and risks of IRS markets, return to the example presented in Section I and depicted in Table 1. This section assumes that all amounts are in 5-year equivalents, which are described earlier and explained in more detail in Appendix 2.

Pension funds typically have long-term pension liabilities that they fund with investments in corporate bonds. But since the maturity of most corporate bonds is shorter than the maturity of most pension liabilities, pension funds need to take on more interest rate risk to balance the risks of their assets and liabilities. One common way to do this is to received fixed in IRS.

In the example of Table 1, a pension fund receives fixed on $300 million notional in IRS in one set of trades, and pays fixed on $200 million notional in another set of trades. These trades might be explained by the fund having first received cash in exchange for taking on some liabilities and, at the same time, received fixed on $300 million to hedge the interest rate risk of those liabilities. Subsequently, as the fund invested the cash in corporate bonds, it took off some of the existing swap hedge by paying fixed on $200 million.

Whatever the reason for the changing interest rate exposure through IRS, the example highlights a feature of swap markets that is different from cash markets. When counterparties undo an IRS position, they typically put on a new IRS position, in the opposite direction, rather than unwinding the original position.

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[13] The bond was posted as collateral against the repo loan, but the repo lender has recourse to the borrower. Reverting back to the somewhat simpler framework of an investor using $100 cash to purchase the bond, a default leads to a loss relative to that initial cash investment.

The reason for this practice is that the most liquid of traded IRS have a fixed rate equal to the prevailing market rate and that there is a one of a set of commonly-traded terms to maturity. The pension fund, when initiating its position, might have received fixed at 6% for 10 years. Six months later, however, the market rate might have moved to 5.5%, and 9.5-year swaps are not as liquid as 10-year swaps.

Therefore, instead of unwinding the 6%, now-9.5-year swap, the pension fund would likely pay fixed on a new 5.5%, 10-year swap. The notional amount of the latter would be chosen to match the desired adjustment to the fund's interest rate risk profile. In any case, these long and short swap positions might very well both remain on the books of the pension fund for years to come.

The stacking of long and short positions, which is typical in IRS markets, is not typical in bond markets. An investor that wants to reduce risk in a particular bond will sell that particular bond, though this might be accomplished in a few steps: a more liquid bond might at first be sold to reduce risk and, then, over time, the original bond might be sold and the liquid bond hedge correspondingly reduced. But the original bond position is typically reduced to the desired level in relatively short order.

The bottom line is that the pension fund in Table 1, to achieve its desired risk position, has a long position of $300 million and a short position of $200 million with the dealer, for a net long of $100 million. The dealer in Table 1 has facilitated both sets of trades, so its position is a mirror image of that of the pension fund: the dealer has a short position of $300 million and a long position of $200 million.

Table 1 also shows a set of IRS trades by an asset manager, which paid fixed on $500 million notional in one set of trades and receive fixed on $400 million notional in another set of trades. This asset manager might have bought corporate bonds and hedged their interest rate risk by paying fixed in swap. Then, having sold most of those bonds, reduced the hedge accordingly by paying fixed on $400 million in swap, leaving a net position of short $100 million. Like the pension fund, the asset manager offset its original position by doing new swaps rather than unwinding its original swaps.

The same dealer that facilitated the trades of the pension fund facilitated the trades of the asset manager. The dealer's position with the pension fund is net short $100 million, while the dealer's position with the asset manager is net long $100 million.

What is a reasonable estimate of the size of the IRS market depicted in Table 1? In terms of notional amounts, the size of the market is the sum of all the trades, that is, in millions, $300 + $200 + $500 +$400, or $1.4 trillion. But, given the significant amount of risk netting in this market, this notional amount of $1.4 trillion clearly overestimates the amount of risk transfer.

The idea behind ENNs is that each pair of entities has exchanged some net amount of risk. Therefore, the right measure of risk transfer in the market is the sum of the longs (or of the shorts) across these entity pairs.

In the example of Table 1, the pension fund is net long $100 million against the dealer and the dealer is net long $100 million against the asset manager. Alternatively, the dealer is net short $100 million against the pension fund and the asset manager is net short $100 million against the dealer. Either way, adding up the net longs or the net shorts, the ENNs equal $200 million, which represents the total amount of risk transfer in the market.

It might be argued that the market size in this example is only $100 million. In this view, the dealer is just intermediating the $100 million pension fund long against the $100 million asset manager short. In other words, the dealer should be taken out of the chain, leaving an amount of risk transfer equal to only $100 million.

This paper rejects that view. Intermediation consists of more than just passing along longs or shorts. The pension fund might be receiving in 30-year swaps to hedge its very long-term liabilities, while the asset manager might be paying in 5-year swaps to hedge purchases of 5-year corporate bonds. Or the pension fund might have customized the cash flows of its swaps to match the cash flows of liabilities, while the asset manager might have tailored the cash flows of its swaps to match the cash flows of a portfolio of corporate bonds.

In terms of risk transfer through bond markets, it is as if the pension fund bought a $100 million bond from the dealer and the dealer bought a completely different $100 million bond from the asset manager. And, expressed this way, the size of the bond market is clearly $200 million.

To the extent that the pension fund bought the same bond that the asset manager sold, it could be argued that the swap dealer is a pure intermediary—like a clearinghouse—and that its trades should be excluded. But discovering exactly which swaps should be left out as intermediary trades,[14] and defining exactly what it means for two swaps to be the same,[15] would introduce an undesirable arbitrariness into the definition of ENNs.

All in all, given the desirability of including swaps that represent value-adding intermediation, along with the difficulties of deciding exactly which swaps are the result of "pure" intermediation, ENNs include all of the IRS positions of swap dealers.

ENNs do, however, exclude the clearly pure intermediary positions of swap clearinghouses. In terms of Table 1, say that all of the IRS between the dealer and the asset manager were cleared. Then the pension fund is net long $100 million against the dealer; the dealer is net long $100 million against the central counterparty (CCP); and the CCP is net long $100 million against the asset manager.

Given how CCPs operate, the CCP's swaps with the asset manager are an exact replica of the dealer's original swaps with the asset manager. By definition, the CCP does not engage in any payment or maturity transformation or any other mismatch of swap terms. Referring back to the bond analogy, the CCP is buying bonds from the asset manager and selling those very same bonds to the dealer.

By this reasoning, ENNs exclude the positions of CCPs. Continuing with the example, the pension fund is net long $100 million (against the dealer) and the dealer is net long $100 million (against the CCP). The CCPs net longs are ignored. Hence, ENNs equal the same $200 million as calculated earlier.

From the perspective of net shorts, the asset manager is net short $100 million (against the CCP) and the dealer is net short $100 million (against the pension fund). Ignoring the CCPs net shorts, ENNs again are calculated as $200 million.

[14] It is not true, for example, that all IRS of a particular broker-dealer are intermediary trades. The broker-dealer might be hedging its own inventory of bonds, which is being held to facilitate customer business in that market.
[15] What if the customization of a swap moves payment dates by a few days forward or backward? What about an 11-year swap vs. a 10-year swap?

It bears repeating that ENNs ignore CCP net longs and shorts, but include the net longs and net shorts that other counterparties have with the CCP. These positions against the CCP are actually quite important in explaining why ENNs are so much less than notional amounts. A dealer typically has large notional amounts of long and short swaps against a CCP. These positions add when computing the notional amount of a market, but they net when computing ENNs.

IV. ENNs Are Not a Measure of Counterparty Credit Risk or Operational Risk

As mentioned in Section I, ENNs are not intended to measure counterparty credit risk. If the market value of the swaps between the pension fund and dealer nets to zero, and if the market value of the swaps between the dealer and the asset manager nets to zero, then there is no counterparty credit risk exposure to an instantaneous counterparty default in this market of $200 million ENNs.

Now change these assumptions so that the net market value of the pension fund's swaps is positive $10 million; that the net market value of the asset manager's swaps is negative $10 million; and that no collateral has been posted against any of these swaps. Then the dealer has a $10 million exposure to the instantaneous default of the asset manager in this same market of $200 million ENNs.

Finally, assume that the asset manager has posted $10 million or more in collateral. Then, once again, there would be no immediate counterparty credit risk in this market. Since the $200 million ENNs take no account of the market value of the swaps nor of collateral posted, they do not measure counterparty credit risk. Appendix 1, for the sake of completeness, discusses some existing metrics for the measurement of counterparty credit risk in IRS markets.

In addition to market risk and counterparty credit risk, markets and market participants are exposed to operational risk. Operational risk in IRS markets include such things as errors in records containing the terms of existing swaps; loss or damage to those records; errors in calculating or processing swap payments; and system failure both in normal times and in times of great volume or volatility, as in a crisis.

The accumulation of operational risk is a major drawback of the practice of layering rather than unwinding swaps. Say that every individual swap trade in Table 1 had a $100 million notional amount. There would then be 5 line items on the books of the pension fund, 14 for the dealer, and 9 for the asset manager, for a total of 28. If market practice were, however, to unwind trades when reducing risk, there would be only 1 line item for the pension fund, 2 for the dealer, and 1 for the asset manager, for a total of only 4.

Since the likelihood of an operational problem is, at least in part, proportional to the number of line items, the market in Table 1, with its 28 line items, has significantly more operational risk than a market with swap unwinds and its 4 line items.

If the sizes of individual swap trades do not vary too much, then the notional amount of a swaps market, which is the sum of the notional amounts of individual trades, is a good proxy for the number of line items in that market. It follows, then, that notional amount is actually a good proxy for operational risk.

V. IRS ENNs for U.S. Reporting Entities, by Sector

Table 2 gives IRS notional amounts and ENNs for U.S. reporting entities as of December 15, 2017. The data include the dominant interest rate swap products, namely fixed-for-floating swaps, FRAs, OIS, and swaptions, though the vast majority are fixed-for-floating swaps.[16] The included swaps are denominated in many different currencies, although all quantities reported in the table have been converted to U.S. dollars. Further details are given in Appendix 2.

Column (1) of the table lists the sectors that have positions in swap markets. Entities were placed into sectors by CFTC staff, and the "Unclassified" column contains entities that have not been categorized or that have missing identifying information.

Columns (2) and (3) of the table give the long and short notional amounts of IRS within each sector. Summing all of the long IRS notional amount across individual entities in the hedge fund sector, for example, gives a total of $11.9 trillion. All of this long notional amount, of course, corresponds to $11.9 trillion shorts in column (3) that are distributed in some way across the various sectors. More generally, since every long (short) corresponds to a short (long), the sum of all the rows of either column (2) or column (3) equals the total notional amount of all positions. The final row of these columns reports this sum as $179 trillion.[17]

Columns (4) and (5) convert columns (2) and (3) into 5-year equivalents. A comparison of columns (4) and (5) with columns (2) and (3) reveals information about the maturity of swaps held within each sector. Pension funds are long longer-term swaps, as their long notional of $900 billion becomes a long 5-year equivalent of $1.3 trillion. By contrast, banks/dealers are holding shorter-term swaps: their long notional of $157.7 trillion translates to a long of only $95.7 trillion 5-year equivalents.

The total notional amount in 5-year equivalents is $108 trillion, which is significantly below the raw notional amount of $179 trillion. From one perspective, this drop is largely due to the relatively short maturity of the swaps of banks/dealers, who hold the vast majority of swaps in the market. From another perspective, this drop is also due to the large percentage of FRAs and OIS that have very short terms: 82% of FRA notional amount and 68% of OIS notional have maturities less than 1 year.

Columns (6) and (7) of Table 2 present the ENNs of the IRS market. Recall that ENNs net longs and shorts within pairs of legal entities, but not across legal entities. These columns show, therefore, that there is an enormous amount of risk netting solely within pairs of counterparties. For the bank/dealer sector, notional 5-year equivalent longs of $95.7 trillion and shorts of $94.9 trillion net down to $11.5 trillion and $10.7 trillion ENNs, respectively.

One reason for this great amount of netting is the nature of the banks/dealers business: they are intermediaries, for the most part buying and selling and then holding both long and short positions,

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[16] See Table 4 for a breakdown of the data by product. See Appendix 2 for a discussion of the products not included in the analysis, namely, money market basis swaps, caps/floors, and inflation swaps. These products will be considered in future iterations of this work.

[17] This sum includes an adjustment for missing CCP trades, which are inferred from longs against the CCP that have no corresponding shorts and shorts against the CCP that have no corresponding longs. See Appendix 2 for further details.

even against individual counterparties. Relative to their large 5-year equivalent notional amounts, they tend not to hold either long or short positions outright.

A second explanation for the extent of netting in this sector is that the vast majority of bank/dealer swaps are cleared, that is, against a CCP. But since there are very few CCPs, large amounts of bank/dealer long and short swaps net within each CCP. In fact, to minimize risk exposure to any particular CCP, banks and dealers running relatively balanced overall swaps books have a strong incentive to run relatively balanced books against each CCP.

The second largest sector with respect to notional amounts, hedge funds, also exhibits a significant amount of netting. Notional amounts in 5-year equivalents of $5.3 trillion longs and $5.5 trillion shorts fall to ENNs of $700 billion and $900 billion, respectively. Hedge funds actively trade in and out of IRS and, like the bank/dealer sector, clear a large fraction of their swaps.

The bottom row of columns (6) and (7) gives the ENNs of the market as a whole. With respect to market risk and the transfer of market risk, the size of this IRS market is about $15 trillion. This is much smaller than traditionally reported IRS market sizes based on notional amounts. Furthermore, under the ENNs metric, the size of this IRS market is on the same order of magnitude as other U.S. fixed income markets: the Treasury market at $16 trillion, the mortgage market at $15 trillion, and the corporate bond market at $12 trillion.[18]

Column (8) gives the net ENNs for each sector, which is simply the difference between each sector's long and short ENNs. This column is not, of course, used to measure market size: the subtraction of column (7) from column (6) essentially nets across counterparties, and the total of the rows is identically equal to 0. But the entries of column (8) do provide the net IRS market risk held by each sector. Furthermore, taken together, columns (6), (7), and (8), give a broad overview of how each sector uses the IRS market.

Many observations can be drawn from column (8), but three are mentioned here.

The bank/dealer sector is long $11.5 trillion ENNs and short $10.7 trillion, for a net of $800 billion. For the most part, this sector uses IRS to facilitate customer business and, consequently, takes little outright market risk relative to the magnitude of their ENNs. In addition, however, many banks receive fixed and pay floating in swap to transform their own fixed rate debt borrowings into synthetic floating rate obligations. This debt management use of IRS may explain much of this sector's net long position.

The corporate sector is long $1 trillion ENNs and short $500 billion. These numbers are consistent with the story that corporations tend to use swaps in two ways. First, they pay fixed in swap to hedge future issuance. Second, like banks, they receive fixed in swap to transform fixed rate debt into floating rate debt. This story is supported by data, not presented in the table, that individual corporations tend to be either mostly long or mostly short IRS.

Insurance companies and pension funds are both net long ENNs. This accords with expectations. Both sectors have long-term liabilities that are funded with investments in corporate bonds. But the

[18] Financial Accounts of the United States, Board of Governors of the Federal Reserve System, Second Quarter 2017.

maturities available in the corporate bond universe are shorter than these liabilities. Hence, these sectors add to their interest rate exposure, that is, receive fixed in swap, so as to hedge their overall interest rate risk.

VI. Conclusion

This paper presents ENNs as a new metric with which to measure the size of IRS markets. By normalizing notional amounts into 5-year equivalents and then netting longs and shorts within pairs of counterparties, ENNs capture the market risk transfer in IRS markets much more accurately than notional amounts. And the need for a more accurate metric is supported by the data. In the IRS market studied in this paper, a notional size of $179 trillion falls to $15 trillion ENNs.

A possible policy implication of the paper is to use a metric like ENNs instead of or in addition to notional amounts to set regulatory thresholds, that is, entity or market sizes below which various rules do not apply.

The analysis of this paper can be extended in three ways. First, the relatively small quantities of the remaining interest rate products (money market basis swaps, caps/floors, and inflation swaps) can be incorporated into the current analysis. Second, ENNs can be calculated for other large markets, like credit default swaps and foreign exchange derivatives. Thirds, ENNs by sector can be studied to improve understanding of how various sectors use derivatives markets. Along these lines, the very preliminary results of this paper indicate that IRS are being used by various sectors to perform their institutional functions.

Appendix 1. Measuring Counterparty Credit Risk

For the sake of completeness, this appendix discusses the measurement of counterparty credit risk in an IRS market. Table 3 supplements the example of Table 1 by adding market values for each of the four sets of trades, along with collateral posted against each, all from the perspective of the dealer.

With respect to its trades with the pension fund, the market has moved in the dealer's direction since the initiation of Trade 1, but against the dealer since the initiation of Trade 2. Hence the market values of plus $3 million and minus $1.5 million, from the perspective of the dealer. The pension fund has not posted any collateral against these trades.

Trades with a single legal entity are usually done under a single agreement, which, in the event of default, allows for the netting of all claims. In the case of the dealer's trades with the pension fund, the net market value is plus $1.5 million. This means that, if the pension fund were to default immediately on the swap, the dealer would face a loss of $1.5 million. Put another way, it would cost the dealer $1.5 million to replace its swaps with the pension fund after the event of default.

Moving to the dealer's trades with the asset manager, assume that both sets of trades were done under a single agreement. The net market value to the dealer is $2 million, against which the dealer has a net $4 million in collateral. Since derivatives agreements typically allow the liquidation of collateral immediately after default, the dealer, in this case, has more than enough collateral to cover the cost of replacing the defaulting swaps of the asset manager.

Putting together all of the trades in this example, the total counterparty credit risk of an immediate default of any counterparty is $1.5 million. In this example, this is just the amount that the dealer stands to lose should the pension fund default.

The discussion now turns to metrics commonly used to describe counterparty credit risk in a swaps market and the application of those metrics to the example in Table 3.

One measure of counterparty credit risk is "gross market value," which is defined as the sum of the absolute market values across all trades. In this example, the gross market value is, in millions, $3 + $1.5 + $4 + $2 = $10.5. This metric vastly overstates the amount of credit exposure because it takes into account neither the netting allowed by derivatives agreements nor the collateral posted against potential losses.

Another measure of counterparty credit risk is "net market value" or "gross credit exposure." These metrics sum the netted market values, where netting is done only within legal netting agreements. In this example, the net market value is, in millions, ($3 - $1.5) + ($4 – $2) = $3.5. This measure gets the netting right, but overstates the amount of credit exposure by ignoring collateral. The name "gross credit exposure," in fact, is intended to convey that the exposure is gross of collateral, i.e., does not subtract collateral value.

The final and most correctly conceived measure of counterparty credit exposure is "net credit exposure," which is defined as gross credit exposure minus any available collateral. In the example of Table 3, net credit exposure is calculated as follows.

The gross credit exposure of the dealer-pension fund trades is $3 million minus $1.5 million, or $1.5 million, against which there is no collateral. Hence, the net credit exposure of these trades is $1.5 million.

The gross credit exposure of the dealer-asset manager trades is $4 million minus $2 million, or $2 million. Against this, however, is $6 million minus $2 million, or $4 million of collateral. Hence, there is no net credit exposure from these trades.

Adding the net credit exposure from all sets of trades gives the total net credit exposure of $1.5 million + $0, or $1.5 million.

Before ending this appendix, note that the exposure metrics described here are referred to in the context of capital requirements as "current exposure." This terminology emphasizes that these exposures measure the impact of an immediate counterparty default. It might happen, however, that the market moves, current exposures get larger, no additional collateral is posted, and then the counterparty defaults. Measuring how much current exposures can worsen without the posting of additional collateral is done through "potential future exposure."

Appendix 2: Details on Data and Calculations

The data set used in this paper is information on swap positions reported to swap data repositories (SDRs). SDR data is required from all U.S. reporting entities and is accessible by the CFTC in its role as a swap regulator. As a result, any swap cleared in the United States and any non-cleared swap with at least one U.S. counterparty is included in the data set. This is the same data set used to produce the CFTC's Weekly Swaps Report. Note that this regulatory data set on positions is consistent with the SDR's publicly available trade data.

For the purposes of this paper, the complete data set is filtered to remove duplicate entries for the same swap and to remove inter-affiliate swaps, that is, swaps between two entities under the same holding company.

The data is also filtered to include only the four most dominant interest rate swap products, namely, fixed-for-floating swaps, FRAs, OIS, and swaptions. Notional amount, 5-year equivalents, and ENNs, by product type, are given in Table 4. The product-level ENNs in this table simply allocate total ENNs in the same proportions as the distribution of product-level notional amounts.

Products not include in the tables and analysis of this paper are money market basis swaps, caps/floors, and inflation swaps, with notional amounts of $13 trillion, $7.4 trillion, and $2.9 trillion, respectively. While these products will eventually be incorporated into the tables and analysis, it is unclear at present how this will effect total ENNs. Money market basis swaps, the largest of the omitted products, have very little interest rate risk in terms of 5-year equivalents. Also, it remains to be determined how inflation swaps should be handled with respect to interest risk. Furthermore, pre-analysis, it is difficult to know the extent to which these products add to or offset risks already included.

The data set includes swaps in 34 currencies. Details on the distribution of notional amount, 5-year equivalents, and ENNs across currencies are given in Table 5.

Notional amounts, 5-year equivalents, and ENNs are ultimately reported by sector. Classifying entities into sectors is done at the level of legal entity identifiers (LEIs). Each classification is based on a legal classification of the LEI or on descriptive information available about that LEI. Its trades or market positions are not used in the classification.

Because classification is done at the LEI level, different entities under the same holding company may be placed into different sectors. For example, the broker/dealer subsidiary of a large bank would fall under Bank/Dealer, but its asset management subsidiary would be considered an Asset Manager.

In addition to the defined sectors, there is an "Unclassified" bucket. This category includes LEIs that have not yet been classified and entities whose unique identifier cannot be attributed to a known entity.

The CCP sector is omitted from the tables. All swaps with CCPs are included in the analysis, but the side of the swap against the CCP itself is omitted. To elaborate on the example in the text, assume that a pension fund receives fixed on $100 million from a dealer in a trade that is cleared. This swap is then effectively broken up into two swaps.

The pension fund receives fixed on $100 million from the CCP and the dealer pays fixed on $100 million to the CCP. The tables record the $100 million as a long for the pension fund and as a short for the dealer, which adds $100 million to both long and short notional amounts. Excluding the legs facing the CCP, however, prevents this single $100 million swap from contributing $200 million to both long and short notional amounts.

There are a few cases in which a foreign CCP faces a U.S. reporting entity on one leg of a swap and faces a foreign entity on the other leg. In these cases, the leg of the swap between the foreign CCP and the foreign entity will not necessarily be reported to the CFTC. As a result, positions reported by CCPs may not appear to be balanced, even though, given how CCPs work, positions must be balanced.

For this reason, before final totals are computed, swaps facing CCPs that are known to exist but that are not reported are added back to the data set. Therefore, totals across sectors do not equal the bottom rows of Tables 2, 4, 5, and 6, which include these extra swaps and are labeled "Total w/ CCP Adjustment."

In order to compute 5-year equivalents from notional amounts, a DV01 is calculated for each swap and swaption using the swap rate curve of the appropriate currency as of the report date.[19] The notional amount of each swap is then scaled to a 5-year equivalent using its computed DV01 and the DV01 of a 5-year par swap for that same date and currency. Swaption notional amounts are expressed in delta equivalents for computing their 5-year equivalents.

Elaborating on the computation of 5-year equivalents, assume that the term structure of interest rates is flat at 3%. Then it can be shown that the DV01s of new 2-, 5-, and 10-year fixed-for-floating swaps are approximately .017, .044, and .084, respectively. Hence, the 5-year equivalent of $100 million of 2-year swaps is $100 million times .017/.044, or $39 million. The 5-year equivalent of $100 million of 5-year swaps is, by definition, $100mm. And the 5-year equivalent of $100 million of 10-year swaps is $100 million times .084/.044, or $191 million.

To calculate ENNs from 5-year equivalents, two restrictions are placed on netting. First, positions are only netted within a counterparty pair: counterparty A's longs against counterparty B are not netted against counterparty A's shorts against counterparty C. This netting restriction gives rise to the name "entity-netted notionals."

Each CCP is considered an individual entity. Therefore, the longs and shorts of a particular legal entity cleared through a particular CCP are netted. Longs and shorts of an entity cleared through different CCPs are not netted.

The second netting restriction is that positions are netted only within a given settlement currency. Long USD swaps are not, for example, netted against short EUR swaps. This restriction reflects a judgment that the correlation of exchange rates is too low to justify long-short offsets across swaps denominated in different currencies.

[19] For a general description of DV01 and DV01 as applied to swaps, see, for example, Fixed Income Securities: *Tools for Today's Markets*, Third Edition, by Bruce Tuckman and Angel Serrat, Wiley, 2011, Chapters 4 and 16.

Netting, subject to these two restrictions, results in a set of net longs and a set of net shorts for each counterparty pair and currency. These net longs and net shorts are then aggregated within a sector to fill the columns of Table 2.

Some statistics on the extent of clearing in this data set are presented in Table 6. The percentage cleared equals the notional amounts or ENNs of any counterparty pair-currency bucket involving a CCP divided by the notional amounts or ENNs of all counterparty pair-currency buckets. Since netting within CCPs typically exceeds netting with other types of counterparties, cleared notional amounts are typically compressed to smaller ENNs than non-cleared ENNs. As a result, the percentages of cleared ENNs are typically lower than the percentage of cleared notional amounts.

Table 1. Example of an IRS Market ($ Millions)

	Pension Fund		Dealer		Asset Manager		
Trades	**Long**	**Short**	**Long**	**Short**	**Long**	**Short**	**Notional**
1	300			300			300
2		200	200				200
3			500			500	500
4				400	400		400
Gross	**300**	**200**	**700**	**700**	**400**	**500**	**1,400**
ENNs	**100**		**100**	**100**		**100**	

Table 2. Notional Amounts and ENNs for U.S. Reporting Entities of Fixed-for-Floating Swaps, FRAs, OIS, and Swaptions, by sector, as of December 15, 2017. ($ Trillions)

	Notional Amounts		**Notional Amounts in 5-Year Equivalents**				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sector	**Long**	**Short**	**Long**	**Short**	**ENNs (Long)**	**ENNs (Short)**	**ENNs (Net)**
Bank/Dealer	157.7	156.8	95.7	94.9	11.5	10.7	0.8
Hedge Fund	11.9	12.1	5.3	5.5	0.7	0.9	-0.2
Asset Manager	5.2	5.4	2.8	3.1	0.9	1.2	-0.3
Insurance Company	0.9	0.7	1.5	1.1	0.7	0.3	0.4
Pension Fund	0.9	0.7	1.3	1.0	0.5	0.2	0.3
Corporate	0.7	0.9	0.7	1.0	0.5	0.8	-0.3
Gov’t/Quasi-Gov’t	0.8	0.8	0.5	0.8	0.1	0.4	-0.3
Unclassified	0.7	0.9	0.5	0.8	0.2	0.4	-0.2
Total w/CCP Adjustment	**179.1**	**179.1**	**108.5**	**108.5**	**15.4**	**15.4**	**0.0**

Table 3. Example of an IRS Market, with Market Values and Posted Collateral ($ Millions)

	Pension Fund		Dealer		Asset Manager		Market Value to Dealer	Posted Collateral to Dealer	
Trades	**Long**	**Short**	**Long**	**Short**	**Long**	**Short**			**Notional**
1	300			300			+3	0	300
2		200	200				-1.5	0	200
3			500			500	+4	6	500
4				400	400		-2	-2	400
Gross	**300**	**200**	**700**	**700**	**400**	**500**			**1,400**
ENNs	**100**		**100**	**100**		**100**			

Table 4. Notional Amounts and ENNs for U.S. Reporting Entities, by product, as of December 15, 2017. ($Trillions)

	Notional Amounts	Notional Amounts in 5-Year Equivalents	
Product	**Long**	**Long**	**ENNs (Long)**
Fixed-for-Floating Swaps	105.4	94.3	13.4
FRAs	35.2	4.7	0.7
OIS	32.8	8.0	1.1
Swaptions	5.2	1.2	0.2
Total w/ CCP adjustment	**179.1**	**108.5**	**15.4**

Table 5. Notional Amounts and ENNs for U.S. Reporting Entities of Fixed-for-Floating Swaps, FRAs, OIS, and Swaptions, by currency, as of December 15, 2017. ($Trillions)

	Notional Amounts		Notional Amounts in 5-Year Equivalents			
Currency	Long	Short	Long	Short	ENNs (Long)	ENNs (Short)
USD	69.1	68.9	39.6	39.4	7.0	6.9
EUR	52.7	52.8	38.5	38.5	4.0	4.0
GBP	15.5	15.4	10.5	10.4	1.6	1.6
AUD	8.7	8.7	3.1	3.1	0.3	0.3
JPY	8.4	8.4	6.3	6.3	0.9	0.8
CAD	5.1	5.1	2.3	2.3	0.2	0.2
Other	19.2	19.2	8.0	8.0	1.2	1.1
Total w/CCP Adjustment	**179.1**	**179.1**	**108.5**	**108.5**	**15.4**	**15.4**

Table 6. Clearing percentages for U.S. Reporting Entities of Fixed-for-Floating Swaps, FRAs, OIS, and Swaptions, by sector, as of December 15, 2017. ($ Trillions)

	Notional Amounts				Notional Amounts in 5-Year Equivalents			
Sector	Long	Cleared (%)	Short	Cleared (%)	ENNs (Long)	Cleared (%)	ENNs (Short)	Cleared (%)
Bank/Dealer	157.7	91	156.8	91	11.5	45	10.7	42
Hedge Fund	11.9	91	12.1	93	0.7	57	0.9	74
Asset Manager	5.2	86	5.4	86	0.9	67	1.2	75
Insurance Company	0.9	65	0.7	73	0.7	49	0.3	47
Pension Fund	0.9	64	0.7	72	0.5	34	0.2	37
Corporate	0.7	28	0.9	20	0.5	21	0.8	10
Gov't/Quasi-Gov't	0.8	73	0.8	72	0.1	24	0.4	57
Unclassified	0.7	64	0.9	54	0.2	27	0.4	20
Total w/CCP Adjustment	**179.1**	**82**	**179.1**	**82**	**15.4**	**45**	**15.4**	**44**