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PREPARED BY NEVILLE ARJANI
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A PRIMER ON CREDIT RISK IN PAYMENTS CANADA'S AUTOMATED CLEARING SETTLEMENT SYSTEM (ACSS)

The research - simplified

Payments Canada's Automated Clearing Settlement System (ACSS) was designated by the Bank of Canada (BOC) as a Prominent Payments System in May 2016. It will therefore be required to meet BOC standards for the management of credit risk. The analytical approach taken in this paper is intended to inform our work to develop a suitable approach to meet these new standards.

As owner and operator of Canada's national clearing and settlement systems, we take a proactive approach to risk measurement and risk management

This paper describes how credit risk emerges between Direct Clearers (DCs) in the ACSS.

Historical data can help us understand future risk

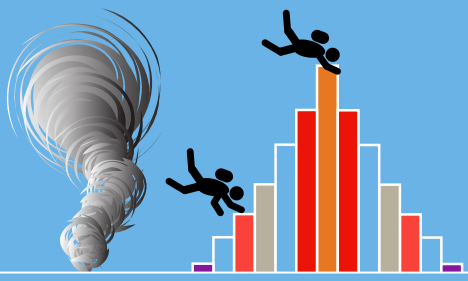
Historical simulation is one approach to measure the magnitude of credit exposure that could emerge for surviving DCs in a default scenario.

We endeavour to share our knowledge

By clearly articulating the risks posed by our systems, and performing ongoing monitoring and measurement of these risks.

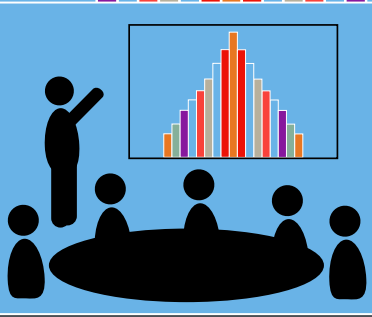
Findings suggest credit exposures could be material in the ACSS

Even credit exposures appearing easily manageable under benign economic conditions could prove problematic for a financial institution in the midst of a market stress event.



Our analysis will inform forthcoming work on policy

We continue to build on our risk analytics expertise to help inform policy judgment. This paper aligns with that objective, and is intended to generate discussion and dialogue among Payments Canada's participating financial institutions, its numerous stakeholders, and the Canadian public.



A primer on credit risk in Payments Canada's Automated Clearing Settlement System (ACSS)

AUTHOR NOTES

Neville Arjani
Payments and Technology
Payments Canada
narjani@payments.ca

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The views expressed in this paper are those of the author, and do not represent an official position of Payments Canada.

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Table of contents

Sommaire

À titre de propriétaire et d'exploitant des systèmes nationaux de compensation et de règlement du Canada, Paiements Canada doit présenter clairement les risques posés par ses systèmes ainsi qu'effectuer une surveillance et une évaluation continues de ces risques[1]. Ce document contribue à cet objectif en décrivant la façon dont le risque de crédit apparaît entre les adhérents dans le Système automatisé de compensation et de règlement (SACR) de Paiements Canada en fonction du cadre des règlements administratifs et des règles du SACR qui régit la défaillance des adhérents. Une approche de simulation historique est utilisée pour mesurer l'ampleur du risque de crédit qui peut survenir dans ce contexte, ce qui permet un calcul du risque de crédit plus global au sein de l'environnement du SACR.

Les principaux résultats sont les suivants :

- Paiements Canada préconise une approche proactive dans la compréhension et la mesure des risques qui découlent de l'infrastructure nationale de compensation et de règlement qu'elle possède et exploite. Elle cherche à partager ces connaissances auprès des institutions financières participantes et des Canadiens en général, le cas échéant, faisant ainsi preuve de prudence et de responsabilisation dans ses activités.

- Les adhérents sont exposés à un risque de crédit dans le SACR. Ce risque prend forme en cas de défaillance d'un autre adhérent par l'entremise d'un mécanisme de répartition des pertes relevant de la responsabilité des solvables intégré directement dans le cadre des règlements administratifs et des règles du SACR.

- La simulation historique représente l'une des approches d'évaluation de l'ampleur du risque de crédit qui pourrait émerger pour les adhérents solvables dans un scénario de défaillance en plus de fournir une mesure plus exhaustive du risque de crédit au sein de l'environnement du SACR. Cette approche donne à penser que le risque de crédit d'un seul adhérent solvable touché par la défaillance d'un autre adhérent au sein de l'environnement du SACR pourrait être considérable et se chiffrer en centaines de millions de dollars. Il convient également de garder à l'esprit que les risques de crédit qui semblent faciles à gérer dans des conditions économiques rassurantes peuvent devenir

[1] Paiements Canada a été créé officiellement sous le nom d'Association canadienne des paiements par une loi du Parlement en 1980. Le nom « Paiements Canada » a été adopté en 2016.

problématiques pour une institution financière en plein cœur d'un choc du marché.

- Il est important de noter que la notion de risque de crédit abordée dans ce document s'apparente à un *risque de défaut* dans la nomenclature type des risques de crédit et se distingue de la notion de *perte anticipée*, qui prend en compte des éléments cruciaux tels que la *probabilité de défaillance*, la *perte en cas de défaillance*, le *taux de recouvrement* ainsi que d'autres dynamiques du risque de crédit du portefeuille.

Le SACR ayant été désigné par la Banque du Canada comme *principal système de paiement* en mai 2016, il devra respecter les normes de la Banque du Canada en matière de gestion de risque de crédit. L'approche analytique adoptée dans ce document vise à faciliter les travaux que devra réaliser prochainement Paiements Canada afin de déterminer une façon adéquate de respecter ces nouvelles normes.

Paiements Canada continue de prendre appui sur son expertise en matière d'analyse de risque pour contribuer à éclairer les avis sur les grandes orientations. Ce document, qui correspond à cet objectif, a pour objet de susciter une discussion et d'entamer un dialogue parmi les institutions financières participantes de Paiements Canada, ses nombreux intervenants et le public canadien en général. Les commentaires et les suggestions sont les bienvenus.

1. Introduction

Payments Canada – formerly the Canadian Payments Association (CPA) – has a legislated mandate to (i) establish and operate national systems for the clearing and settlement of payments and other arrangements for the making or exchange of payments; (ii) facilitate the interaction of its clearing and settlement systems and related arrangements with other systems or arrangements involved in the exchange, clearing or settlement of payments; and, (iii) facilitate the development of new payment methods and technologies.[2]

As owner and operator of Canada's national clearing and settlement systems, Payments Canada must clearly articulate the risks posed by its systems, and perform ongoing monitoring and measurement of these risks. This paper builds on earlier contributions to this purpose (e.g., CPA (2005)) by describing how credit risk emerges between Direct Clearers (DCs) in the Automated Clearing Settlement System (ACSS) in accordance with the ACSS by-law and rules framework governing DC default. A historical simulation approach is used to measure the magnitude of credit exposure that could arise in this circumstance, which allows for more holistic measurement of credit risk in the ACSS environment. Specifically, this paper suggests that the credit exposure generated by the default of an ACSS DC and collectively faced by surviving DCs could range in the billions of dollars. One needs to be mindful as well that credit exposures appearing easily manageable under benign economic conditions could prove problematic for a financial institution (FI) in the midst of a market stress event. Further, the paper is relevant to the designation of the ACSS in May 2016 as a *Prominent Payments System* (PPS) by the Bank of Canada (BOC). With this designation the ACSS will be required to meet credit risk management standards established by the BOC for PPS.

The remainder of the paper is structured as follows. Section 2 introduces the ACSS and highlights its contribution to Canadian economic well-being. Section 3 offers a detailed description of the ACSS' clearing methodology, while Section 4 articulates how credit risk can emerge in the ACSS environment in accordance with the system's by-law and rules framework governing default. Section 5 demonstrates use of historical simulation to inform the prospective size of credit exposure that could arise in the ACSS

[2] The legislated mandate and duties of Payments Canada are articulated in the Canadian Payments Act, which came into force in 2001 (succeeding the Canadian Payments Association Act). It is available for download via the Payments Canada website at www.payments.ca.

environment. Section 6 contemplates designation of the ACSS as a PPS and touches on some practical aspects of meeting anticipated requirements for management of credit risk. Concluding remarks are offered in Section 7.

2. Background: The ACSS as an enabler of Canadian economic activity

The ACSS is one of two national clearing and settlement systems owned and operated by Payments Canada.[3] It began operation on November 19, 1984 with the objective of enhancing operational and cost efficiency within the Canadian clearing and settlement environment by automating related record-keeping, reconciliation, balance calculation, and settlement procedures. Up to that time, these were predominantly manual functions performed by the major Canadian FIs. Moreover, the timely electronic data capture introduced by the ACSS offered a more transparent and informative user experience for participating FIs, and would lend greater insight over time on the evolving Canadian payments landscape (e.g., on the migration from paper to electronic means of payment).[4]

Today, the ACSS continues to facilitate central clearing and settlement of many electronic and paper-based payments that underpin economic life in Canada. These are non-cash payments between a payor and payee that require a transfer of funds between accounts held at different FIs. Some examples are as follows.[5]

- Cheques and other paper-based instruments.
- Online bill payments (e.g., utilities, taxes).
- Employee payroll and other direct deposit payments.

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[3] The other national system operated by Payments Canada is the Large Value Transfer System (LVTS). Reference to the ACSS in this paper encompasses the by-law, rules and procedures governing exchange, clearing and settlement of eligible payments, as well as the technical application itself. More information on the ACSS and LVTS can be found on the Payments Canada website at www.payments.ca.

[4] Dingle (2003) offers a detailed account of the underlying drivers behind creation of the CPA in 1980 and of the ACSS in 1984.

[5] While it began operation in November 1984, the ACSS has undergone numerous updates to all facets (e.g., technology, rules, by-law) to accommodate the evolving payments landscape in Canada.

- Business-to-business payments (e.g., one-off and recurring supplier payments).
- Pre-authorized debit transactions (e.g., mortgage payments, gym membership dues).
- Debit card purchases of goods and services at the point-of-sale (i.e., in-store and online purchases).
- Cross-institution Automated Banking Machine (ABM) withdrawals.

In 2015, the ACSS cleared over $6.4 trillion in value, representing roughly $7 billion individual payments (Figure 1). Moreover, and as expected, a close relationship is observed between domestic economic output and ACSS clearing activity (Figure 2).

Figure 1 – ACSS annual clearing volume and value, 2005-2015

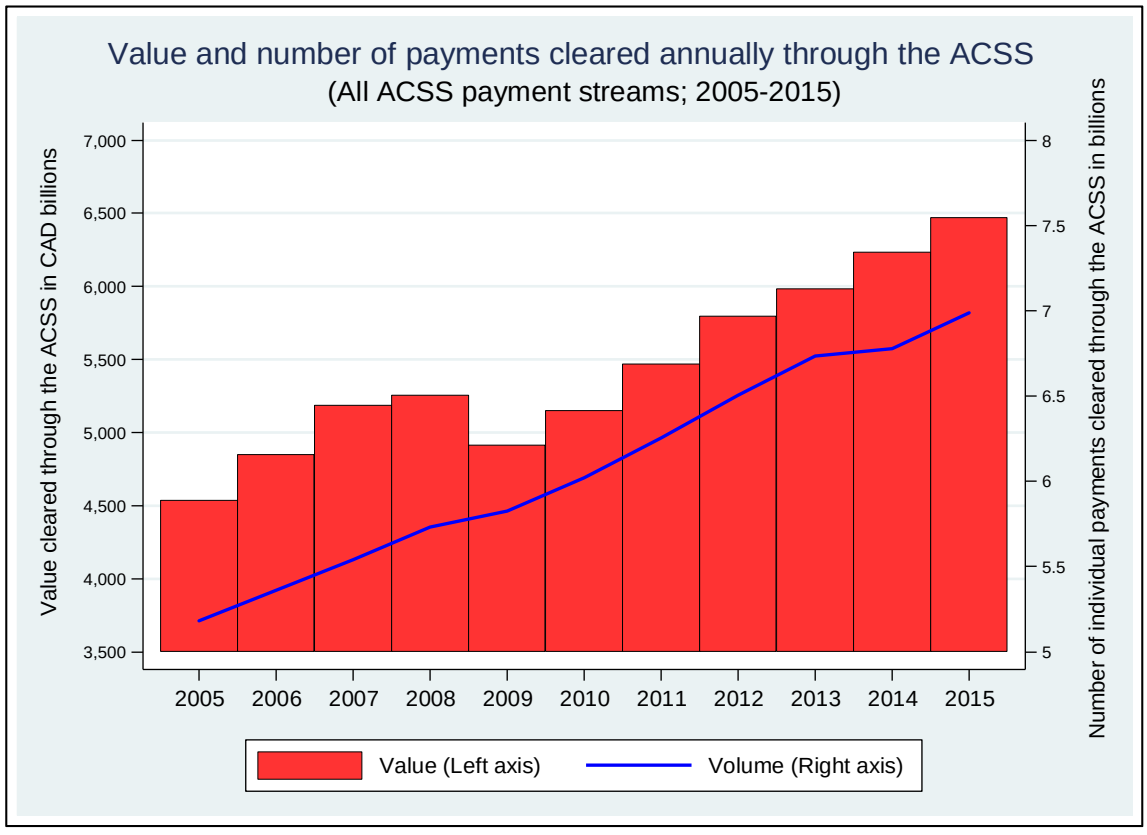
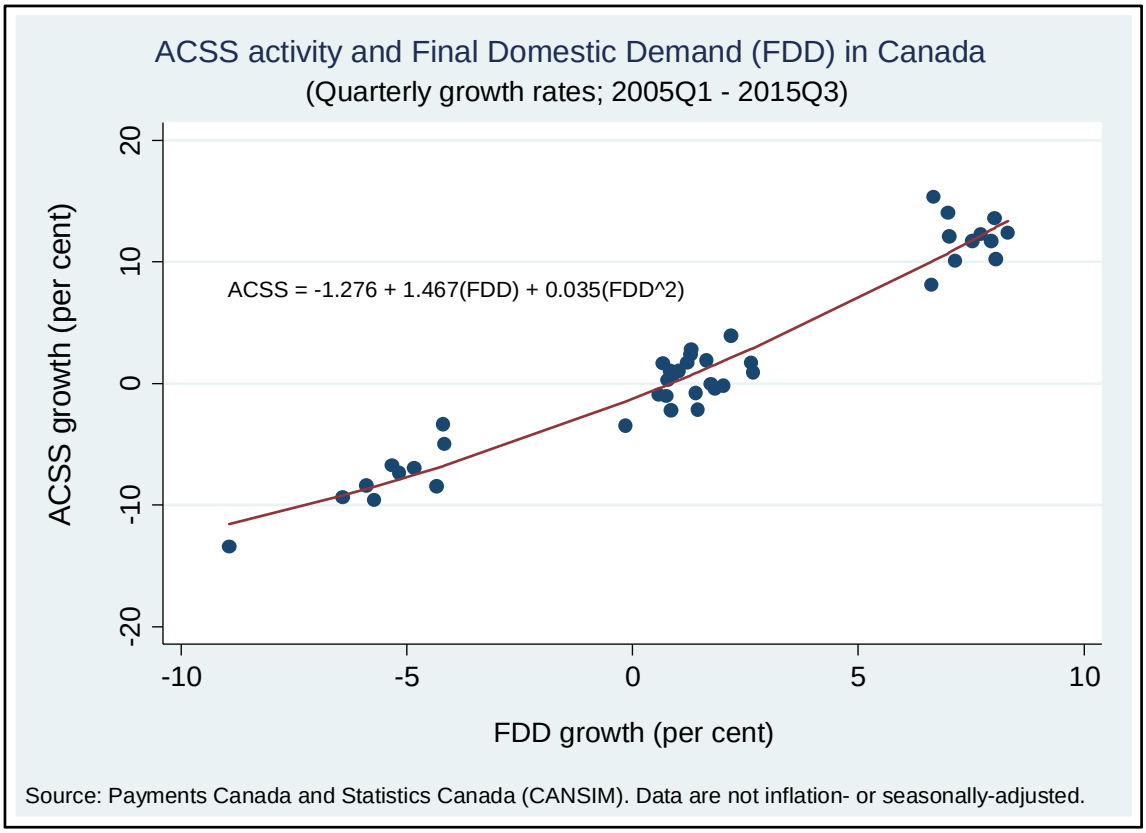


Figure 2 – Relationship between quarterly growth rates of ACSS clearing value and final domestic demand in Canada



Source: Payments Canada and Statistics Canada (CANSIM). Data are not inflation- or seasonally-adjusted.

3. ACSS: Underlying clearing methodology

The ACSS is a batch-total debit-entry system. Put simply, this means that individual payment items are batched (or grouped) in accordance with each eligible payment stream, and only the total volume and value of each batch is entered into the ACSS by direct-participating FIs for central clearing and settlement. Direct-participating FIs are known as ACSS *Direct Clearers,* or *DCs* for short.[6]

Payments comprising each batch are those exchanged daily between FIs, and stem from FIs' and their customers' financial activity (e.g., bill payments, payroll, debit card purchases). The ACSS utilizes a decentralized clearing model as opposed to the hub-

[6] In this paper, the term ACSS Direct Clearer is used generally and includes Group Clearers (GCs). For simplicity, the BOC is also referred to as a DC in this paper, despite maintaining its own distinct category of ACSS participation. By this definition, there are currently 12 DCs in the ACSS and over 20 eligible payment streams. Figures A1-A4 in the Appendix demonstrate the shares of ACSS clearing value and volume by DC and by payment stream.

and-spoke clearing model adopted in many other jurisdictions around the world (e.g., Automated Clearing House or "ACH" models). In the ACSS model, bilateral exchange of payments between FIs is carried out on separate networks that are external to the ACSS. For example, the CPA Services Network (CSN) is used for exchange of Automated Funds Transfer (AFT) and Electronic Data Interchange (EDI) files between FIs. As indicated, batch-total volume and value amounts arising from this exchange are then manually entered into the ACSS *on a bilateral basis* through DCs' back-office ACSS terminals to facilitate clearing and settlement.

Although both debit (e.g., cheques) and credit (e.g., direct deposit) payments are eligible for ACSS clearing, the ACSS operates as a debit-entry mechanism. That is, following FI exchange of either debit or credit payments, it is the ACSS DC that is *owed money* in an eligible payment stream that enters into the ACSS the batch total volume and value amount against each other DC that owes it money in that stream. For example, for debit payments such as a pre-authorized debit (PAD) transaction, the payee's FI originates payment exchange on the CSN, and also makes the accompanying manual entry in the ACSS. For credit payments such as direct deposit, the payor's FI initiates exchange on the CSN, but the payee's FI makes the accompanying manual entry in the ACSS.[7]

Narrowly interpreted, the process of ACSS clearing encompasses multilateral position netting and preparation of DCs' final balances for settlement. Based on the bilateral batch entries made by DCs to the ACSS across eligible payment streams, the ACSS' core information system calculates what each DC owes (or is owed) vis-à-vis all other DCs in the form of a single balance . This final balance is referred to as a DC's multilateral net position, or MNP, for the completed payments cycle. Each DC's MNP is equal to the total value of its batch entries into the ACSS (including entries made as a CA on behalf of an IC) during the cycle less the total value of the batch entries entered

[7] This assumes that the payee's and payor's FIs are both ACSS DCs. A DC may act as Clearing Agent (CA) to other FIs in Canada that are not DCs and thus are not authorized to make ACSS entries on their own and their customers' behalf. An FI that is a Payments Canada member and relies on a CA to enter items into the ACSS on its behalf is recognized as an Indirect Clearer (IC) in the ACSS rules. Counterparty risks emerging from the relationship between an IC and its CA are outside the scope of this paper. See CPA (2005) for more information on ACSS participation and as well on counterparty risks emerging within and between ACSS participant categories.

into the ACSS against it by all other DCs.[8] It follows that summing over all 12 DCs' MNPs produces a zero balance. This can be described in equation form as follows.

$$(1) \qquad MNP_j = \sum_{j \neq i} SENT_{ji} - \sum_{i \neq j} SENT_{ij}$$

$$(2) \qquad \sum_{j=1}^{N} MNP_j = 0$$

where

MNP_j	=	The multilateral net position (or final ACSS balance) of DC *j* at the end of the payments cycle. This position could be positive (> $0) or negative (< $0) or $0 for a given cycle.
$\sum_{j \neq i} SENT_{ji}$	=	Total value of all entries made by DC *j* into the ACSS drawn on or payable by all other DCs (*i≠j*).
$\sum_{i \neq j} SENT_{ij}$	=	Total value of entries made by all other DCs (*i≠j*) into the ACSS that are drawn on or payable by DC *j*.

[8] For certain eligible payment streams, including the "B" stream (i.e., MICR encoded Canada bonds), "G" stream (i.e., government cheques), "H" stream (i.e., T-bills and older Canada bonds), "M" stream (i.e., government direct deposit), and "F" stream (i.e., paper-based remittances), following ACSS clearing of these streams the resulting bilateral net balances between DCs are extracted and subsequently settled directly through the LVTS. These balances are thus not reflected in DCs' final ACSS balances calculated at the end of the payments cycle.

Settlement of final ACSS balances takes place over the books of the BOC on the next business day.[9] In payments parlance, this is referred to as a Deferred Net Settlement (DNS) arrangement. Payments Canada's LVTS is used to transfer final ACSS balances to (from) the BOC from (to) DCs to facilitate the settlement process. More specifically, on the settlement date ACSS DCs with a negative MNP – referred to as a multilateral net *debit* position (MNDP) – are required to initiate an LVTS payment to their ACSS settlement account at the BOC in the amount of the MNDP. These funds are subsequently debited from their settlement accounts by the BOC and credited to the ACSS settlement accounts of DCs' with a positive MNP – referred to as a multilateral net *credit* position (MNCP).[10] The credited funds are delivered by the BOC to these DCs via an LVTS payment. ACSS settlement is final when the BOC posts the ACSS account transfers to cover the MNCPs. Moreover, this sequence of entries to DCs' ACSS settlement accounts by the BOC brings these accounts to zero at the end of the settlement process.

To provide further clarity, Figure A5 in the Appendix offers a diagrammatical depiction of exchange, clearing and settlement for debit and credit payments in the ACSS environment.

4. Credit risk in the ACSS: Background

As is widely acknowledged in the payments literature, a DNS arrangement has potential to expose participating FIs to credit (default) risk.[11] The ACSS is no exception in this regard. Importantly, with every batch entry to the ACSS a credit risk is generated, where this risk is borne by DCs. The risk materializes where a DC owing funds to the BOC in order to complete ACSS settlement (i.e., a DC with an MNDP) is incapable of meeting its settlement obligation when due. That is, it cannot ascertain the required funds for transfer to the BOC at time of ACSS settlement, nor can it obtain a credit

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[9] Each ACSS DC is required to maintain an ACSS settlement account with the BOC – and as well have access to a reliable source of liquidity at the BOC – to meet the ACSS DC participation requirements.

[10] Corresponding entries are made to the BOC's Exchange Suspense Account to facilitate this process.

[11] See, for example, the seminal articles by Borio and Van den Bergh (1993) and Rochet and Tirole (1996) which explore settlement risk in payments systems and means of controlling this risk. By employing netting, however, DNS arrangements help to economize on funds needed to complete settlement, thereby reducing liquidity (funding) risk. See Figure A6 in the Appendix.

advance in that amount from the BOC. A critical contributor to credit risk in all DNS arrangements is the duration between exchange of payment items for the purpose of clearing and settlement and when settlement takes place. The longer the duration, the more that could happen before settlement (e.g., one or more DCs become distressed) and the more complex it could become to address the ramifications. For example, given a longer duration an FI may choose to grant its customer (the payee) access to funds following payment exchange and prior to settlement, which means that the payee's FI could be left exposed in the event that the payor's FI becomes distressed before settlement. In this scenario the payee's FI may be unable to recover the funds from the payee's account upon learning of this risk materializing.[12]

Procedures pertaining to the default of an ACSS DC, including the allocation of credit exposures to other DCs in this event, are explicitly covered in Payments Canada By-law No. 3 – *Payment Items and the Automated Clearing Settlement System*, and by ACSS Rule L1 – *Procedures Pertaining to the Default of a Direct Clearer*. According to the by-law, an ACSS DC is declared to be in default in the event that (a) its settlement account at the BOC has a shortfall that would preclude ACSS settlement; and, (b) it does not obtain an advance from the BOC sufficient to enable settlement.[13]

Upon receiving notification from the BOC that a DC is in default, surviving DCs (i.e., those that are not in default) are required to meet an Additional Settlement Obligation (ASO) representing their share of the credit exposure related to the default.[14] This ASO

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[12] It deserves mention that DNS arrangements have come a long way in terms of risk management over the years. There are a number of credit risk control mechanisms that modern-day DNS arrangements employ to mitigate potential losses to participants. These include risk-based access criteria, position limits or "caps", pledging of collateral, participant "holds" on funds, and legally-enforceable novation netting.

[13] A DC's access to funding in the LVTS environment is critical to its ability to settle its final ACSS multilateral position and thus the probability of an ACSS default event occurring.

[14] Effective December 2012, amendments were made to Payments Canada By-law No. 3 and Payments Canada Rule L1 to remove payment unwinding procedures in the event of ACSS default. Labelle and Taylor (2014) perform a policy evaluation of this change. The empirical approach used later in this paper is similar to that used by these authors. The seminal paper looking at the impact of a DC default in the ACSS – published when payment unwinding procedures were still in place – is Northcott (2002a).

value is to be transferred by surviving DCs to the BOC via the LVTS and subsequently deposited into the ACSS settlement account of the defaulting DC to enable settlement.

Specifically, assuming the default of ACSS DC *j*, the ASO of surviving DC *i* (ASO_{ij}) is determined by the following formula.

$$(3) \qquad ASO_{ij} = S_j \times \frac{SENT_{ij}}{\sum_{i \neq j} SENT_{ij}}$$

or, more simply as

$$(4) \qquad ASO_{ij} = A \times \frac{B}{C}$$

where

S_j = Shortfall generated by defaulter *j* during the ACSS cycle. ("A")

$SENT_{ij}$ = Value of payment items survivor *i* entered into the ACSS during the cycle that are drawn on or payable by defaulter *j*. ("B")

$\sum_{i \neq j} SENT_{ij}$ = Total value of payment items that all survivors *i≠j* entered into the ACSS during the cycle that are drawn on or payable by defaulter *j*. ("C")

It follows that the sum of surviving DCs' ASOs will equal the total settlement shortfall of the defaulting DC. In practice, and for purposes of the empirical exercise below, this total settlement shortfall will be equal to the MNDP of the defaulting DC.[15] Based on

[15] In other words, it is assumed in this exercise that a defaulting DC is unable to obtain an advance from the BOC to help meet its shortfall amount and enable ACSS settlement to occur.

the formula above, a positive ASO is only incurred if a surviving DC makes an ACSS entry against the defaulting DC during the preceding payments cycle (i.e., B in the equation defining ASO_{ij} will be zero if no entry is made, and thus so will ASO_{ij}). This procedure remains the same in the event of multiple defaults during the same ACSS cycle.

5. The ACSS and credit risk: Empirical estimation

This section presents a straightforward empirical exercise to inform the magnitude of credit exposure in the ACSS using historical data, which lends to an overall picture of credit risk in the system. The exercise aims to construct an empirical distribution of surviving DCs' ASOs based on a large number of simulated DC defaults.

In standard financial risk nomenclature, this exercise is loosely aligned with a historical Value-at-Risk (VaR) approach, but, importantly, the VaR parameter being calculated here represents an exposure at default. The analysis does not address other critical ingredients typically used in an expected loss calculation associated with credit risk, including *probability of default, loss given default*, *recovery rate*, and any portfolio credit risk dynamics that might be at play around correlated default probabilities. The analysis is not intended as a holistic treatment of credit risk in the ACSS.

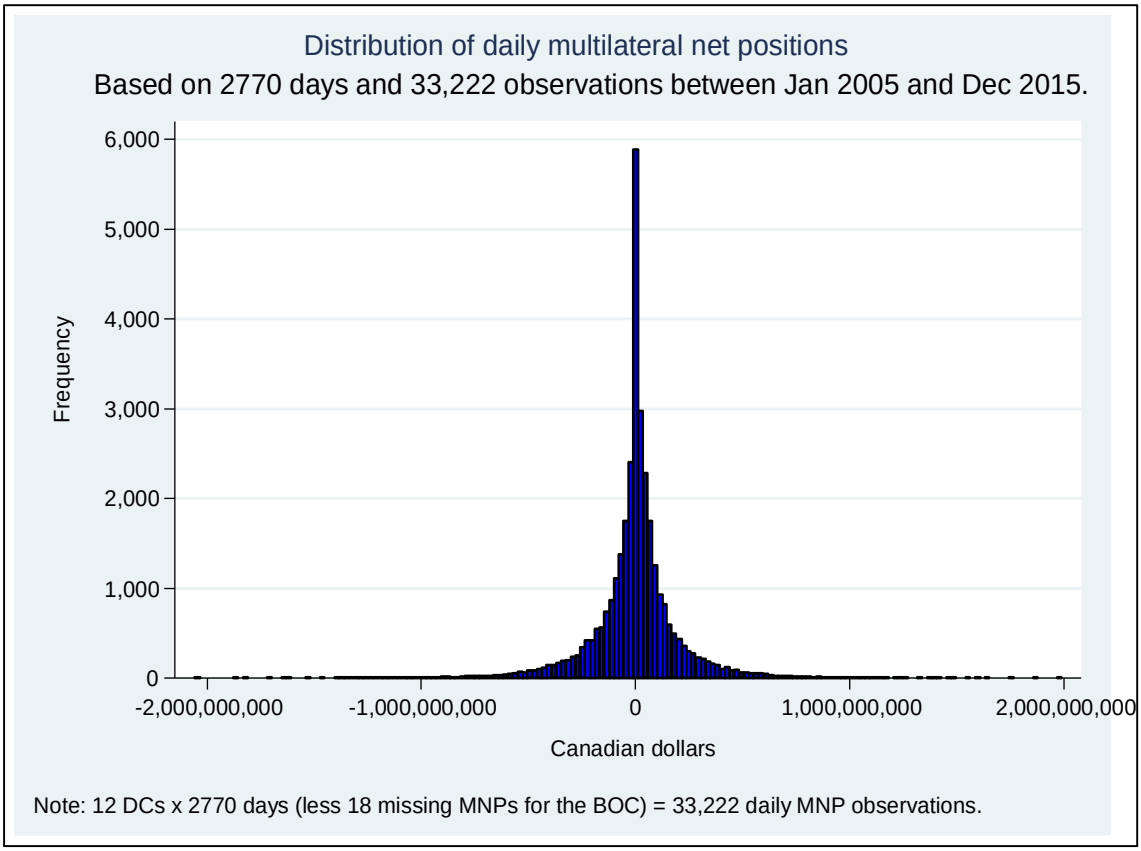
The analysis is structured as follows. There are 2,770 days of ACSS batch entry data observed between January 2005 and December 2015. During this sample period the ACSS was used to clear $59.8 trillion in value, in the form of approximately 14.8 million batch entries representing 66.9 billion individual payments. Batch entries related to ACSS payment streams "B", "G", "H", "M" and "F" are eliminated for this exercise; as described earlier in footnote eight, they are included in the ACSS clearing but not in the determination of DCs' end-of-cycle settlement positions (MNPs).

During the 2,770 day sample period, a total of 33,222 DC MNPs were observed (Figure 3), of which 14,747 of these observations were MNDPs, i.e., approximately 5 MNDPs observed per day (Figure 4).[16] The exercise treats these historical MNDPs as hypothetical DC default events, where surviving DCs' ASOs are calculated in accordance with the formula laid out in Payments Canada By-law No. 3 and are based

[16] There are 2,770 days in the sample and 12 MNPs observed per day (given that there are 12 DCs including the BOC). This should give rise to a total of 33,240 MNPs observed over the period; however, there are 18 daily MNPs missing from the available data for the BOC which brings the total to 33,222 MNPs observed.

on ACSS clearing activity during the relevant payments cycle. Excluding 545 daily MNDPs observed for the BOC during the sample period, this amounts to 14,202 MNDPs that can be simulated as single-DC default events.[17]

Figure 3: Empirical distribution of ACSS DCs' MNPs, daily observations from 2005-2015.



[17] It is assumed that the BOC will not default on its ACSS settlement obligation.

Figure 4: Empirical distribution of ACSS DCs' MNDPs (in positive dollars), daily observations from 2005-2015

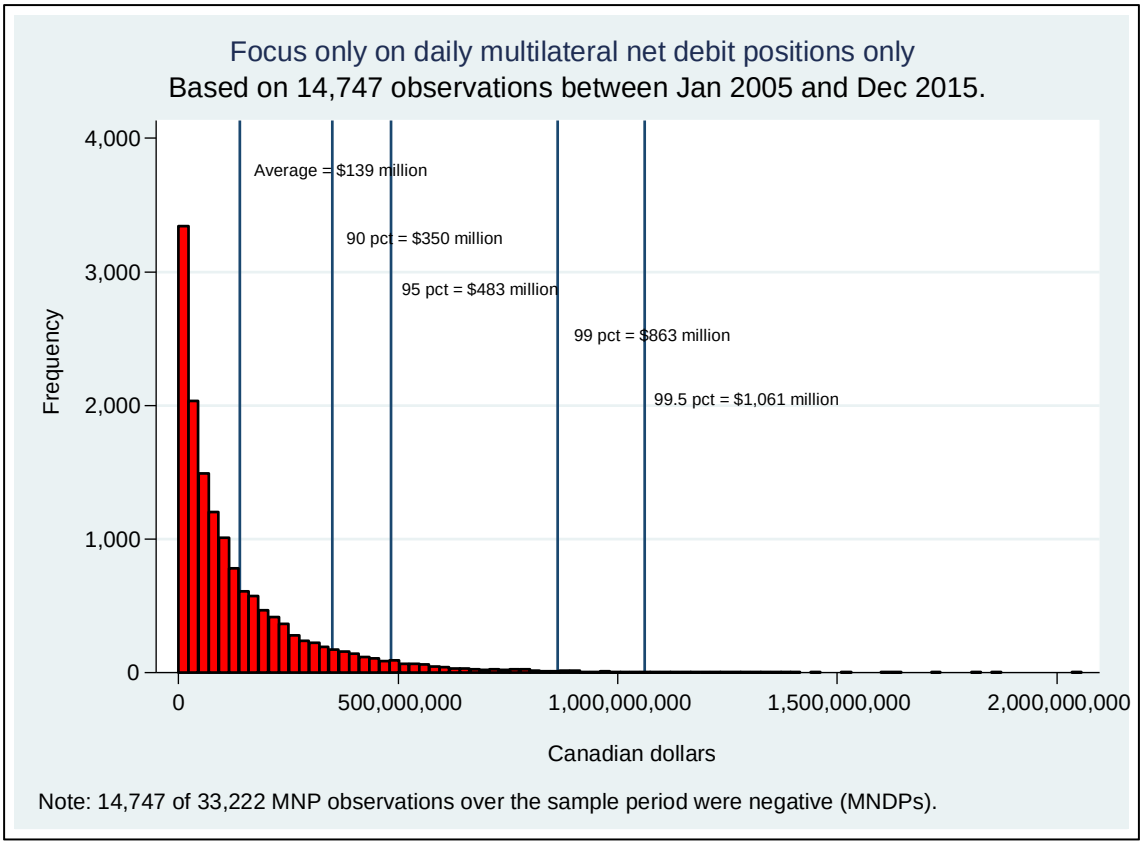


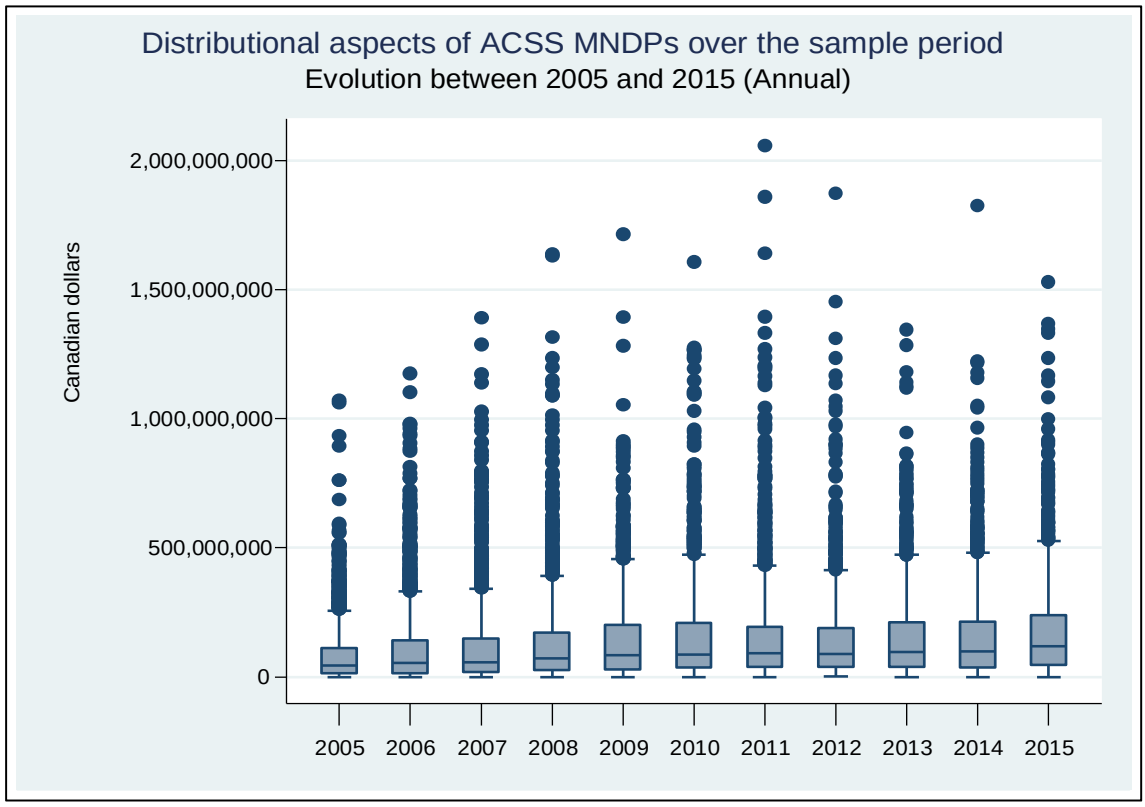
Figure 3 shows that, as expected, the historical distribution of MNPs is bell-shaped and centered on $0. This is both a demonstration of the high level of sophistication exhibited by the treasury functions of the major Canadian FIs, and of the merit of specific tools available to ACSS DCs to help manage material dislocations in their settlement obligations within the ACSS/LVTS environment.[18] Figure 4 isolates the left-hand side of the distribution in Figure 3 (with negative values converted to positive),

[18] As an example, two FIs that both participate as an ACSS DC and as an LVTS Participant could enter into a Settlement Exchange Transaction (SET) with each other prior to LVTS settlement to mutually address material dislocations in their settlement obligations in the two systems. An FI that is long (or positive) in the LVTS and short (or negative) in the ACSS could seek out another FI that is short in the LVTS and long in the ACSS to engage in a SET, which would help to "flatten" (i.e., bring closer to $0) both FIs' settlement obligations in the two systems. More information on SETs can be found on the Payments Canada website at www.payments.ca.

focusing only on MNDPs incurred by DCs during the sample period. While most MNDPs are relatively small, there are some extraordinary days in the sample where a DC faced a settlement obligation of over $1 billion dollars. In fact, this occurred on over 70 days during the sample period (i.e., on roughly 3 out of every 100 days). As shown in Figure 4, the largest MNDP observed by a DC over the period is $2.06 billion. Were the DC with this MNDP to have defaulted on this particular day, surviving DCs would have had to share in ACSS-related credit exposures equal to this amount.

For further context, Figure 5 demonstrates how the distribution of MNDP values has evolved over time using a series of box-plots. The height of each of the shaded blue rectangles in Figure 5 represents the inter-quartile range for the observed MNDPs in each year – that is, the difference between the 75th and 25th percentile MNDP values measured in dollars. The horizontal line within each rectangle represents the median MNDP in the respective year. The dots in Figure 5 capture the tail of each annual distribution. Particularly interesting in Figure 5, and a potential focus for further research, is the slight upward trend in the annual median MNDP, and as well the variability in the annual distributions of MNDPs across the 11-year sample period.

Figure 5: Evolution in value of ACSS DCs' MNDPs; daily MNDP observations by year, 2005-2015



Recall that there are essentially two key components to the ASO calculation of a surviving DC. The first is the shortfall component ("A") discussed above and demonstrated in Figures 3-5. The second is the quotient (i.e., the "$\frac{B}{C}$") representing a surviving DC's share of the total clearing value entered into the ACSS against the defaulter during the payments cycle. This quotient can be calculated for each DC pairing and in both directions of that pairing for a given payments cycle (i.e., the quotient value for DC *A* vis-à-vis DC *B* will be different than the quotient value for DC *B* vis-à-vis DC *A* for the same cycle). Example time series of this quotient for two anonymized DC pairings over the sample period are provided in Figures 6 and 7. These figures are intended to demonstrate that the time series can take on varying patterns and levels of daily volatility depending on the DC pairing in question. Moreover, and though not shown in these particular figures, bilateral ACSS entries between certain DC pairings can be significant – in part reflecting the highly concentrated nature of the Canadian financial system – where on some days a single DC could be responsible for 50 per cent or more of the total clearing value entered against another DC.

Figure 6: Example of a daily quotient time series for two ACSS DCs, 2005-2015

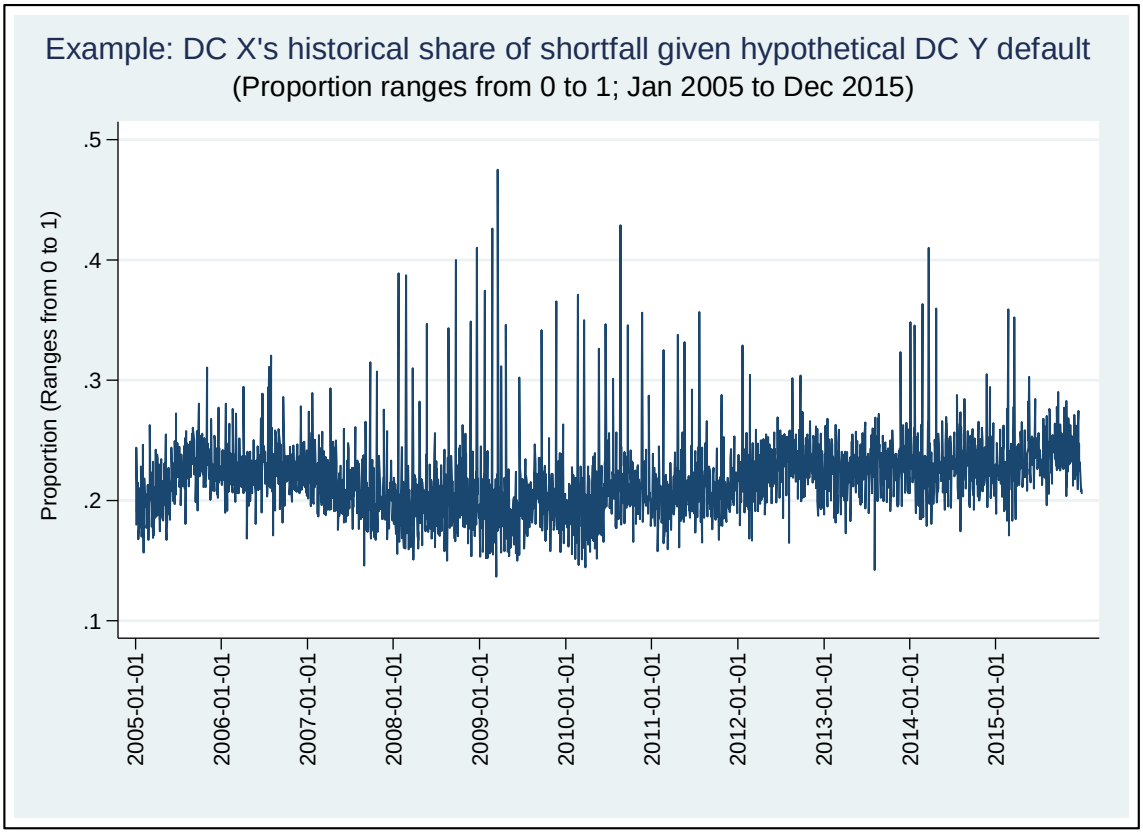
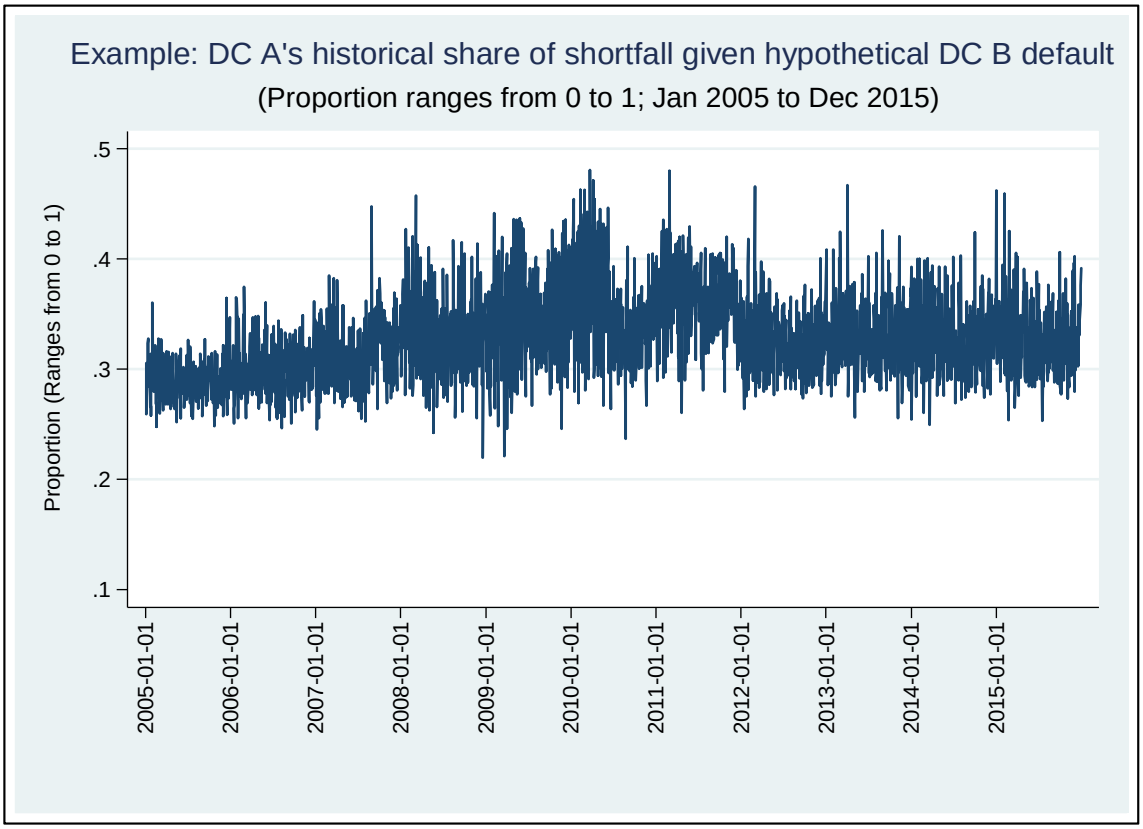


Figure 7: Example of a daily quotient time series for two ACSS DCs, 2005-2015



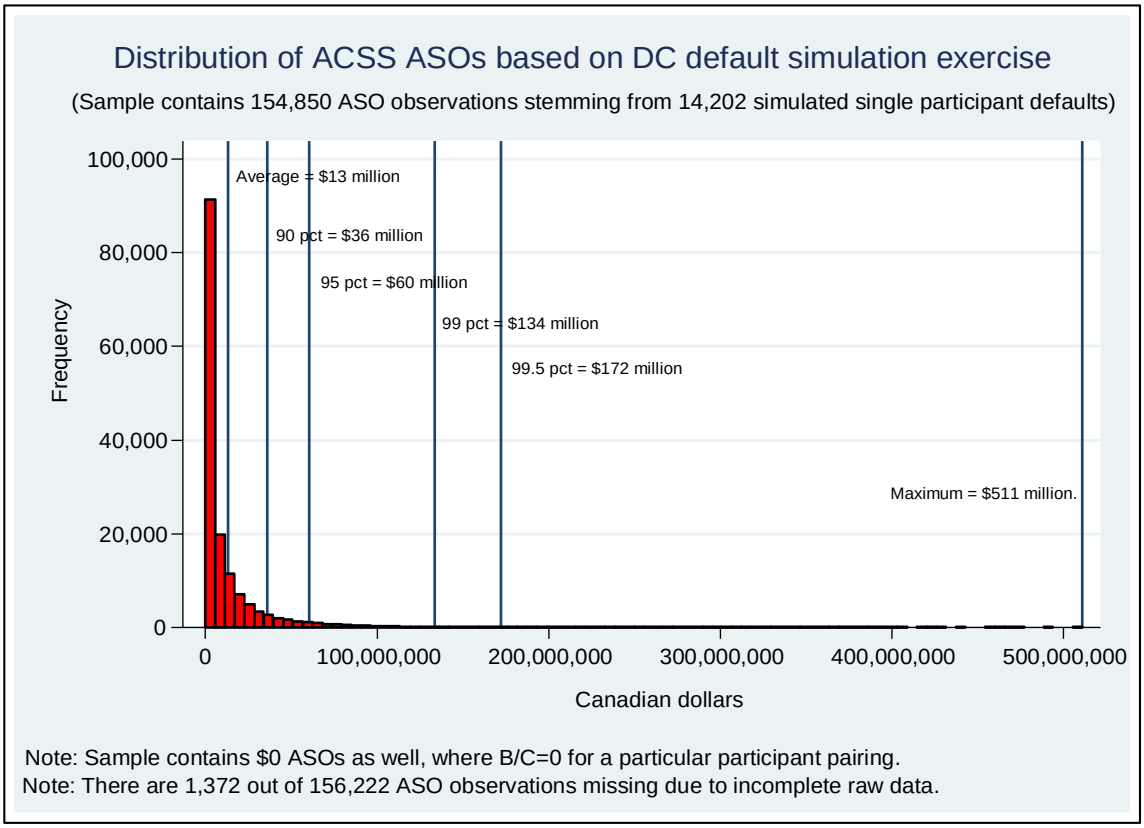
With all of the necessary ingredients in place, we complete the exercise by constructing the empirical distribution of surviving DCs' ASOs based on the 14,202 simulated defaults (Figure 8). The simulation generates approximately 155,000 ASOs which are used to construct the distribution in Figure 8. Recall that, for a single DC default, there could be up to 11 surviving DCs with a positive (non-zero) ASO. That said, there are over 2,000 ASOs in the sample equal to $0 (these too are reflected in Figure 8), most of which are ASO requirements of the BOC.

Similar to the distribution constructed for MNDPs, the ASO distribution in Figure 8 exhibits a positive skew and a relatively long tail. It shows that, while on average the ASO of a surviving DC stemming from a simulated default is roughly $140 million (the median is less than $100 million), there were close to 800 instances during the sample period where a surviving DC would face an ASO greater than $170 million, and in the largest instance up to $511 million. It is important to keep in mind that the largest ASO

observation in the simulation need not correspond with the default of the largest total shortfall, given that the quotient is also a key component in the ASO calculation.[19]

One must also remember that ASOs would need to be met by surviving DCs on short notice, and under adverse market conditions, where credit exposures appearing easily manageable under benign economic conditions could prove problematic for an FI in the midst of this type of stress event. Finally, and as mentioned earlier, assessment of credit exposure in this analysis focuses on the risk generated between DCs as part of the ACSS loss allocation mechanism; the precise distribution of this exposure between ACSS DCs and ICs – where DCs are acting as CAs – is outside the scope of this paper.

Figure 8: Empirical distribution of ACSS DCs' ASOs, daily observations from 2005-2015



We can also compare the summary ACSS credit exposure data from this study with those for the LVTS, where the latter are readily available from Hossfeld and Zhang

[19] For instance, the largest ASO of $511 million in the simulation is based on a total shortfall of $1,168 million, which is around half the value of the largest shortfall observed during the sample period ($2,056 million).

(2010). Table 1 below indicates that, while the LVTS is used to clear roughly six times the value of the ACSS annually, the largest credit exposure observed for a single participant in a hypothetical LVTS default scenario is less than twice that calculated for the ACSS. Similarly, the mean ACSS ASO is also less than twice the mean LVTS ASO as calculated by the two studies. This is due in part to the collateralization of MNDPs that takes place in the Tranche 1 payments stream of the LVTS (i.e., the defaulter would have pledged collateral to support its own T1NDC), coupled with use of bilateral and multilateral net debit caps and collateral to contain credit risk in the Tranche 2 payments stream.[20]

Table 1: Comparing the magnitude of credit exposure in the ACSS and LVTS

	Zhang and Hossfeld LVTS calculation		CPA current study: ACSS calculation	
	Shortfall ($M)	**ASO ($M)**	**Shortfall ($M)**	**ASO ($M)**
Max	3,600	829	2,057	511
99pct	2,503	267	863	133
95pct	1,666	154	482	60
Mean	386	28	138	13

* N. Zhang and T. Hossfeld. 2010. "*Losses from Simulated Defaults in Canada's Large Value Transfer System.*" Bank of Canada Discussion Paper No. 2010-14. October.

Note: Shortfall and ASO combinations per percentile need not have occurred on same day. Distributional aspects of each series are presented separately in table, as in Zhang and Hossfeld.

[20] For a detailed account of the LVTS, including a breakdown of the Tranche 1 and Tranche 2 payments streams, see Arjani and McVanel (2006).

6. The ACSS and designation as a 'Prominent' payments system: Credit risk and collateralization

While Payments Canada's LVTS has been designated as a systemically-important payment system subject to formal oversight by the BOC under its authority granted by the Payment Clearing and Settlement Act (PCSA), the ACSS had not, by the beginning of 2016, been designated for oversight by the BOC since it is not viewed as posing a systemic risk to the Canadian financial system and economy.[21]

In December 2014 the BOC's responsibilities under the PCSA were expanded to include the designation and oversight of Prominent Payment Systems (PPS). These are systems not viewed as posing a systemic risk to the Canadian financial system and economy. However, in the BOC's view they are still critical to the economic well-being of Canadians where any disruption or failure within these systems could pose a material risk to the domestic economy and/or affect general confidence in the Canadian payments ecosystem. The ACSS was designated by the BOC as a PPS on May 2, 2016.

As with systemically-important systems, the BOC has emphasized the importance of having appropriate risk controls in place for PPS. The BOC also notes that the nature and magnitude of the risks faced by PPS are different than those for systemically-important systems, and thus risk control standards for the two designations should appropriately differ in some areas. In February 2016 the BOC published its Criteria and Risk-Management Standards for Prominent Payment Systems.[22] While this designation will entail consequences for various aspects of the ACSS, it is perhaps on the management of credit risk (and settlement risk more generally) where the implications may be most important.

The following is a paraphrasing of language in the BOC's standards paper around PPS and credit risk management.

> *A PPS should effectively measure, monitor and manage its credit exposures to participants and those arising from its payment clearing and settlement processes. A PPS should maintain sufficient collateral and/or*

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[21] See Northcott (2002b) for the formal policy evaluation conducted by the BOC in this regard.

[22] See Criteria and Risk-Management Standards for Prominent Payment Systems, Bank of Canada, February 1, 2016. The document is available on the BOC website at www.bankofcanada.ca. Payments Canada's response to the preceding consultation document can be found on the Payments Canada website at www.payments.ca.

> *other equivalent financial resources to cover – with a high degree of confidence – its credit exposure arising from the default of the single participant that would generate the largest aggregate credit exposure for the PPS in extreme but plausible market conditions.*

How might this requirement be interpreted in the context of the ACSS and the earlier discussion? First, it is important to acknowledge from the preceding discussion that, contrary to the language above, the ACSS itself is not exposed to credit loss at any time in its daily function, nor is Payments Canada exposed to credit loss as owner and operator of the ACSS. Rather, as outlined in the ACSS by-law and rules and as demonstrated above, credit risk in the ACSS is borne collectively by DCs. Notwithstanding, this standard is likely to require that, in aggregate, at any time there should be sufficient collateral pledged by all DCs (including a prospective defaulter) to ensure that the ACSS can complete settlement if the DC with the largest total shortfall (i.e., the largest MNDP) defaults on its settlement obligation.

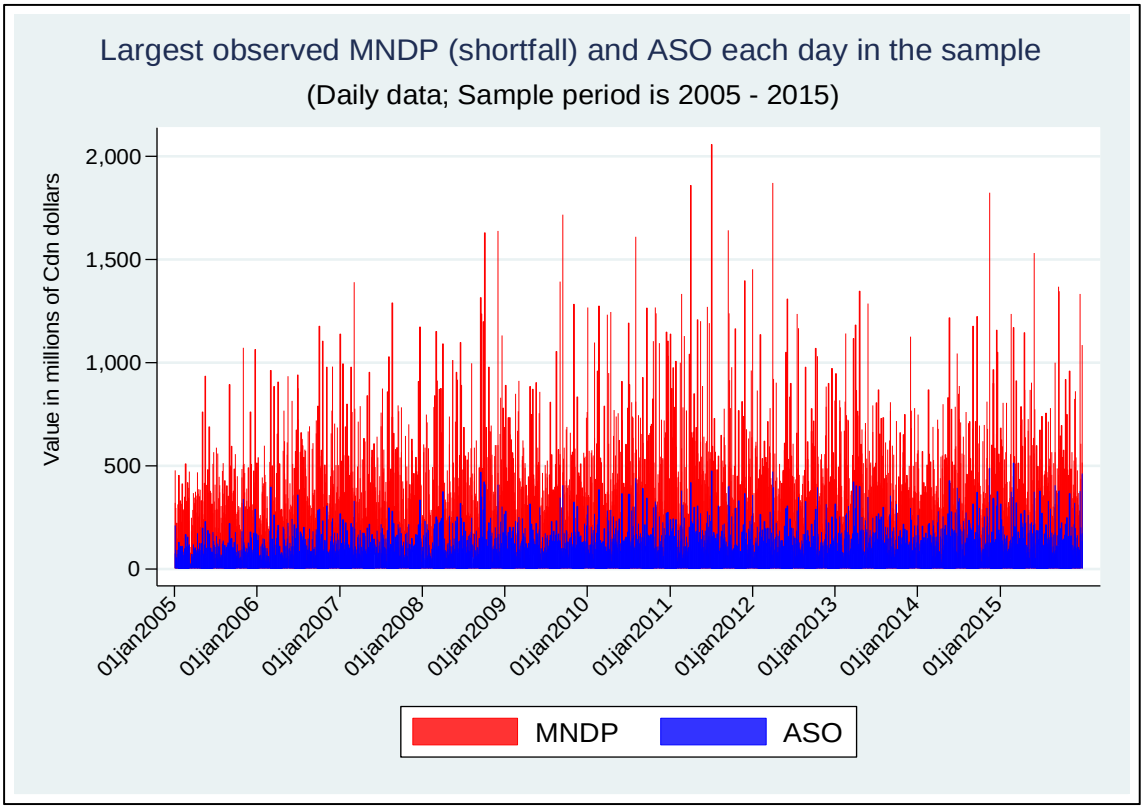
Several approaches could be used to determine what amount of collateral should be pledged by ACSS DCs to satisfy this credit risk standard. The historical simulation approach outlined earlier is one candidate given its simplicity in calculation and its ease of understanding. That is, one could observe the full or partial history of ACSS MNDPs and related ASOs and then simply target some percentile value of each DC's historical ASO distribution. Alternatively, a target percentile could be chosen based on the empirical shortfall distribution itself, which could serve as the foundation for some other collateral-allocation mechanism. To this point, Figure 9 demonstrates the time series properties of ACSS MNDPs and related ASOs over the sample period 2005-2015 – there is some degree of volatility in these data which could pose practical implications in devising any collateral-allocation scheme.

Instead of a "VaR-type" approach, one could use an expected shortfall approach for this purpose, which is also a relatively straightforward calculation and can be estimated using the same empirical distribution.[23] Alternatively, one could simply choose either the maximum shortfall or the maximum ASO observed for each DC historically and use that to determine the collateral requirement, possibly tacking on some pre-determined buffer to address uncertainty underpinning the exercise. Of course, one must be mindful that use of any risk measure driven largely by historical data has a well-

[23] The *Expected Shortfall* approach – sometimes referred to as conditional VaR – is generally defined as the expected loss conditional on the VaR being realized.

understood drawback – that is, history is not necessarily a good indicator of the future. This case is no different.[24]

Figure 9: Largest observed MNDP and ASO each day during the sample period



Exploiting historical data, however, is not necessarily the only way to calculate a risk parameter to inform this discussion, and financial risk management offers other

[24] The exercise depends heavily on the historical shortfall distribution and time series of the bilateral quotients; however, their use draws on the critical assumption that history repeats itself. This could be misleading since the Canadian financial system has not experienced the magnitude of event being contemplated in the exercise. Further, there are other structural changes that might challenge the relevance of historical ACSS data for this purpose. For example, the distribution of ASOs considered above does not take into account that, with the ACSS designated as a PPS, the defaulter would post collateral to the ACSS ("defaulter pays") which presumably would reduce – perhaps substantially – ASOs assigned to surviving DCs.

sophisticated, forward-looking and dynamic approaches to address the question at hand. For example, scenario analyses and stress-testing models that emphasize endogeneity of risk come to mind.[25] At the end of the day, there are many possibilities for how the credit risk standard for PPS could be met. With the ACSS now designated as a PPS, Payments Canada is investigating various risk methods to inform policy judgement.

A final point with regard to the designation of the ACSS is that collateral alone should not be viewed as a panacea in regard to addressing credit risk, even where collateral haircuts are established. That is, by employing collateral in the absence of formal limits on DCs' MNDPs, there is still no mechanism to constrain the level of credit exposure that can be generated by a DC, and thus there is potential for the system to fall short of the PPS standard in the event of a default even if 'collateralized'. The BOC acknowledges this point in its standards document by stating the following.

> *A PPS should identify sources of credit risk, routinely measure and monitor credit exposures, and use appropriate risk-management tools to control these risks.*

Moreover, as a PPS the ACSS should maintain an appropriate standard of access eligibility for DCs (and CAs and ICs) to control credit and other risks that can emerge in this environment.

7. Concluding Remarks

It is important for Payments Canada to clearly articulate the risks posed by its national clearing and settlement systems, and to perform ongoing monitoring and measurement of these risks. This paper aims to contribute to this purpose through comprehensive explanation of how credit risk can emerge in the ACSS in accordance with Payments Canada's by-laws and rules framework, and as well by attempting to measure the magnitude of credit exposure in the ACSS through use of historical simulation. Payments Canada maintains a keen interest in furthering its expertise and knowledge in this area, and conveying important insights from this work to participating financial institutions and Canadians more generally.

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[25] To the extent that these models are also predicated (calibrated) on historical events, they too could suffer from a similar drawback. Notwithstanding, what is critical with use of any model is to understand clearly what are its strengths and limitations, to articulate model results accordingly, and to ensure that its calibration/estimation reflects available information.

Moreover, as Payments Canada continues down its path of modernization, a framework for measuring and comparing credit risk across different payments system designs will be critical to decision-making around enhancements to existing systems and even the design of a new system.

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APPENDIX: ACCOMPANYING FIGURES AND TABLES

Figure A1: Proportion of total quarterly ACSS value entered by DC; DC names anonymized.

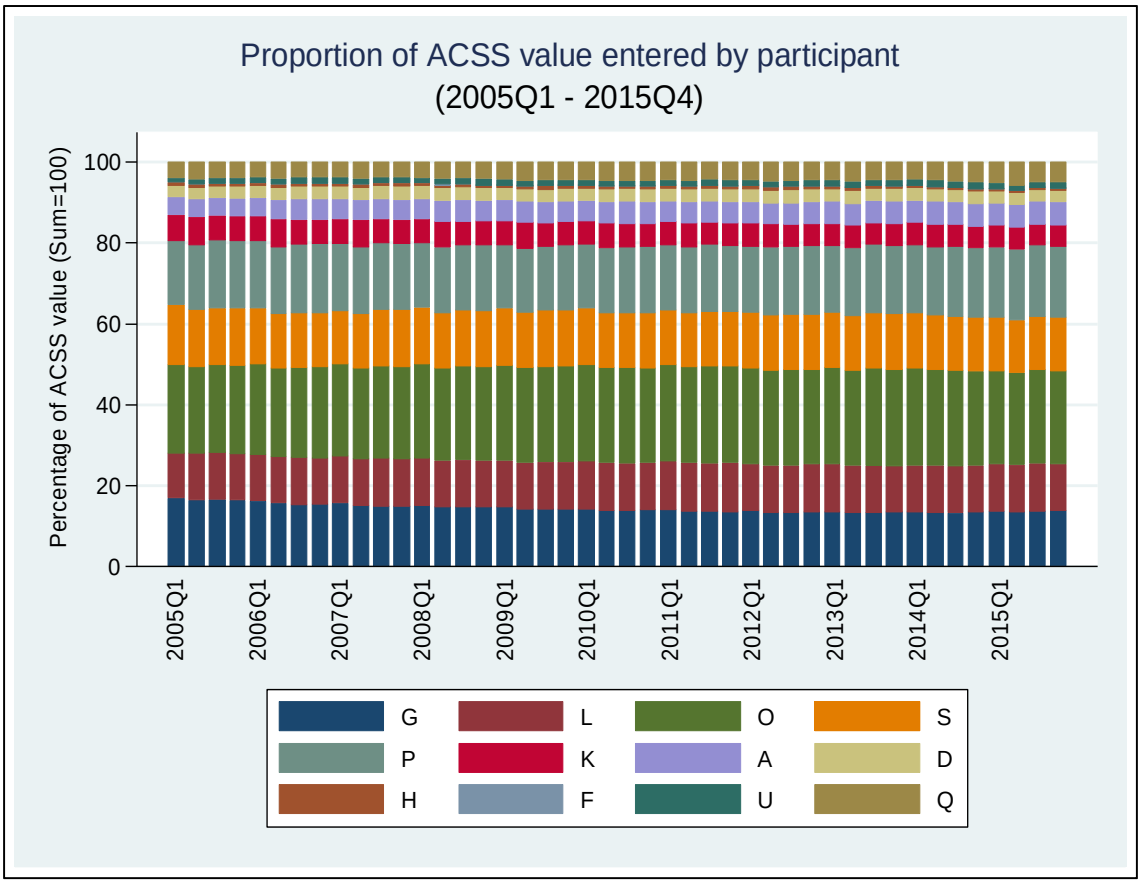

Figure A2: Proportion of total quarterly ACSS volume entered by DC; DC names anonymized.

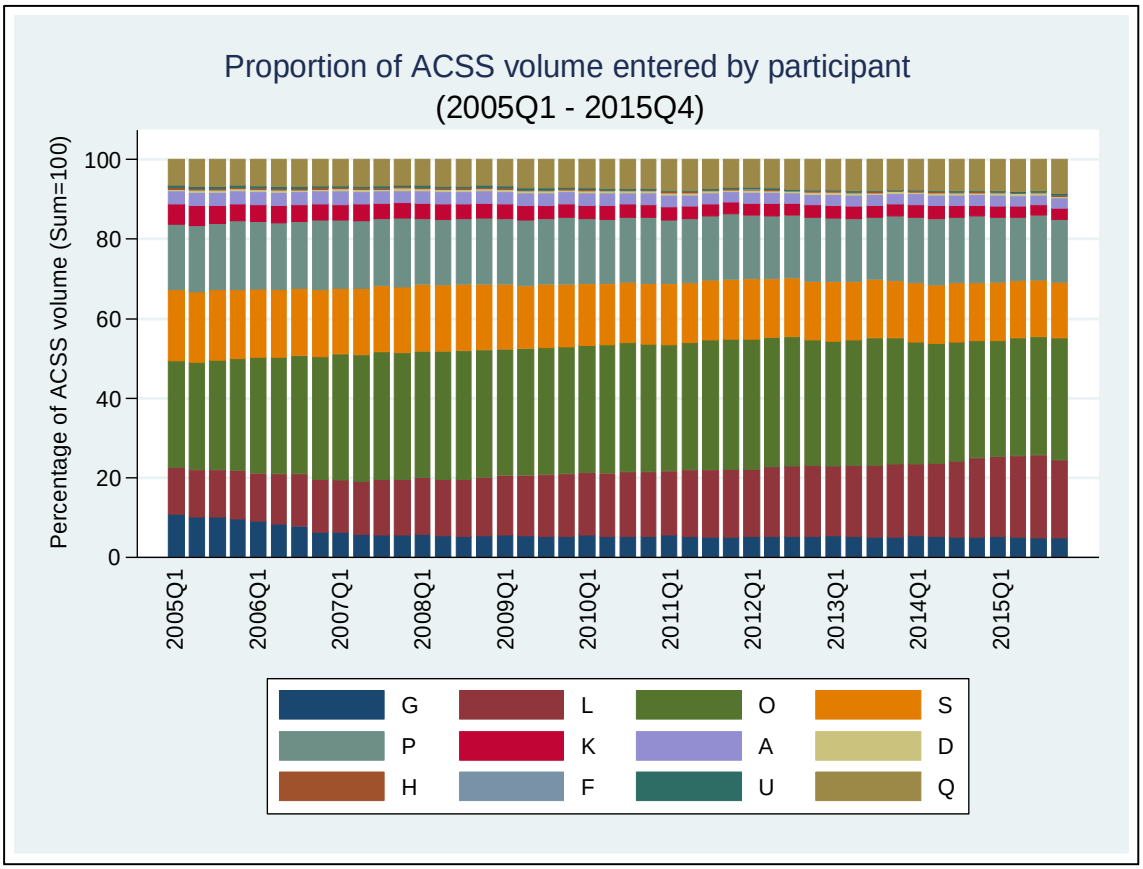

Figure A3: Proportion of total quarterly ACSS volume cleared by eligible payments stream

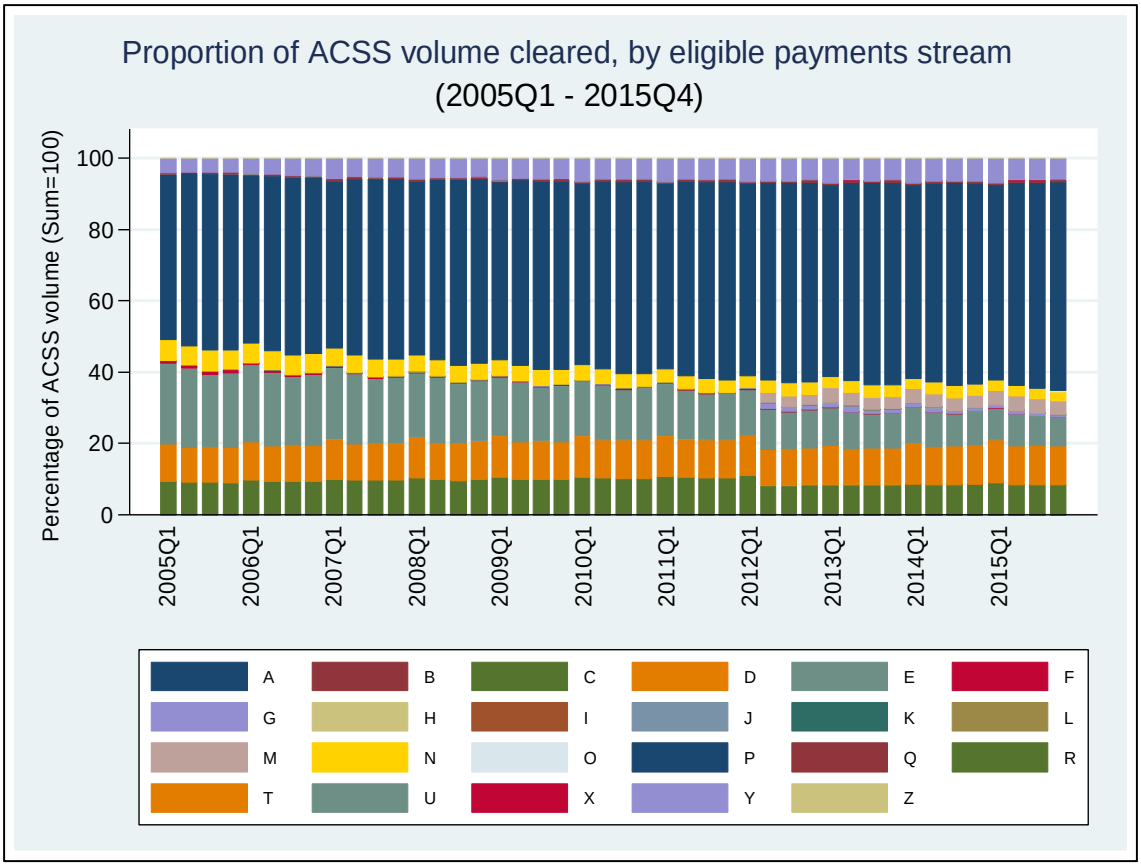

Figure A4: Proportion of total quarterly ACSS value cleared by eligible payments steam

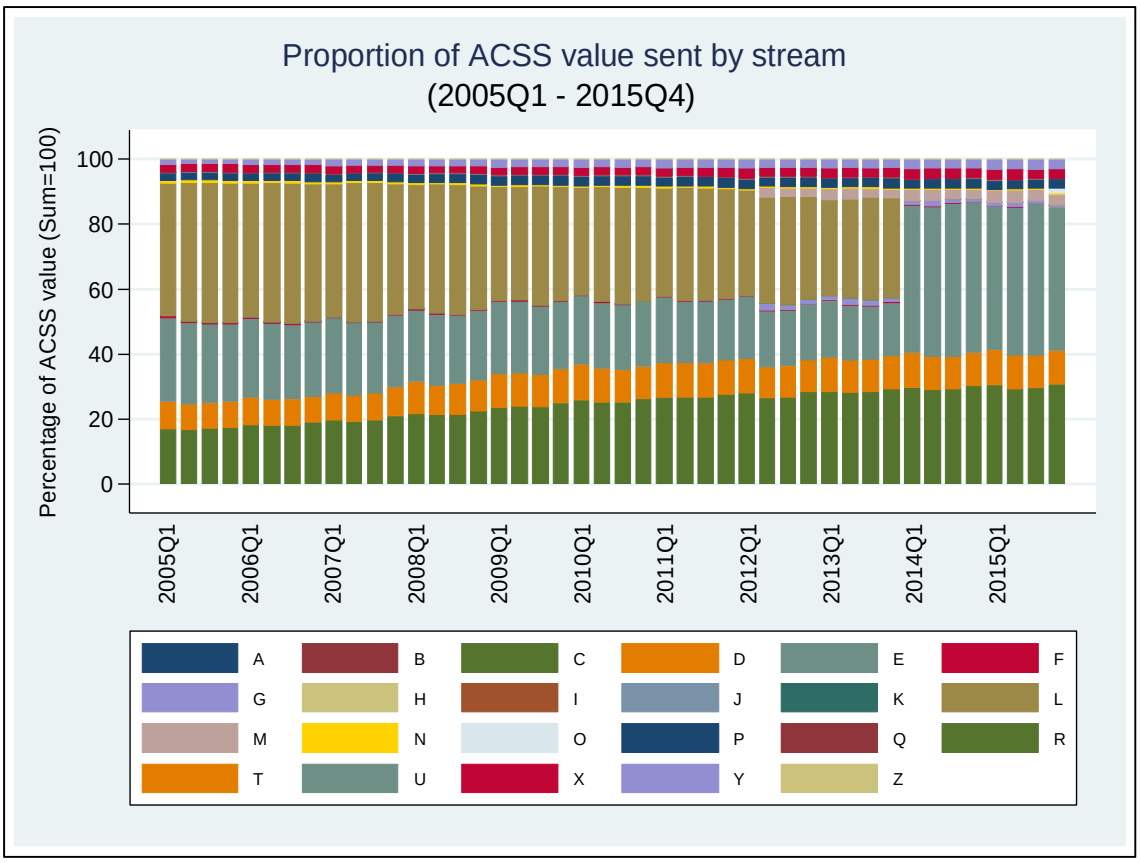

Figure A5: Process of exchange, clearing and settlement in the ACSS environment

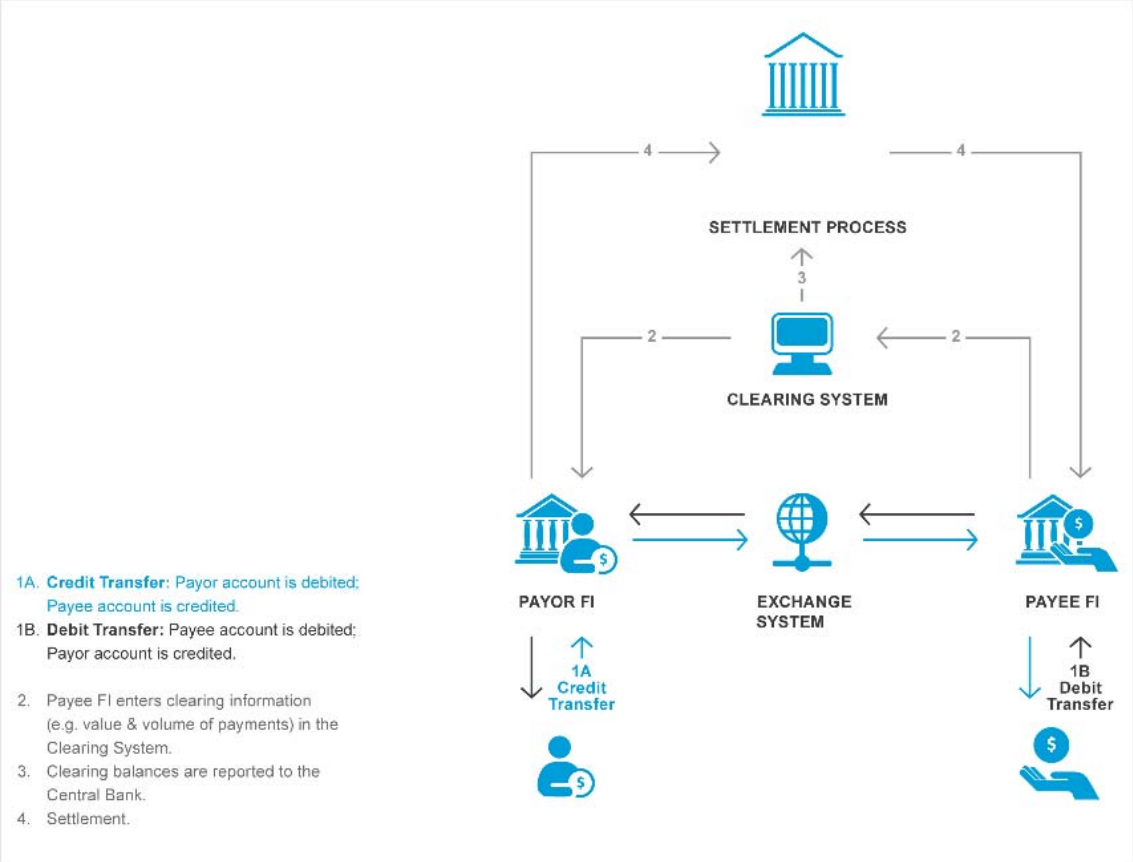

Figure A6: Comparison of ACSS funding needs under multilateral and bilateral netting arrangements