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An Economic Perspective on Payments Migration

by Anneke Kosse, Zhentong Lu and Gabriel Xerri

Financial Stability Department
Bank of Canada, Ottawa, Ontario, Canada K1A 0G9

akosse@bankofcanada.ca, zlu@bankofcanada.ca and gxerri@bankofcanada.ca

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Abstract

Canada is in the midst of developing three new core payment systems: Lynx, Settlement Optimization Engine (SOE) and Real-Time Rail (RTR). Lynx and SOE will replace the current Large Value Transfer System (LVTS) and Automated Clearing Settlement System (ACSS), whereas RTR will be a new capability. This paper examines the expected migration of ACSS and LVTS payments into RTR, SOE and Lynx. To that end we define a methodology for comparing the current and future payment instruments that end-users will be faced with in the new payments landscape. Similarly, we develop a method to assess the current and future payment systems from the perspective of banks. Based on this we estimate that a substantial portion of the current value of ACSS and LVTS payments might find its way to RTR due to changing end-user behaviour. Our analysis also suggests that banks might migrate a considerable amount of LVTS transactions to either SOE or RTR. The findings provide a good starting point for future research on the implications of the new payments infrastructure.

Topics: Payment clearing and settlement systems; Financial services; Financial system regulation and policies
JEL codes: E42, G, G2, G21

1 Introduction

Safe and robust payment systems are crucial to overall financial stability, as they enable consumers, businesses and governmental organizations to safely and efficiently purchase goods and services, make financial investments and transfer funds. There are currently two core payment systems in Canada that clear and settle transactions sent between banks and their account holders: the Automated Clearing Settlement System (ACSS)[1] and the Large Value Transfer System (LVTS).[2] Together they form the backbone of the Canadian financial system (Chapman, Chiu, Jafri and Saiz (2015)).

Although they still function and are regularly being upgraded, ACSS and LVTS began operations more than 30 and 20 years ago, respectively. As a result, it is increasingly challenging to keep them equipped with the latest technological developments and related risk controls. Moreover, there is increasing user demand for faster, safe and information-rich payments that ACSS and LVTS cannot fulfill. Therefore, Payments Canada—the owner and operator of ACSS and LVTS—is undertaking a large initiative to replace ACSS and LVTS as part of its broader initiative to modernize the Canadian payments

[1]The ACSS is owned and operated by Payments Canada and overseen by the Bank of Canada as a prominent payment system. The ACSS processes a high volume of lower-value, less time-sensitive payments that do not require intraday finality. By default, all payments initiated through cheques, debit cards, AFT debit, AFT credit, paper and electronic remittances and EDI are sent to ACSS if the payor and payee have a bank account at different financial institutions. The ACSS is a deferred net settlement (DNS) system. Each day, direct participants of ACSS (i.e., banks) enter the above payments into ACSS. At the end of the day, the ACSS determines the net payment obligation of each bank. Settlement of these obligations takes place the next day on the settlement accounts that the banks hold with the Bank of Canada via an LVTS payment. Since 2018, the banks participating in ACSS are required to pledge collateral such that the single largest credit exposure in the system is covered in case of a default.

[2]The LVTS is owned and operated by Payments Canada and overseen by the Bank of Canada as a systemically important payment system. LVTS processes large payments in near real time with the certainty that those payments will settle at the end of day. LVTS payments include interbank transactions and client wire payments, as well as the net obligations calculated in other systems, such as ACSS, Interac e-transfer, credit card systems and securities settlement systems. LVTS has two tranches that banks can choose from. LVTS Tranche 1 (T1) is a real-time gross settlement (RTGS) equivalent, as participants have to fully back each dollar sent with liquidity. LVTS Tranche 2 (T2) is based on deferred net settlement (DNS), where participants set bilateral credit limits (BCLs) between each other, and where banks' required collateral is based on their largest BCL granted.

ecosystem.[3] In this modernized world, there will be three new core payment systems: a real time gross settlement (RTGS) system for large-value payments (Lynx), a deferred-net-settlement (DNS) system for less urgent lower-value payments (SOE), and a new system for real-time processing of small-value payments (RTR).

Lynx and SOE will fully replace LVTS and ACSS, respectively. Their features, however, will not be the same. Unlike LVTS, Lynx will be a full RTGS system, meaning that all credit exposures are fully backed by the users of the system (e.g., the banks). This eliminates the need for the Bank of Canada's current end-of-day settlement guarantee and brings the Canadian large-value system into line with international best practices and risk management standards. As part of the ACSS replacement, SOE will enable Canadian consumers and businesses to send more information along with their payments and will provide them with speedier settlements than provided currently. RTR will be an entirely new capability for faster payments. The introduction of RTR is meant to spur the development of new payment instruments that allow end-users to make real-time payments.

In the new ecosystem, banks will have to decide what systems to participate in as well as which RTR-based and other payment instruments to offer and at what price. Consumers and businesses will have more choice due to the opportunity to make payments using the new RTR-based payment instruments offered to them. So end-users and banks will together decide which instruments and which systems to use. Since the characteristics of the new RTR-based instruments and the new systems will be different from those of the current options, these so-called payments migration decisions are likely to affect the utility that end-users and banks obtain from making payments and therefore influence total social welfare. Also, the migration of current payments might introduce externalities,

[3] See Payments Canada (2016).

including payment system risks. For example, a migration of large LVTS payments into SOE could lead to large end-of-day credit exposures, since SOE is based on end-of-day instead of real-time settlement. Also, a migration of particularly large LVTS transactions into RTR might possibly increase fraud risks. Being a prominent instead of a systemically important payment system, RTR may be subject to less stringent cyber security controls, and its broader access regime will allow smaller participants that might not have the same fraud risk controls as the participants in Lynx (and currently LVTS). As a result, RTR may be more susceptible to fraud risks than Lynx, which might even be exacerbated by a migration of LVTS payments, as this would increase the yields of a potential RTR fraud attack. These payment system risks could eventually affect overall financial stability.[4] Hence, the migration of current ACSS and LVTS payments might have various welfare and risk implications. In order to identify and quantify these, it is crucial to first understand the direction of the migration flows, which is the main objective of this paper.

At the moment, the granular details of the future systems are still under discussion. This paper contributes to these discussions in various ways. First, we define a methodology for describing the main attributes of a payment *instrument*. Based on the existing retail payments literature,[5] we state six key attributes that can be used to describe any given payment instrument: convenience, speed, safety and privacy, functionality, acceptance and cost. Based on this, we score the current instruments that Canadian end-users can use for making their payments to determine the main comparative advantages of the potential future RTR-based instruments. Second, inspired by the existing research on the payment choices of banks,[6] we assess the current and future payment *systems* using two

[4]Such a migration might actually create a snowball effect and fortify the risks. The lower the volume of transactions processed in the large-value system, the more difficult it gets to recover its costs, which might lead to an increase in fees and potentially further promote a substitution towards the retail systems (CPMI (2016)).

[5]See for instance Kosse (2014) and references therein.

[6]Galbiati and Soramaki (2010), Martin and McAndrews (2008), Bech and Garratt (2003), Arjani

key attributes: timeliness of payments and liquidity costs. Based on this, we determine the main comparative advantages of the three future systems. The third and most important contribution of this paper is the estimation of an upper bound of the potential migration flows of the payments currently processed in ACSS and LVTS.[7] We take a holistic approach looking at i) the potential migration driven by end-users substituting current wire transfers (LVTS) and ACSS-based instruments by RTR-based instruments, and ii) the migration caused by banks migrating the remaining LVTS transactions to Lynx, SOE or RTR.[8]

We estimate that a substantial portion of ACSS and LVTS payments might find its way to RTR due to changing end-user behaviour. ACSS payments that are not moving over to RTR as a result of end-users' choices will likely be substituted by SOE-based instruments and consequently processed in SOE. LVTS payments, however, could migrate to either system, depending on the criticality and international nature of the payments. This suggests that a considerable amount of LVTS transactions could move over to one of the two future retail systems. These transactions may include transactions larger than the current maximum cheque value of $25 million, which currently make up 3 per cent of the total number of LVTS payments and which account for almost 90 per cent of the total LVTS value.

Our findings are in line with those presented in Kosse, Lu and Xerri (forthcoming), which studies the potential migration of ACSS and LVTS payments by estimating an empirical model of payments and payment system demand using actual historical payments data. As such, this paper provides a valuable contribution to the current policy

(2006), Chapman et al. (2015).

[7]See Table 1 for an overview of the type of payments currently processed in ACSS and LVTS.

[8]Theoretically, payments currently processed in ACSS and LVTS may also migrate to a system other than one of the three new ones, for example, if the modernization initiative leads to end-users moving from cheques to credit cards or from wires to Interac e-Transfer. However, since end-users can already do so now, and since the new payment systems are meant to bring improvement, we assume such an outflow to be minimal. Thus we assume all current ACSS and LVTS payments will migrate to either Lynx, SOE or RTR.

discussions on how to design the future payment systems that meet individuals' needs while ensuring a stable and efficient financial system. The potential migration of large-value transactions to one of the systems designed for smaller-value payments highlights the need for careful consideration of the risks that such a migration can bring, and of how these could be mitigated. If deemed necessary, various policy measures could be taken to reduce the migration of large-value transactions into the smaller-value systems, such as imposing a maximum transaction value for RTR and SOE payments, increasing the collateral requirements for SOE, or forcing particular payments to be processed in Lynx.

The conclusions and recommendations should be read with the caveat that the payments market is rapidly changing. It is difficult to say what innovative developments are currently happening behind the scene, and the systems we know will be launched have not yet fully taken shape. Our conclusions should be read in this context and might change as we gain more knowledge.

The next section describes the key features of Lynx, SOE and RTR and explains how the expected payments migration is driven by an interaction between end-users and banks. Section 3 provides a high-level indication of the migration of ACSS and LVTS payments due to end-users' choices by assessing the comparative advantages of RTR-based instruments in terms of convenience, speed, safety and privacy, functionality, cost and acceptance. It also discusses lessons that can be drawn from other countries' experiences. Section 4 determines the potential migration direction of ACSS and LVTS payments as a result of banks' preferences in terms of timeliness of payment and liquidity requirements. Section 5 concludes and discusses the implications of our results as well as areas for future research.

2 Payments modernization and payments migration

2.1 Differences between current and future payment systems

By introducing RTR and replacing ACSS and LVTS with SOE and Lynx, Payments Canada aims to achieve a modern payments landscape that is fast, flexible and secure, promotes innovation and strengthens Canada's competitive position. The current and future systems differ from each other in a variety of ways. See Table 2 for a detailed summary of their main attributes.[9] In short:

- SOE will have many similar characteristics to the current ACSS, with the exception of having end-of-day instead of next-day settlement. Also, SOE aims to have less restrictive access criteria than ACSS, meaning that a larger number of financial institutions are able to use the system. As currently foreseen, SOE will be able to process the same payment instruments that are currently processed in ACSS.[10]

- LVTS is often said to be equivalent to an RTGS system, as payments are processed with finality while netted and settled end-of-day.[11] Lynx, by contrast, will be a full RTGS system that settles payments on an immediate basis. Lynx also differs from LVTS in that every payment sent through Lynx will need to be fully backed by either payments received or credit that is fully backed by collateral, such that any default is fully covered. In LVTS, liquidity is generated by either payments received and credit limits, with the latter only being partly collateralized.

[9]Chapman et al. (2015) and Payments Canada (2016) use the following five attributes to describe and compare payment systems: timeliness of payment, functionality, credit risk management, interoperability, access. The attributes that we use are slightly different in order to better identify the major differences between the current and future payment systems given the information currently available to us.

[10]See Table 1 for an overview of the payment instruments currently processed in ACSS.

[11]For a detailed description of LVTS, see Arjani (2006).

- Today, LVTS offers two mechanisms that banks can choose between when submitting a payment: LVTS Tranche 1 (T1) and LVTS Tranche 2 (T2). Lynx, too, will offer two distinct mechanisms: Lynx LSM and Lynx UPM. Lynx's liquidity savings mechanism (LSM) will enable banks to delay a payment and to reduce the amount of liquidity required to settle payments because it uses a combination of queuing, intraday liquidity recycling, and payment offsetting. For payments that must be settled without delay, participants may use Lynx's urgent payment mechanism (UPM).

- RTR will be a new capability for smaller-value payments. It is aimed to foster the availability of new payment instruments that enable end-users to make payments in real time. Although RTR will have the same funds availability and liquidity requirements as Lynx UPM, it will have a more open access regime and will not be able to process international (i.e., correspondent banking) transactions.

- All three future systems will use the international ISO 20022 standard for messaging. This will allow for higher interoperability across systems, both nationally and internationally.

2.2 Payments migration: a joint decision

The migration of current ACSS and LVTS payments will be the outcome of an interaction between end-users and banks. Banks will decide what systems to participate in as well as which payment instruments to offer and at what price. By doing so, banks can influence their end-user clients' payment choices through pricing or other features, such as ease of use (i.e., the ability to pay via online banking). Banks' decisions like these will be a function of various factors, such as the costs of the systems, client demand and competition pressures. Based on the sets of payment instruments offered and driven by their needs and preferences, end-users will decide which bank to bank with and which of their payment instruments to use.

Since SOE and Lynx are the replacement systems for ACSS and LVTS, it can be assumed that all banks that currently offer ACSS- and LVTS-related payment instruments will migrate to SOE and Lynx and that they will keep offering the same sets of instruments. Moreover, in this paper we assume that all these banks will also adhere to RTR and start offering RTR-based payment instruments. Although banks will have to incur a cost for connecting to an additional third system, they are likely to do so to satisfy the demand of their clients.[12] In the past, end-user demand has played an important role in banks' decisions on what payment instruments to offer, so banks may run the risk of losing their clients when not also moving to RTR.[13]

Hence, the final magnitude of the payment flows processed in Lynx, SOE and RTR will be strongly driven by end-users' uptake of RTR-based instruments as well as by banks' discretion of how to process their clients' and their own payments. When end-users make a payment using their instrument of choice, their banks will execute these through the appropriate systems. The RTR-based payments will by default be submitted to RTR, and the SOE-based instruments will have to be processed through SOE. However, when end-users make a wire payment, banks can technically send these to either system. It is reasonable to assume that this decision is heavily driven by banks' preferences: clients do not really care what system is used, as long as their payment needs, e.g., expected speed, are satisfied. The same is true for the banks' own transactions—these could potentially

[12] These additional costs will likely be passed on to their clients, either directly, e.g., through transaction fees, or indirectly, e.g., through higher account fees.

[13] There are various examples that show that the set of payment instruments offered by banks is strongly driven by end-user needs, such as the quick adoption of Interac e-Transfer by banks and the speed with which they lowered the Interac e-Transfer charges to their clients. Similarly, despite the high costs of issuing, handling and processing cheques, Canadian banks continue to offer cheques as a payment instrument due to client demand.

be processed through Lynx, SOE or RTR, and the banks make this decision.[14] Based on this, in the remainder of this paper, we study the following two questions:

- How many ACSS and LVTS payments will migrate to RTR due to end-users' uptake of RTR-based instruments offered to them?
- Which of the future systems will banks use for the processing of the remaining end-user payments and for their own payments currently processed in ACSS and LVTS?

Section 3 will dive into the first question, whereas Section 4 will discuss the second one.

[14]Banks currently have a similar choice set: all ACSS-related payments, such as cheques, automated funds transfers (AFTs), automated banking machine (ABM) transactions, electronic and paper bill payments and electronic data interchange (EDI) payments, are by default processed in ACSS. Client wire payments and interbank payments are commonly submitted to LVTS, for which banks can choose between LVTS T1 and LVTS T2. However, anecdotal evidence suggests that banks also use cheques or AFTs to process wire payments or their own payments, meaning that some of these payments are processed in ACSS.

3 ACSS and LVTS migration driven by end-users

3.1 Introduction

Canadian consumers, businesses and governmental organizations have numerous payment instruments that they can choose among when making and receiving payments.[15] Currently, in terms of volume, about 45 per cent and 0.03 per cent of total end-user payments are processed in ACSS and LVTS, respectively. In terms of value, ACSS and LVTS account for about 46 per cent and 50 per cent, respectively.[16] In the modernized world, both LVTS and ACSS will be decommissioned and these payments will have to migrate to either of the two replacement systems, Lynx and SOE, or to the new RTR system.

In this section, we provide a high-level indication of the potential migration of current ACSS and LVTS payments into RTR due to the uptake of RTR-based instruments by end-users. Although this uptake is still a joint decision between end-users and banks, we assume that all banks will offer these instruments due to competition pressure. We estimate the migration potential by first defining the features and main attributes that can be used to describe and assess a payment instrument. We then use these to assess how the current ACSS- and LVTS-based instruments compare to the future RTR-based instruments, both from a consumer and business point-of-view.

It should be noted that our focus is on the long-term RTR migration potential, which means our results provide insight into the take-up of RTR after a transition period. That is, end-users, and businesses in particular, will have to incur costs when switching

[15] Table 1 provides an overview of the main payment instruments available in Canada, the systems used for processing these, as well as the transaction types for which these are commonly used.

[16] These estimates are based on the total transactions made in Canada in 2017 by consumers and businesses using cash, cheques, drafts, money orders, paper remittances, Interac debit card, Interac Online, prepaid cards, AFT debit, AFT credit, credit card, online remittances, EDI payments, and online transfers, as reported in Tompkins and Galociova (2018), supplemented with LVTS data on client wires.

to RTR-based payment instruments. Examples include the cost of investing in a new infrastructure and devices, the cost of writing off existing software and terminals, and the cost of replacing current business administration processes. Hence, it might take some time before these switching costs are outweighed by the benefits of the main attributes described below. Due to missing data, we are not able to include these switching costs in our analyses.

3.2 Key instrument features and attributes

Each payment instrument has a unique set of characteristics. A large body of literature demonstrates that these play an important role in end-users' adoption and use of payment instruments. Convenience, speed, financial cost, safety and privacy, functionality and acceptance have been shown to be important drivers.[17] We use these six attributes to rank and compare the payment instruments that Canadians will have available in the modernized world. In particular, we compare the main attributes of the payment instruments currently processed in ACSS and LVTS with those of two potential RTR-based instruments. At the time of writing, it is difficult to say what the future RTR-based instruments will look like. The exact RTR configurations are still under discussion, and the development of concrete payment instruments that use the RTR for processing will be up to market innovation. Therefore we run our comparisons using two hypothetical RTR-based instruments, RTR-1 and RTR-2, which we assume to have the following characteristics:

- RTR-1: meant for person-to-person (P2P) payments, has the same characteristics as the current faster payment instrument offered by Canadian banks,[18] but uses the

[17] See Kosse (2014) and Stavins (2017) for a summary.

[18] Canadian banks currently offer Interac e-Transfer to consumers and businesses to make real-time online payments to other individuals. Apart from any new RTR-based payment instruments, all payments made with Interac e-Transfer will also be processed through RTR when it is introduced.

ISO 20022 messaging standard and is initiated using the recipient's account number instead of email address.[19]

- RTR-2: has the same characteristics as RTR 1 but can also be used in stores and for bill payments.[20]

For each instrument, we generate six attribute scores based on the 22 features listed in Table 3. These are calculated by taking an unweighted average of its underlying features. The list of features and their values are the outcome of thorough discussions with payments experts, as well as public information and data collected from the industry.[21] Limited by the available data, the features and attributes take on a value from 1 to 3, with 1 (3) being least (most) attractive from an end-user perspective.

We calculated the six attribute scores from both a consumer and a business perspective, as the two play an important role in the final decision of which payment instruments to adopt and to use (e.g., Huynh, Nicholls and Shcherbakov (2019)). Figures 1 to 5 show how the current ACSS and LVTS instruments perform on the six main attributes from the perspective of consumers and businesses, respectively, and how they compare to RTR-1 and RTR-2.[22] Overall, the hypothetical RTR-based instruments score higher than the others on various attributes, from both a consumer and business perspective.

[19]This hypothetical RTR-based instrument reflects the characteristics of an overlay service offered on top of the foreseen Single Credit Transfer (SCT) scheme that is currently developed by Payments Canada for the RTR.

[20]This hypothetical RTR-based instrument reflects the characteristics of an overlay service that has the same characteristics as RTR-1 but also allows beneficiaries to send out payment requests.

[21]Data collected from the industry include fraud data from the Royal Canadian Mounted Police (RCMP).

[22]Apart from offering RTR-based instruments, banks can also influence their uptake by changing the features, including prices, of the other payment instruments. For this analysis we assume that the current features and prices of the ACSS and LVTS-based instruments do not change when migrating to one of the future systems, due to competition pressure.

3.3 Methodology for comparison and ranking

It is difficult to draw conclusions from the above figures only, as payers and payees perceive some attributes to be more important than others. Arango and Welte (2012) study the point-of-sale (POS) payment preferences of Canadian consumers and find that they attach the highest importance to both convenience and speed, followed by acceptance, security, anonymity and costs. Moreover, the most common demand of Canadian businesses has been found to relate to speed, followed by enhanced functionalities, convenience, safety and privacy, costs and acceptance (Payments Canada (2016)). Hence, to get a better sense of the potential adoption of RTR-1 and RTR-2, we rank them against the other instruments based on a weighted overall score. We used the average importance ratings reported in Arango and Welte (2012) to calculate the weights (see Table 4). The results are summarized in Figures 6 - 8, with each table focussing on one particular transaction type, as each of these can be paid using a different set of instruments: person-to-person (P2P) transactions, point-of-sale (POS) transactions, and bill and business transactions.[23] For the P2P instruments, we calculated the six weighted attribute scores based on the consumer scores only, as P2P transactions do not involve any businesses. When looking at POS and bill and business transactions, the weighted rankings are based on an average of the consumer and business scores, as they are both an important party to the transaction and to the decision on how it is finally paid.

When interpreting the findings, one should keep in mind that, with a lack of more detailed information, our methodology is based on two main assumptions. First, when calculating the six main attributes, we assign equal weight to each of the underlying features. For instance, when calculating the attribute "Functionality" we assume that

[23]Since we categorize our results by transaction type, the "Acceptance" attribute is automatically accounted for and therefore not included in the rankings.

end-users attach the same weight to the ability to submit multiple payments as to the ability to send more data with the payment. Similarly, the ability to receive rewards is assumed to equally affect the attribute “Financial cost” as the obligation to pay per-transaction charges. Unfortunately we do not have further qualitative or quantitative information to either support or reject this. Nevertheless, we believe that this approach does not have a large impact on the ranking for “Convenience” as the RTR instruments performed best on all underlying features. Similarly, the variability of the values for the individual “Cost” features is rather small, which means that the overall “Cost” scores are less sensitive to the weighting of the underlying features.

The attributes “Safety and privacy” and “Functionality” are subject to some more variation in the underlying feature scores. For example, although the RTR-1 and RTR-2 score higher than many other instruments on their 24/7 availability and the ability to submit more detailed information, they are outperformed on a few other characteristics. Hence, the overall RTR scores for these two attributes would have been a bit higher (lower) if we had attached a larger (smaller) weight to these former (latter) features. The degree to which this influences our results and conclusions strongly depends on our second assumption—that of the relative importance of the six attributes. Based on Arango and Welte (2012), we assume that end-users attach the highest importance to “Convenience” and “Speed,” followed by “Safety and privacy,” “Cost” and “Functionality.” We conducted some sensitivity analyses to see how the results would change when applying a different order. The results of these tests are incorporated in the discussion of our results below.

3.4 Results

3.4.1 Person-to-person payments

Figure 6 compares RTR-1 with the other ACSS- and LVTS-based instruments that are currently used for P2P transactions while putting the highest weight on "Convenience" and "Speed," followed by "Safety and privacy," "Cost" and "Functionality." RTR-1 clearly outperforms cheques and wires, mainly because of its improved convenience.[24] This suggests that there is considerable potential that consumers will start using RTR-1 for their P2P cheque and wire transactions. In particular, P2P wires (currently processed in LVTS) are likely to be substituted; they do not score higher than RTR-1 on any attribute.

The relative advantage of using RTR-1 instead of cash for P2P transactions is limited, at least based on the features currently known to us. Although RTR-1 outperforms cash in terms of "Convenience," the overall weighted cash score is a little bit higher than that of RTR-1, especially because of its higher scores for "Safety and privacy" and "Cost." This suggests that the likelihood of consumers replacing cash by RTR-1 for their P2P transactions will strongly depend on the future safety and privacy levels of RTR-1 as well as on its fees charged to consumers.

In order to test the robustness of our conclusions, we re-calculated the rankings using the alternative set of attribute weight factors listed in Figure 4. Figure 6 shows how the overall rankings stay the same when attaching the highest weight to "Cost" and "Functionality," followed by "Safety and privacy," "Convenience" and "Speed." This underlines that are our conclusions are not sensitive to the assumptions we used for the relative importance of the six attributes.

[24] The fact that cash ranks higher than cheques and wires is in line with the actual payment behaviour of Canadians; cash is still the most popular payment instrument for person-to-person transactions (see Henry, Huynh and Shen (2015)).

3.4.2 Point-of-sale payments

Figure 7 ranks RTR-2 against the ACSS-based instruments currently used for POS transactions. Remember that the attribute scores in this table are calculated as the average of the consumer and business scores. By doing so, the perspective of merchants is taken into account as well, as they decide whether or not to accept a certain payment instrument in their store.[25] RTR-2 scores higher than debit cards on the majority of attributes as well as on the overall weighted score. This suggests that, in the long run, the use of debit cards might decrease if an instrument like RTR-2 were to be launched into the market. Such a migration is not likely to happen overnight, as businesses in particular will be faced with switching costs. For example, they will have to invest in a new RTR infrastructure and will incur a cost when writing off their existing debit card terminals before the end of their economic lifespan.

The overall comparative advantage of RTR-2 to cash for POS transactions is limited—their overall weighted scores are almost similar. Although RTR-2 outperforms cash in terms of "Convenience," cash scores higher on "Safety and privacy" and "Cost." This suggests that the degree of cash substitution by RTR-based instruments will depend heavily on their future safety and privacy levels as well as on their fees charged to consumers and businesses. These conclusions are robust to changing the underlying weights such that "Cost" and "Functionality" get the highest weights.

3.4.3 Bill and business payments

Figure 8 shows that RTR-2 has the highest overall weighted score of all other instruments that end-users can choose among when paying for bills and business transactions. Even

[25]The fact that the overall weighted score of cash exceeds that of the debit card might seem counterintuitive given the decline in cash usage at points-of-sale (POS). Yet, cash transactions still play an important role at the POS.

when assigning a higher weight to "Functionality" and "Cost."[26] RTR-2 outperforms the others on "Convenience," and there is no other instrument that scores higher on "Speed." On top of that, RTR-2 has a comparative advantage to EDI, wires and paper remittances in terms of "Functionality." Hence, it is likely to expect a migration into RTR for most of these instruments. Again, it might take some time for such a migration to materialize given the costs of, for example, replacing existing EDI infrastructures and the current administrative business processes behind receiving paper remittances.

3.5 Magnitude of migration flows and some considerations

The comparisons suggest that enhanced convenience, speed and functionality of future RTR-based instruments are likely to result in certain ACSS and LVTS payments migrating into RTR. Figure 9 shows a breakdown of the total value of end-user payments currently processed in ACSS and LVTS and hence how much would migrate into RTR if all these payments were to be replaced by an instrument like RTR-1 or RTR-2. In the very extreme scenario (Scenario 9) where all current ACSS and LVTS payments are substituted by an RTR-based instrument, over $15 trillion per year would migrate into RTR.

This number, however, should be interpreted as the extreme upper bound of the migration potential, as this scenario is unlikely to become a reality. The large majority (70 per cent) of this yearly $15 trillion migration potential consists of client wires currently processed in LVTS. Unfortunately, we lack information on the breakdown of these transactions by user case; however, information received from Payments Canada suggests that a considerable part of these wire payments is meant for beneficiaries abroad. These cross-border payments require more-detailed payment messages, and as currently foreseen, the

[26]The ranking of the other payment instruments provides a good reflection of their usage. In 2018, the largest share of non-POS and non-P2P transactions was paid using AFT debit and AFT credit, whereas cheques and paper-based remittances accounted for a considerably smaller proportion of transactions. Source: ACSS data.

initial RTR-based instruments will not be able to support this. As such, international wire payments are not likely to migrate to RTR. However, due to data limitations, we are unable to filter these out.

A second consideration is that the ranking of the attributes is heavily based on the preferences reported in Arango and Welte (2012). They however focus on POS payment preferences, and it is unclear whether end-users have the same preferences and drivers for P2P and bill payments. Perhaps other factors play a role here too, such as switching costs that we were not able to account for. A first look at the correlation between the historic growth of the various payment instruments in Canada and their levels of convenience, speed, functionality, safety and privacy, cost and acceptance suggest that convenience has indeed played an important role in shaping the current payments landscape in Canada (see Table 5).[27] Yet, more fundamental research on P2P and bill payments is needed to further our understanding of the role of the underlying preferences and drivers for non-POS payments.

Another consideration to keep in mind when interpreting the numbers in Figure 9 is that the degree and speed of adoption of RTR-based instruments will differ across end-users. Henry, Huynh and Welte (2018) show how the adoption of alternative payment methods in Canada is associated with younger age groups, higher incomes and higher levels of education. These population groups are likely to be the first to use new RTR-based instruments. General attitudes towards technology play a role here too.[28] A recent global

[27]We acknowledge that this is a rough approach to examine the impact of the different attributes on end-user payment choices. Ideally one would like to have data on how the attributes have changed over time, so to account for the fact that the features of payment instruments evolve over time, as payment service providers, payment schemes and payment system operators are constantly working to enhance their products. Examples include the launch of contactless cards to speed up the transaction time, the implementation of the EMV technology to improve the safety of card payments and the introduction of the two-hour funds availability option for AFT debits and AFT credits.

[28]For example, Hayashi and Klee (2003) and Schuh and Stavins (2010)) find that consumers who regularly use the internet, computers or other new technologies are more likely to pay electronically.

study among 47,000 consumers classifies 11 per cent of Canadian consumers as *Pioneers* who are tech-savvy and keen to explore new financial services and channels (Accenture (2019)). The majority (63 per cent) of Canadian consumers are either *Skeptics* or *Traditionalists* who are less interested in new financial products and rather avoid technological innovations. Hence, it might take a while before RTR-based instruments gain market share.

3.6 Experiences abroad

Canada will not be the first country to introduce a real-time system for smaller-value payments. Other countries have launched similar initiatives,[29] and various lessons can be learned from these.

First, in terms of numbers of transactions, real-time payment instruments have quickly gained ground in various countries (see Figure 10). The literature reports a number of drivers and barriers that might affect the uptake, such as the role of coordination of public authorities, the transaction speed of the legacy systems, as well as consumers' characteristics and preferences.[30] In terms of value, the use of real-time payment instruments is still relatively small (see Figure 11), in particular because they are mainly used for smaller-value payments. Three years after their introduction, the value shares of the real-time retail systems ranged between 0.003 per cent in Poland to 0.80 per cent in the UK.[31] Depending on the exact features of the future RTR-based instruments, Canada might expect to see similar trends. In that case, the total value of ACSS and LVTS payments

[29] For example, UK (FPS, 2008), Mexico (SPEI, 2004), Sweden (BiR, 2012), India (IMPS, 2010), Singapore (FAST, 2014), USA (RTP, 2017), Australia (NPP, 2018), Argentina (DEBIN, 2017), China (IBPS, 2010), Denmark (Straksclearing, 2014), Poland (SPBC, 2012; Express Elixir, 2012), South Korea (HOFINET, 2001), South Africa (RTC, 2007), Chile (TEF, 2008), Nigeria (NIBSS Instant Payments, 2001), Sri Lanka (CEFTS, 2015), Bahrain (Fawri+, 2015), Spain, (SEPA ICT, 2017).

[30] See Hartmann, Hernandez, Plooij and Vandeweyer (2017) and references therein.

[31] Calculated based on the payment system data from the BIS Redbook. The estimate for the UK is calculated using data over the fourth year after its introduction, as earlier data are not available.

migrating into RTR would be much lower than the extreme upper bound discussed above. If RTR-based instruments accounted for 0.80 per cent of total payments value, like in the UK, the total value migrating away from ACSS and LVTS would be around $300 billion (see Scenario 10 in Figure 9).

Second, the direction of migration depends on various factors. Hartmann et al. (2017) study the introduction of real-time retail (or instant) payments in six specific countries. They show that the type of transactions migrating to the instant systems varies by country. The growth of instant payments in Mexico and Singapore has mostly come at the expense of cheques. In contrast, in the UK instant payments have become the default for online direct credits, followed by cheques and cash. In Sweden, where instant payments were launched as a P2P service and where they are only available via mobile phone, it is mainly cash transactions that have moved over. In Denmark, the majority of instant payments are mobile payments, but Danmarks Nationalbank (2017) also suggests a certain migration away from intraday credit transfers and cash. Various factors seem to have affected the specific substitution patterns, such as regulations regarding funds availability,[32] the type of transactions targeted by the instant payments scheme (e.g., P2P or P2B), the type of channels through which the scheme is offered (e.g., online or mobile), and the kind of payment instruments used at the time of the introduction (e.g., the level of cheque usage).

In all six countries studied by Hartmann et al. (2017), the instant payment instruments focused on P2P and/or single online credit transfers. As such, they serve as a good example of how the introduction of our hypothetical instrument RTR-1 could impact Canadians' payment behaviour. In the previous section we concluded that P2P payments currently paid by cheque, wire and potentially also cash might be substituted by RTR-1.

[32] In the UK, instant payments became the default for direct credits initiated via online banking after a change in regulation based on the Payment Services Directive, which required funds to be available to the creditor by the next business day.

This would be in line with what has been observed in the above case studies.

A third conclusion to take away from other countries' experiences is that the migration of LVTS payments to RTR might indeed be much lower than the upper bounds presented in Scenario 9 in Figure 9. Figure 11 shows that the share of value processed in other large-value systems is hardly impacted by the introduction of instant payments. This confirms that the instant payment instruments are mainly competing with payments processed in either the traditional retail systems (e.g., cheques, direct credits) or outside any system, such as cash payments. The experiences of the UK and Sweden in particular might provide an indication of what to expect for Canada, since their large-value systems process quite a large number of smaller-value transactions, just like Canada's LVTS.[33] Nevertheless, they have not seen a substantial migration of these payments into the instant payments system. There are several explanations for this.[34] First, instant payment schemes are commonly subject to value limits, and most banks impose an even lower value cap on their customers. Second, payments sent through large-value systems can often carry more information. This seems especially relevant for cross-border payments, as these would have to be reformatted to be sent via the real-time retail systems. This is a costly and, if done manually, time-consuming exercise. Third, real-time retail systems are generally not more liquidity-efficient compared with the large-value systems, as they require banks to fully collateralize their exposures at all times. Since RTR is likely to be more costly to banks than Lynx LSM (see Section 4), and since a considerable portion of wire transfers currently processed in LVTS are cross-border payments, Canada might see a similarly limited migration of large-value payments to RTR. This would confirm our earlier conclusion that the estimate presented in Scenario 9 should be considered an

[33]Based on an analysis of annual transaction data published by the Bank of International Settlement (https://www.bis.org/statistics/payment˙stats.htm?m=3%7C16%7C385).

[34]Based on discussions with the Bank of England and the Sveriges Riksbank.

extreme upper bound. The expected migration might even be further tempered if RTR becomes subject to value limits as well (see Scenarios 11 and 12 in Figure 9). Our upper-bound migration potential would, for example, be $8 trillion lower if RTR were subject to the $25 million value limit currently applied in ACSS for cheques. A value limit similar to the one applied in the UK would even reduce our upper-bound migration potential by almost $11 trillion.[35]

[35] This estimate is based on a hypothetical value limit of Can$ 400,000, which would be similar to the GBP 250,000 limit currently applied in the UK.

4 ACSS and LVTS migration driven by banks

4.1 Introduction

The migration of current ACSS and LVTS payments also depends on the behaviour of banks. As discussed in Section 2.2, we assume that banks will continue to offer the same sets of instruments plus the addition of an RTR-based instrument because of the strong bargaining power of consumers. Moreover, SOE-based instruments and RTR-based instruments are assumed to be processed in SOE and RTR, respectively. This means that banks will mainly influence the migration of payments through their decision on which systems to use for the processing of wire payments and their own transactions that are currently processed in LVTS. These payments will have to migrate to either SOE, RTR or one of the two mechanisms offered in Lynx: Lynx LSM, which provides banks with opportunities to save on liquidity, or Lynx UPM, which settles payments on an immediate and gross basis (see Table 2 for more details on these two mechanisms). In this section, we define the key attributes that play a role in banks' decision on which payment system to use, and we use these to compare the current and future systems available to them. Based on this we provide a high-level indication of the migration direction of current LVTS payments as a result of banks' preferences.

4.2 Key system attributes

Many studies have shown how banks' payment behaviour is influenced by the trade-off between the timeliness of a payment on the one hand and liquidity costs on the other (see, for example, Galbiati and Soramaki (2010), Martin and McAndrews (2008), Bech and Garratt (2003), Arjani (2006)). We therefore use these two attributes to compare the current and future systems from a bank's perspective. We score each system on each of these two attributes using a 5-point scale similar to the one used by Chapman et al.

(2015), with 1 (5) representing the least (most) desirable option for banks. The score for "Timeliness of payment" is based on the speed with which the funds are received and final. The "Liquidity requirements" attribute is based on the settlement frequency, the tools available to optimize liquidity, collateral requirements and intraday credit provisions (see Table 6).

4.3 Comparison of systems and migration directions

Figure 12 shows how the current and future payment systems compare on both dimensions. Given the distinct characteristics of Lynx LSM and Lynx UPM (see Table 6), both mechanisms are displayed separately. Of the future systems, Lynx UPM and RTR will provide the quickest funds availability, whereas SOE will be the least costly.

The expected migration direction of current LVTS payments is not straightforward. Lynx LSM and Lynx UPM will both be more expensive than the current LVTS stream Tranche 2 (T2), and payments sent through Lynx LSM will be available and final less quickly than currently with both LVTS Tranche 1 (T1) and LVTS T2. These two differences will change banks' incentives. Their final migration choices are likely to differ by type of payment. LVTS payments that are less urgent, such as scheduled payments or smaller-value payments, have a potential to migrate to Lynx LSM, or to the DNS system SOE if they can wait for a few hours. By contrast, urgent LVTS payments for which a delay is not acceptable could either be processed through Lynx UPM or RTR, depending on the banks' liquidity balances in both systems as well as their appetite for fraud risk, since RTR might have less stringent cyber security controls and more vulnerable points due to the more open access regime. Another factor that will influence the migration of LVTS payments is the future systems' ability to support cross-border (i.e., correspondent banking) transactions. As a considerable portion of current LVTS payments is meant for beneficiaries abroad, a substantial portion of current LVTS payments will either migrate to Lynx UPM or Lynx LSM, as SOE and RTR will not be able to process these.

4.4 Quantification of migration flows

The above comparisons suggest that, if not replaced by RTR-based instruments by end-users, current LVTS transactions may find their way to any of the three future systems. Today, using LVTS T1 is more costly for banks than using LVTS T2, since every payment needs to be fully backed with liquidity (see also Table 2). Therefore, all LVTS T1 payments are likely to be the most urgent payments for which banks have no other choice, such as settlement payments of ancillary systems or other critical payments.[36] Hence, the majority of LVTS T1 payments can be expected to migrate to Lynx UPM, or even RTR in case of domestic payments when RTR balances are sufficient and without restrictions such as value caps. The migration of LVTS T2 payments will strongly depend on the criticality and international nature of the payments. Unfortunately we cannot derive the nature of the current LVTS T1 and LVTS T2 payments from the available data. Given these limitations, Table 7 presents the upper bounds of the total LVTS values that could potentially flow into each of the three future systems, while accounting for the fact that transactions made by banks to flatten out their LVTS positions at the end of the day (i.e., flattening transactions) and transactions between banks to relocate balances across LVTS and ACSS (i.e., SET transactions) will never migrate to any system as they are specific to LVTS.

[36]LVTS T1 and T2 data indeed show that banks act rationally. They fully use their LVTS T2 net debit gaps and only use LVTS T1 for interbank payments if their available LVTS T2 credit is insufficient, which rarely happens.

5 Conclusions

This paper sheds light on the expected migration of ACSS and LVTS payments to the three new payment systems Lynx, SOE and RTR. We take a holistic view by looking at the migration caused by end-users moving over to RTR-based instruments as well banks migrating their and their clients' LVTS transactions to Lynx, SOE or RTR.

We conclude that a substantial portion of ACSS and LVTS payments might migrate to RTR due to end-users' preferences for convenience, speed and functionality. The migration of all remaining LVTS payments lies in the hands of banks, whose choices we assume to be mainly driven by the liquidity requirements of the future systems and the speed with which these systems settle their payments. Here we conclude that LVTS payments could migrate to either system, including RTR and SOE, depending on the criticality and international nature of the payment and banks' liquidity balances in each system.

Due to data limitations and uncertainty around the exact design of the future systems, we are not able to provide a precise estimate of the expected migration flows. Yet, our findings provide a good high-level indication of the *direction* of the flows, see Figure 13. The arrows that point straight down suggest that certain transactions will migrate to those systems designed for it: SOE for the less urgent lower-value payments processed in ACSS, and Lynx for the large-value payments processed in LVTS. The cascaded arrows flowing out of LVTS into SOE or RTR, however, summarize an important take-away of our paper: there is a likelihood of large-value LVTS payments migrating into one of the systems developed for lower-value payments. This conclusion is in line with the findings presented in Kosse et al. (forthcoming). In that paper we take a more quantitative approach to the payment migration question and estimate an empirical model of payments and payment system demand using actual historical payments data.

A second key conclusion is that the expected migration depends heavily on what end-users care about. Although previous payment trends show an important role for convenience and speed, more fundamental research on end-users' preferences is warranted, in particular, when it comes to P2P, bill and business payments.

Our conclusions provide a good starting point for an analysis of the potential implications of the new payments infrastructures. How does the expected uptake of future RTR-based instruments, for instance, impact overall social welfare? How do the potential migration flows impact the risks associated with payment systems, such as credit risk, operational risk and fraud risk? And what is the potential for certain risk mitigation tools, such as value limits for SOE and RTR, higher collateral requirements for SOE, or requirements to settle certain transactions in a certain system? The results show that there is a potential for LVTS transactions to migrate to RTR or SOE instead of Lynx. This is not necessarily undesirable from a risk perspective, as many of these transactions are for much less than the current $25 million value limit for cheques applied in ACSS. Yet, 3 per cent of the current LVTS payments exceed this limit and account for almost 90 per cent of the current value processed in LVTS.[37] This asks for a careful risk analysis. As such, this paper provides a valuable contribution to the current policy discussions on how to exactly design the future payment systems that meet individuals' needs while ensuring a stable and efficient financial system. Moreover, the framework presented in this paper can be applied to any potential instrument or system when one has the proper information to determine the attributes of each of them. For Canada, the framework can be re-used in the future, for example, to assess the comparative advantages of other payment innovations, such as digital currencies. Hence, it serves as a useful tool for future studies.

[37] This 3 per cent is exclusive of the transactions made to the Bank of Canada for the settlement of banks' balances in other systems. These so-called settlement transactions are commonly large in value too.

A Appendices

A.1 Tables and figures

Table 1: Main retail payment instruments in Canada

	Payment system used for processing	POS payments	E-commerce payments	P2P payments	Consumer bill payments	Business payments
Cash	ACSS*	✓		✓		✓
Cheque, money order, bank draft	ACSS			✓	✓	✓
Interac debit	ACSS	✓				✓
Interac online	ACSS		✓			✓
Credit card	Proprietary credit card systems	✓	✓		✓	✓
Interac e-Transfer	Proprietary Interac system			✓	✓	✓
Prepaid card (load/reload; store/cc)	Proprietary prepaid card systems	✓	✓		✓	✓
Online/mobile e-wallet	Proprietary card or online systems	✓	✓	✓	✓	✓
Electronic remittance	ACSS				✓	✓
Paper remittance	ACSS				✓	✓
AFT debit	ACSS			✓	✓	✓
AFT credit	ACSS			✓		✓
Wire	LVTS			✓	✓	✓
EDI payment	ACSS					✓

Note: The first column lists the main payment instruments available in Canada to consumers and businesses (incl. governmental organizations). Column 2 contains the systems that process the transactions made using these instruments, and columns 3 to 7 show the transaction types for which each instrument is commonly used. For a description of the instruments, see Appendix A.2. *Given their nature, individual cash payments are not processed in any system. ABM cash withdrawals are however processed in ACSS.

Table 2: Payment system attributes

	CURRENT SYSTEMS			FUTURE SYSTEMS			
	ACSS	LVTS		SOE	Lynx		RTR
		Tranche 1 (T1)	Tranche 2 (T2)		LSM	UPM	
Settlement type	DNS	DNS	DNS	DNS	RTGS	RTGS	RTGS
Settlement frequency	Once	Once	Once	Once	Real-time	Real-time	Real-time
Settlement time	Next day	End-of-day	End-of-day	End-of-day	Real-time	Real-time	Real-time
Settlement finality	Next day	Real-time	Real-time	End-of-day	Real-time	Real-time	Real-time
Credit risk management	Collateral pool	Net debit positions fully collateralized	Collateral pool	Collateral pool	Net debit positions fully collateralized	Net debit positions fully collateralized	Net debit positions fully collateralized
Default coverage model	Cover 1 Survivor pay	Cover-all Defaulter pay	Cover 1 + CB guarantee Survivor pay	Cover 1 Survivor pay	Cover-all Defaulter pay	Cover-all Defaulter pay	Cover-all Defaulter pay
Liquidity saving mechanisms	Netting	None	Bila credit limits Liquidity recycling Netting	Netting	Queuing Liquidity recycling Payment offsetting	None	None
Transactions supported	Interbank End-user	Interbank End-user International Settlement	Interbank End-user International Settlement*	Interbank End-user	Interbank End-user Correspondent banking Settlement	Interbank End-user Correspondent banking Settlement	Interbank End-user
Value caps	$25M for cheques	None	None	t.b.d.	None	None	t.b.d.
Access	Banks NBDP	Banks NBDTI NDTFI	Banks NBDTI NDTFI	Banks NBDP t.b.d. t.b.d.	Banks NBDTI NDTFI	Banks NBDTI NDTFI	Banks NBDTI NDTFI PSP
Based on ISO 20022	No	No	No	Yes	Yes	Yes	Yes

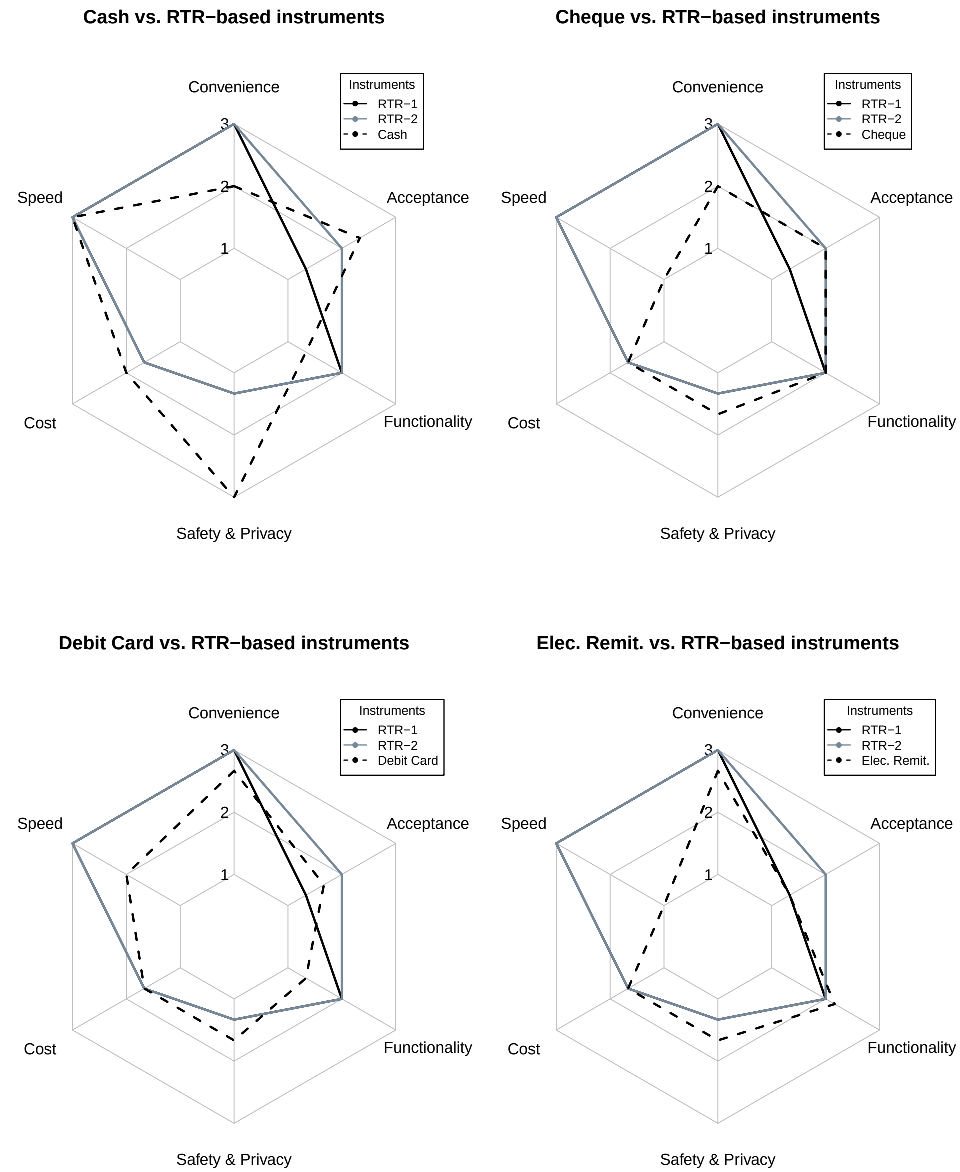
Notes: This table presents the main payment system attributes as foreseen at the moment of writing. * Technically possible, but due to bilateral credit limits LVTS Tranche 2 is hardly used for this purpose. NBDTI = non-bank deposit taking institutions, NDTFI = non-deposit-taking financial institutions, PSP =payment service providers. For a further description of the various attributes, see Appendix A.3

Table 3: Retail payment attributes

	Rating of underlying features
Attribute 1: Convenience	
Visit to ABM/bank/payee/mail box needed	1=yes, 2=depends, 3=no
Money deposited on deposit account of payee	1=no, 2=depends, 3=yes
24/7/365 available for initiating and receiving payments	1=no, 2=depends, 3=yes
Attribute 2: Speed	
Funds availability to payee	1=>1 day, 2=same day/it depends, 3=(almost) immediate
Attribute 3: Cost	
Per-transaction fee (imposed by FI, scheme, payee)	1=yes, 2=depends, 3=no
Non-per-transaction fee	1=yes, 2=depends, 3=no
Ability to receive rewards	1=no, 2=depends, 3=yes
Attribute 4: Safety and privacy	
Fraud	1= >10%, 2= 2% - 10%, 3 = <2%
(Quasi) anonymity of payments	1=no, 2=depends, 3=yes
Alternative routing	1=no, 2=depends, 3=yes
Attribute 5: Functionality	
Ability to submit multiple payments	1=no, 2=depends, 3=yes
Ability to check payment status 24/7/365	1=no, 2=depends, 3=yes
Ability to schedule recurring payments	1=no, 2=depends, 3=yes
Credit facility	1=no, 2=depends, 3=yes
Provision of more data with the payment	1=no, 2=depends, 3=yes
Using ISO 20022 for payment messaging	1=no, 2=depends, 3=yes
Attribute 6: Acceptance	
Person-to-person capability	1=no, 2=depends, 3=yes
Value limit (imposed by FI, merchant or scheme)	1=yes, 2=depends, 3=no
Ability to pay remotely	1=no/rare, 2=depends, 3=yes
Ability to use in physical stores (if accepted)	1=no/rare, 3=yes
Ability to use in online stores (if accepted)	1=no/rare, 3=yes
Ability to use for cross-border payments	1=no, 2=depends, 3=yes

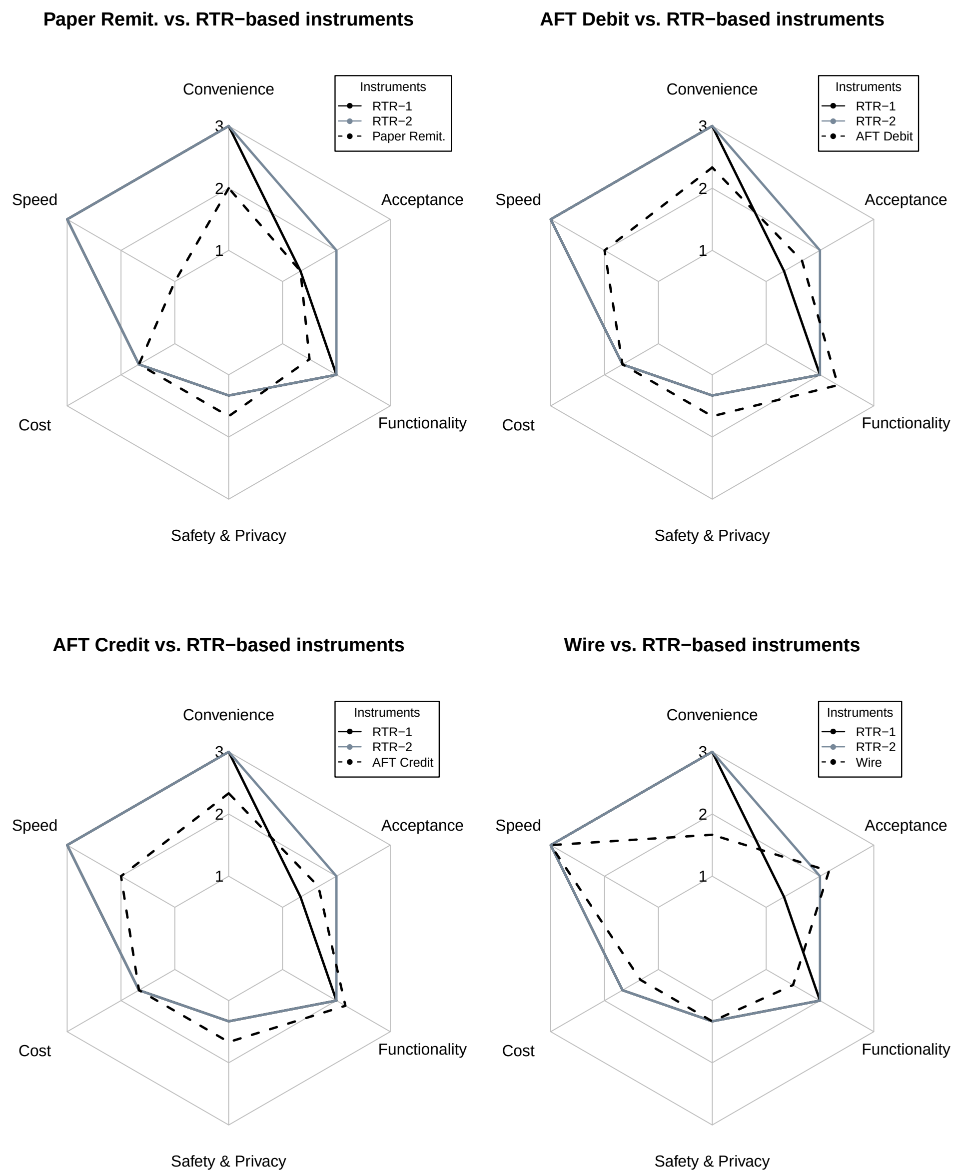
Note: The feature fraud represents the degree to which the payment instrument was used in 2018 to remit money to criminals, expressed as the percentage share of total fraud complaints that involved a victim, using data from the RCMP. Alternative routing means that the routing of the transaction is based on information other than a bank account, credit card or other financial information. Sometimes the value of an underlying feature depends on various factors, such as the bank with which end-users are banking. In that case the value "2=depends" applies.

Figure 1: Main attributes of payment instruments from a consumer perspective



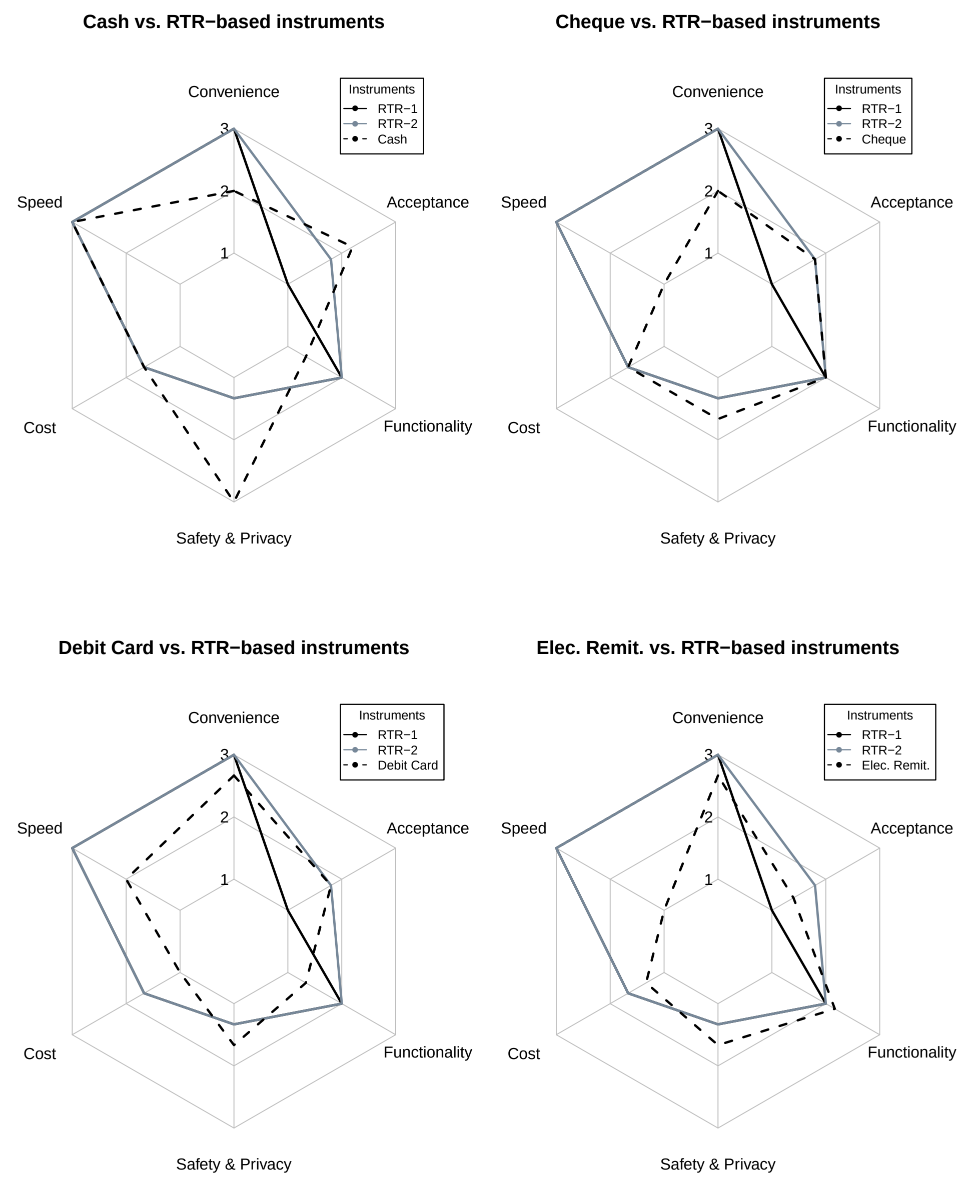
Note: The above radar graphs present the total attribute scores of the various instruments. The scores for each attribute are calculated by taking the average of the consumer scores on the sub-criteria listed in Table 3. So the further away from the centre, the more positive the instrument is rated from a consumers' perspective.

Figure 2: Main attributes of payment instruments from a consumer perspective (continued)



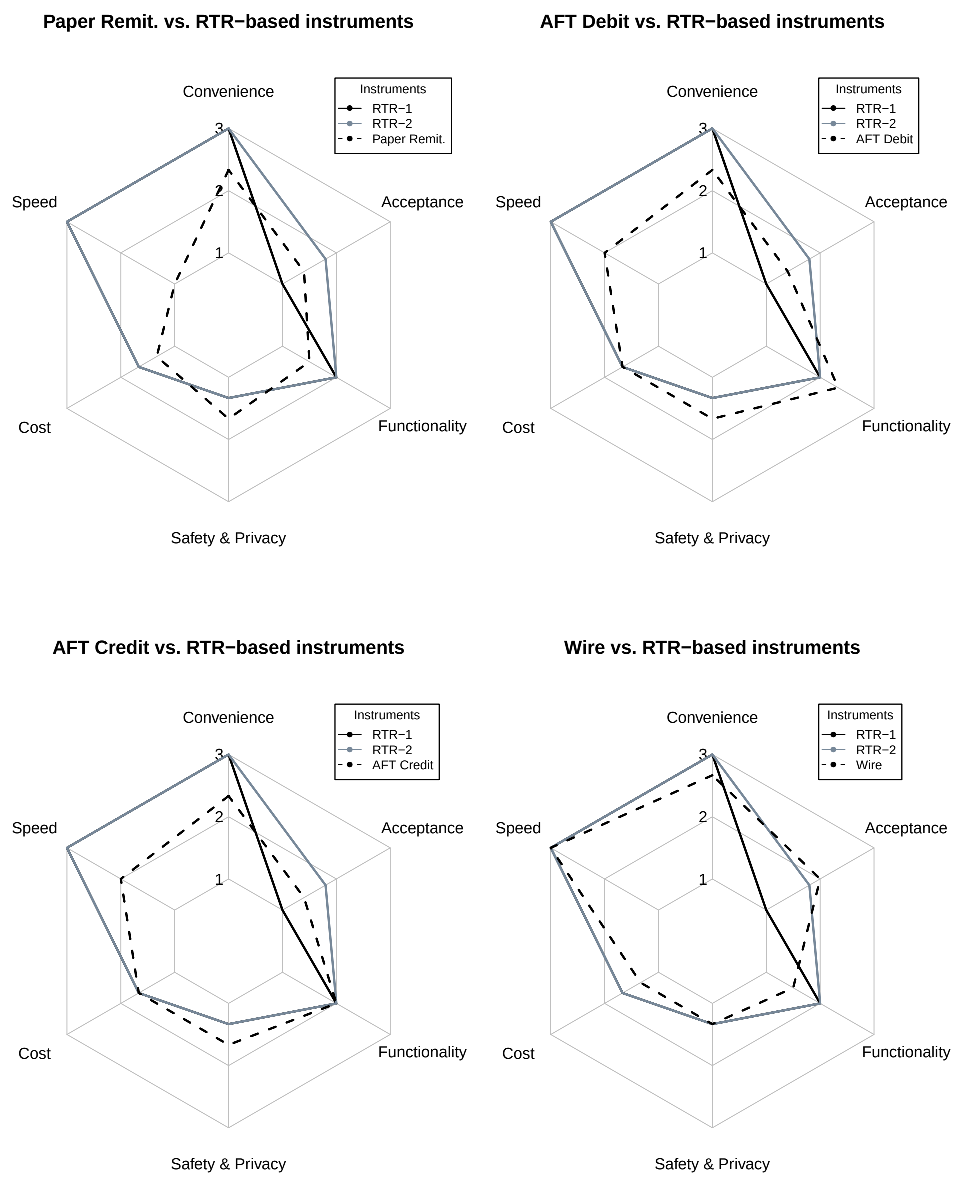
Note: The above radar graphs present the total attribute scores of the various instruments. The scores for each attribute are calculated by taking the average of the consumer scores on the sub-criteria listed in Table 3. So the further away from the centre, the more positive the instrument is rated from a consumers' perspective.

Figure 3: Main attributes of payment instruments from a business perspective



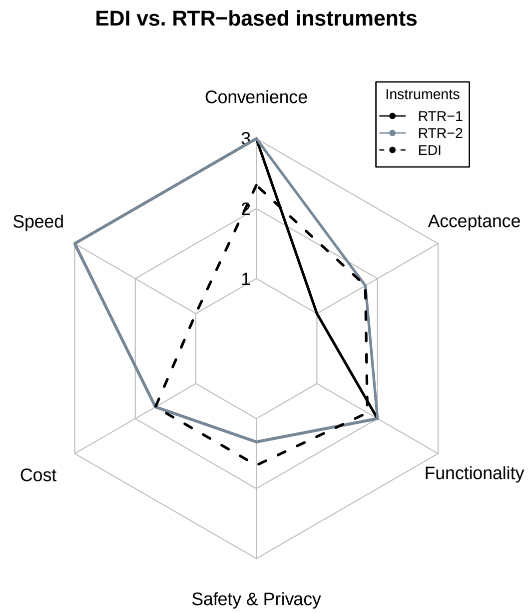
Note: The above radar graphs present the total attribute scores of the various instruments. The scores for each attribute are calculated by taking the average of the business scores on the sub-criteria listed in Table 3. So the further away from the centre, the more positive the instrument is rated from a business perspective.

Figure 4: Main attributes of payment instruments from a business perspective (continued)



Note: The above radar graphs present the total attribute scores of the various instruments. The scores for each attribute are calculated by taking the average of the business scores on the sub-criteria listed in Table 3. So the further away from the centre, the more positive the instrument is rated from a business perspective.

Figure 5: Main attributes of payment instruments from a business perspective (continued)



Note: The above radar graph presents the total attribute scores of the various instruments. The scores for each attribute are calculated by taking the average of the business scores on the sub-criteria listed in Table 3. So the further away from the centre, the more positive the instrument is rated from a business perspective.

Table 4: Weights of payment instrument attributes

	Average rating according to Arango and Welte (2012)*
Security	8.9
Ease/speed	8.9
Costs	8.5
Acceptance	8.6
Record keeping	8.0
Timing/delay	7.7
Anonymity	7.5
Control spending	7.5
Rewards	7.1
	Average ratings converted into our attributes
Convenience	8.9
Cost**	7.8
Functionality***	7.7
Safety and privacy****	8.2
Speed	8.9
	Average ratings converted into weight factors
Convenience	0.2146
Cost	0.1881
Functionality	0.1849
Safety and privacy	0.1977
Speed	0.2146
	Alternative weight factors
Convenience	0.1849
Cost	0.2146
Functionality	0.2146
Safety and privacy	0.1977
Speed	0.1881

Note: *Average represents the average importance rating for a certain attribute, which could range between 1 to 10. ** Calculated as the average of "Costs" and "Rewards." *** Calculated as the average of "Record keeping," "Timing/delay," and "Control spending." **** Calculated as the average of "Security" and "Anonymity."

Figure 6: Weighted ranking of P2P payment instruments

	Total	Convenience	Speed	Safety & Privacy	Cost	Functionality	Rank
RTR-1	2.20	0.64	0.64	0.26	0.31	0.33	2
Cash	2.29	0.43	0.64	0.59	0.38	0.25	1
Cheque	1.66	0.43	0.21	0.33	0.31	0.37	4
Wire	1.79	0.36	0.64	0.26	0.25	0.28	3
Based on alternative weight factors							
RTR-1	2.13	0.55	0.56	0.26	0.36	0.39	2
Cash	2.24	0.37	0.56	0.59	0.43	0.29	1
Cheque	1.67	0.37	0.19	0.33	0.36	0.43	4
Wire	1.74	0.31	0.56	0.26	0.29	0.32	3

Note: This table presents the weighted scores of RTR-1 and the instruments that are commonly used for P2P transactions. They are calculated based on the average of the consumer scores on the sub-criteria listed in Table 3 and the weights presented in Figure 4.

Figure 7: Weighted ranking of POS payment instruments

	Total	Convenience	Speed	Safety & Privacy	Cost	Functionality	Rank
RTR-2	2.23	0.64	0.64	0.26	0.31	0.37	2
Debit	1.83	0.57	0.43	0.33	0.25	0.25	3
Cash	2.26	0.43	0.64	0.59	0.34	0.25	1
Based on alternative weight factors							
RTR-2	2.17	0.55	0.56	0.26	0.36	0.43	2
Debit	1.77	0.49	0.38	0.33	0.29	0.29	3
Cash	2.21	0.37	0.56	0.59	0.39	0.29	1

Note: This table presents the weighted scores of RTR-2 and the instruments that are commonly used for POS transactions. They are calculated based on the average of the consumer and business scores on the sub-criteria listed in Table 3 and the weights presented in Figure 4.

Figure 8: Ranking of business payment instruments

	Total	Convenience	Speed	Functionality	Safety & Privacy	Cost	Rank
RTR-2	2.24	0.64	0.64	0.37	0.26	0.31	1
AFT debit	2.01	0.50	0.43	0.43	0.33	0.31	2
AFT credit	1.96	0.50	0.43	0.39	0.33	0.31	3
Wire	1.93	0.47	0.64	0.28	0.30	0.25	4
E-remit	1.80	0.57	0.21	0.40	0.33	0.28	5
EDI	1.70	0.50	0.21	0.34	0.33	0.31	6
Cheques	1.66	0.43	0.21	0.37	0.33	0.31	7
P-remit	1.57	0.47	0.21	0.28	0.33	0.28	8
Based on alternative weight factors							
RTR-2	2.17	0.55	0.56	0.43	0.26	0.36	1
AFT debit	2.00	0.43	0.38	0.50	0.33	0.36	2
AFT credit	1.94	0.43	0.38	0.45	0.33	0.36	3
Wire	1.87	0.40	0.56	0.32	0.30	0.29	4
E-remit	1.80	0.49	0.19	0.47	0.33	0.32	5
EDI	1.70	0.43	0.19	0.39	0.33	0.36	6
Cheques	1.68	0.37	0.19	0.43	0.33	0.36	7
P-remit	1.56	0.40	0.19	0.32	0.33	0.32	8

Note: This table presents the weighted scores of RTR-2 and the instruments that are commonly used for paying bills and by businesses. They are calculated based on the average of the consumer and business scores on the sub-criteria listed in Table 3 and the weights presented in Figure 4.

Figure 9: Estimated upper-bound migration potential of RTR due to end-user choices

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Cash	CAD 113,910	CAD 113,910	CAD 113,910	CAD 113,910	CAD 113,910
Cheque, money order, bank draft		CAD 751,941	CAD 751,941	CAD 751,941	CAD 751,941
Debit card			CAD 192,974	CAD 192,974	CAD 192,974
Paper remittance				CAD 2,063	CAD 2,063
EDI payment					CAD 213,587
AFT debit					
AFT credit					
Electronic remittance					
Wire					
Total upper bound of yearly migration potential (in CAD million)	**CAD 113,910**	**CAD 865,851**	**CAD 1,058,825**	**CAD 1,060,888**	**CAD 1,274,475**

	Scenario 6	Scenario 7	Scenario 8	Scenario 9
Cash	CAD 113,910	CAD 113,910	CAD 113,910	CAD 113,910
Cheque, money order, bank draft	CAD 751,941	CAD 751,941	CAD 751,941	CAD 751,941
Debit card	CAD 192,974	CAD 192,974	CAD 192,974	CAD 192,974
Paper remittance	CAD 2,063	CAD 2,063	CAD 2,063	CAD 2,063
EDI payment	CAD 213,587	CAD 213,587	CAD 213,587	CAD 213,587
AFT debit	CAD 816,114	CAD 816,114	CAD 816,114	CAD 816,114
AFT credit		CAD 2,383,625	CAD 2,383,625	CAD 2,383,625
Electronic remittance			CAD 235,795	CAD 235,795
Wire				CAD 11,027,566
Total upper bound of yearly migration potential (in CAD million)	**CAD 2,090,589**	**CAD 4,474,214**	**CAD 4,710,009**	**CAD 15,737,575**

	Scenario 10	Scenario 11	Scenario 12
Cash	RTR accounts for 0.80% of total payments value, like in the UK four years after introduction	CAD 113,910	CAD 113,910
Cheque, money order, bank draft		CAD 751,941	CAD 751,941
Debit card		CAD 192,974	CAD 192,974
Paper remittance		CAD 2,063	CAD 2,063
EDI payment		CAD 213,587	CAD 213,587
AFT debit		CAD 816,114	CAD 816,114
AFT credit		CAD 2,383,625	CAD 2,383,625
Electronic remittance		CAD 235,795	CAD 235,795
Wire		CAD 216,244	CAD 2,635,218
Total upper bound of yearly migration potential (in CAD million)	**CAD 283,830**	**CAD 4,926,253**	**CAD 7,345,227**

Note: This table presents the value of payments processed in 2018 by payment instrument. Scenario 9 constitutes the upper bound of the value that could potentially migrate into RTR if end-users were to substitute all these instruments with RTR-based instruments. Due to lack of data, the cash value is taken from Tompkins and Galociova (2018) and refers to 2017. The wire value is taken from LVTS data, and all other values are taken from the ACSS data. Scenario 11 assumes an RTR value limit of CAD 400,000 (similar to the UK) and Scenario 12 assumes a $25 million value cap similar to the current cheque limit in ACSS. Both scenarios assume that this will mainly affect the migration of wire payments currently processed in LVTS.

Table 5: Correlation between payment instrument growth over 2001–2018 and their core attributes

	Mean volume growth		Mean value growth	
	Corr. coefficient	p-value	Corr. coefficient	p-value
Acceptance	-0.294	0.40904	-0.420	0.22646
Convenience	0.694**	0.02611	0.710**	0.02131
Cost	-0.048	0.89595	-0.087	0.81116
Functionality	0.017	0.96324	0.0677	0.85264
Safety and privacy	0.046	0.89950	0.023	0.95050
Speed	0.532	0.11345	0.434	0.21073

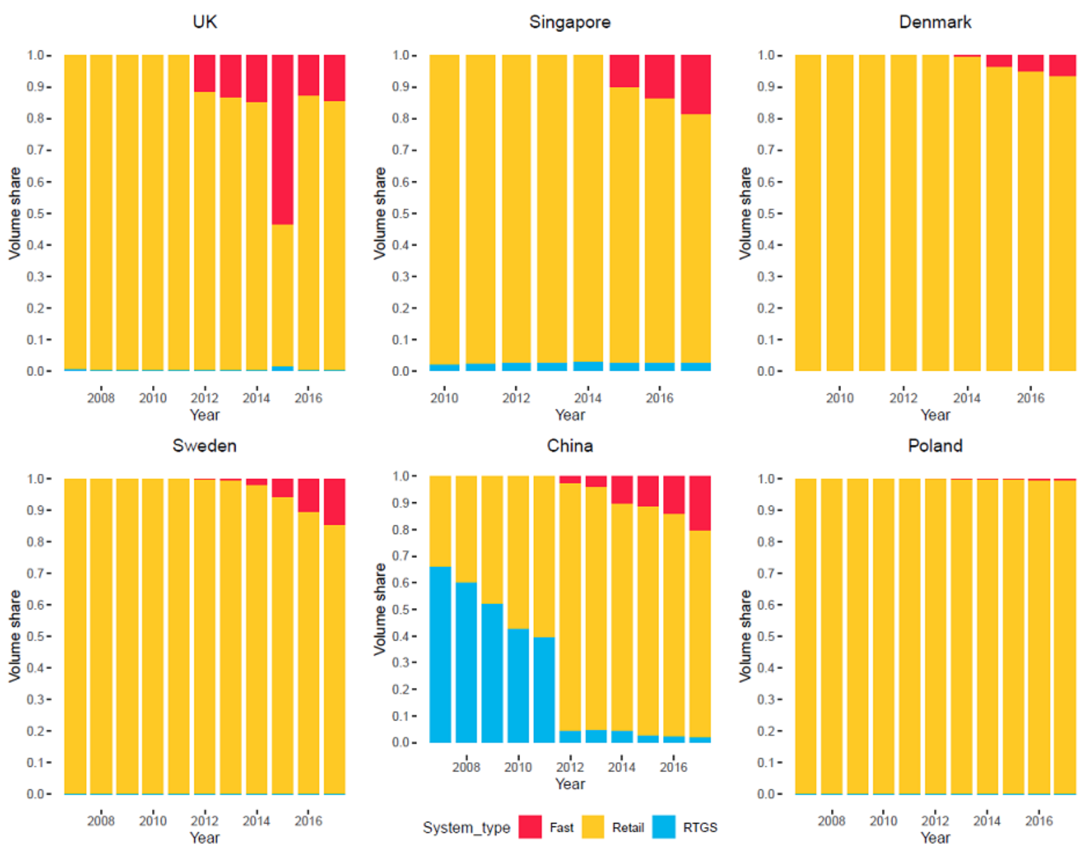
Note: This table contains the coefficients and p-values for the correlation between the average annual growth in volume (column 2) and value (column 3) over 2001–2018 of the main payment instruments used in Canada (AFT credit, AFT debit, cash, cheque, credit card, debit card, Interac e-Transfer, electronic remittance, paper remittance, wire payments) and their six attribute scores. Data sources: LVTS data, ACSS data, CBA, Interac, Tompkins and Galociova (2018) and own calculations. *, **, and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively.

Table 6: Payment system attributes and criteria for ranking

Attribute	Criteria (1 = least desirable for banks; 5 = most desirable for banks)
Timeliness of payment	(1) T+2 or later (2) Next day (3) Same day (4) Multiple intraday, for example, due to queuing (5) Real-time or near-real-time for all payments
Liquidity requirements	(1) RTGS + no offsetting in queue + no uncollateralized intraday credit provision by the central bank, or DNS + immediate finality + collateralized to withstand all defaults. (2) RTGS + bilateral or multilateral offsetting in queue + no uncollateralized intraday credit provision by the central bank. (3) DNS + immediate finality + collateralized to withstand at least a single default + guaranteed settlement, or DNS + collateralized to withstand at least a single default. (4) DNS + uncollateralized intraday credit and no central bank guarantee + system rules dictate how to allocate losses ex post to survivors. (5) DNS + uncollaterialized intraday credit and no central bank guarantee + partial or full unwind in the event of participant default, or any system based on gross settelement fully backed by end-user money.

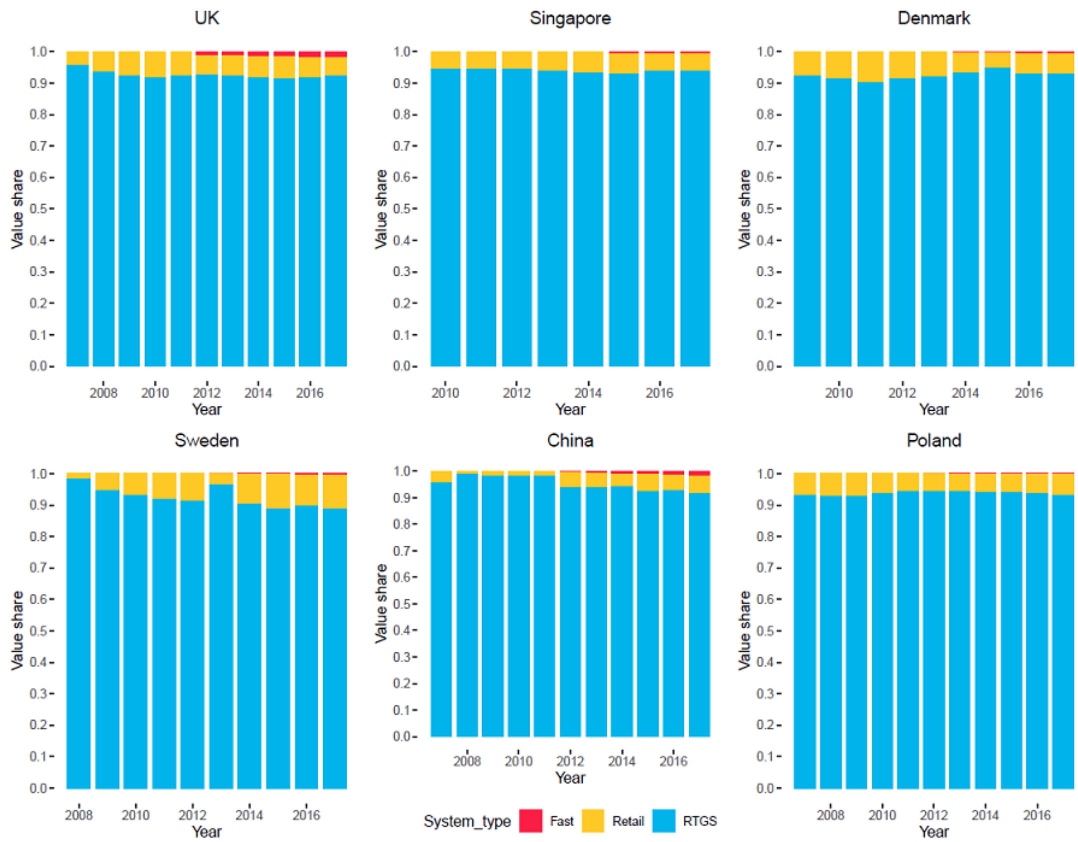
Note: The attributes and scores are inspired by the classification used in Chapman et al. (2015). RTGS = real time gross settlement; DNS = deferred net settlement.

Figure 10: Payment system shares over time (in volume)



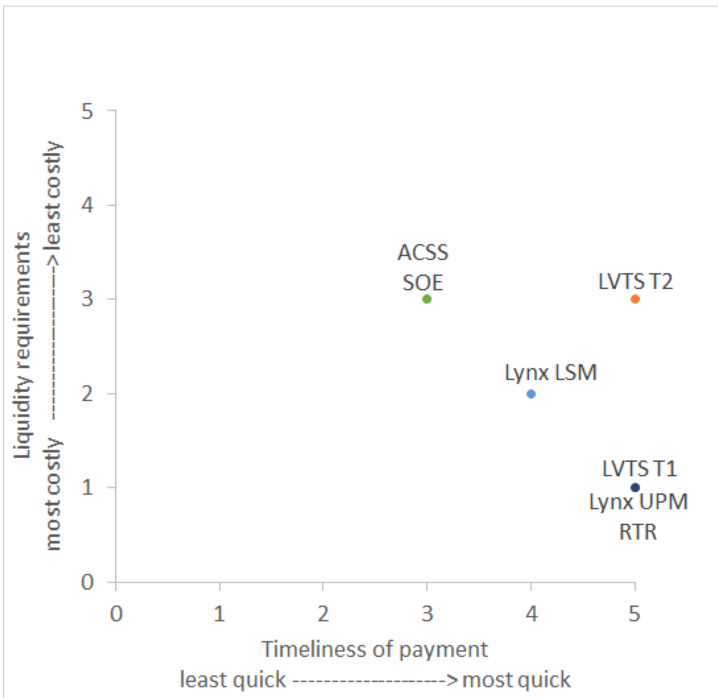
Note: The above figures represent the volume shares of payments processed in real-time low-value systems (FAST), traditional retail systems (Retail) and large-value systems (RTGS) in a selection of countries that have introduced a real-time low-value system in the past decade. Data are taken from the BIS Redbook.

Figure 11: Payment system shares over time (in value)



Note: The above figures represent the value shares of payments processed in real-time low-value systems (FAST), traditional retail systems (Retail) and large-value systems (RTGS) in a selection of countries that have introduced a real-time low-value system in the past decade. Data are taken from the BIS Redbook.

Figure 12: Comparison of current and future payment systems



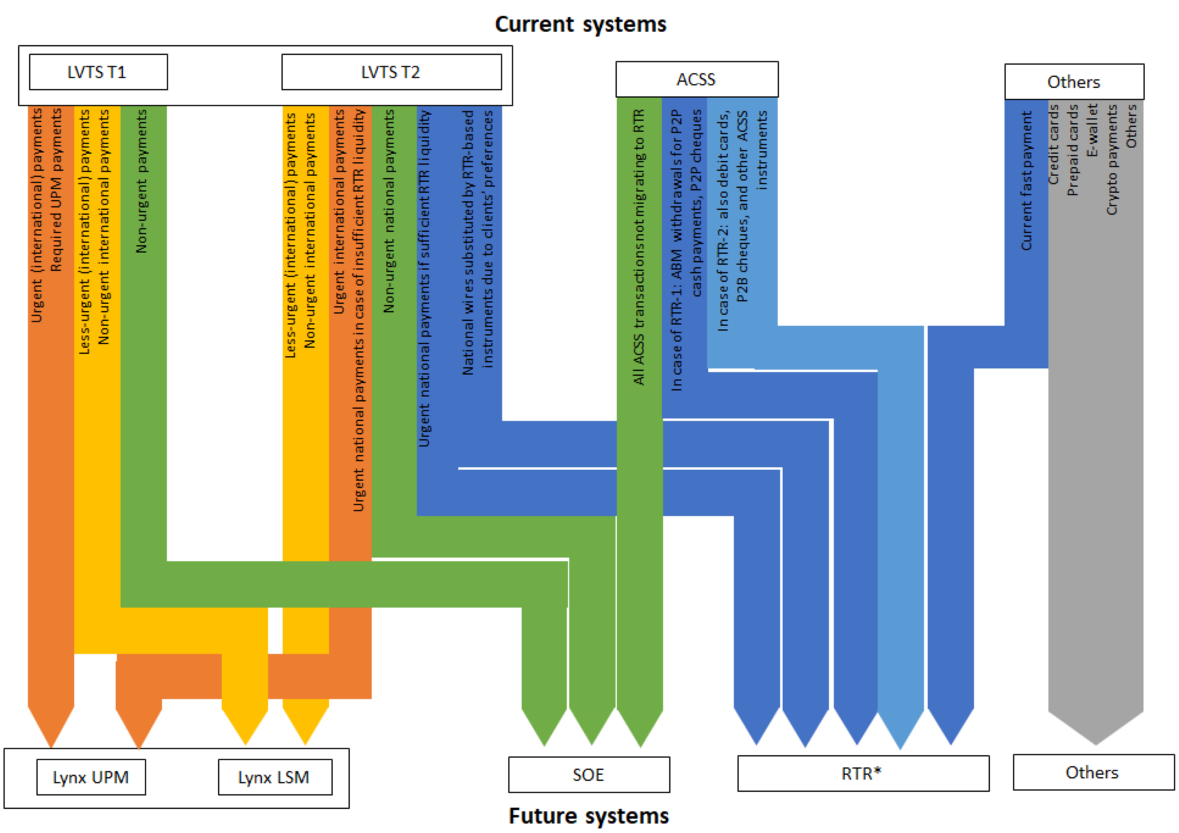
Note: The above figure plots the current and future payment systems based on their speediness of payment and liquidity requirements as described in Table 6.

Table 7: Upper bound of LVTS migration flows to SOE, Lynx and RTR due to banks' preferences

	LVTS Tranche 1	**LVTS Tranche 2**
Value of payments processed in 2018 (CAD million)	CAD 12,158,129	CAD 33,484,684
Estimate of SET and flattening payments (CAD million)	CAD 26,473	CAD 105,891
Total migration potential if not already substituted by RTR by end-users (CAD million)	CAD 12,131,656	CAD 33,378,793
Most likely to migrate to:	Lynx UPM RTR	Lynx LSM SOE
Determining factors	Available liquidity? International payment? RTR value limit?	Criticality? International payment? SOE value limit?

Notes: This table displays the total value of LVTS payments processed in 2018. Estimates of settlement exchange transactions (SET) and flattening payments are based on the share of LVTS payments settled during the pre-settlement cycle, which is when these transactions typically happen. Data source: LVTS.

Figure 13: Overview of expected migration direction of current payments



Notes: This figure summarizes the conclusions drawn in this paper regarding the potential migration direction of payments currently processed in LVTS Tranche 1 (LVTS T1), LVTS Tranche 2 (LVTS T2), ACSS and other ancillary systems. The thickness of the arrows is uninformative and should not be interpreted as an indication of the migration size.

A.2 Definitions and data sources

AFT credit Direct deposits to a bank account. Commonly used by business for payroll transactions. Annual transaction data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

AFT debit Pre-authorized debit to a bank account. Most commonly used for mortgage and other bill payments as well as for funds transfers between consumer and/or business accounts. Recurring often, but can also be sporadic. Annual data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

Cash Coins and bank notes. The annual number and value of cash transactions in 2007, 2008, 2010, 2012–2017 are taken from Tompkins and Galociova (2018). The data for the missing years are estimated using linear regressions.

Cheques, money orders, bank drafts Different forms of paper-based instruments that are handed over by the payor to the payee, which enable the payee to collect the specified amount from its bank.

Credit card Credit card payments made at physical points-of-sale and online stores using a Visa or Mastercard credit card. Data are taken from the Canadian Bankers Association.

Crypto Payments made using cryptocurrencies, such as Bitcoin, Litecoin and Ethereum. Due to data unavailability, the annual number and value of crypto payments made in

Canada are not included in the figures and empirical analyses in this paper.

EDI payment A payment initiated through the electronic data interchange. EDI is often used by large businesses to process business-to-business invoices in an automated way that is integrated with the businesses' back-office systems. Annual transaction data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

Electronic remittance Bill payments initiated in one's online banking environment or by phone that include data related to the recipients' Corporate Creditor Identification Number (CCIN). Annual data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

Interac debit Debit card payments made at physical points-of-sale using the domestic Interac debit scheme. Data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

Interac e-Transfer Funds transfer service owned and operated by Interac and offered to consumers and businesses by their financial institutions. An Interac e-Tranfer payment can be initiated in one's online or mobile banking account 24/7/365, using the email address or mobile phone number of the payee. Once the payee receives and accepts the payment, the money is received in near real time (up to 30 minutes). The annual number and value of Interac e-Transfer transactions are received from Interac.

Interac online Debit card payments made at online stores using the domestic Interac debit scheme. Data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

Online/mobile e-wallet Transfer services that either use prefunded balances (stored in the cloud or on mobile devices) or that are linked to one's deposit or credit card account. Examples include PayPal, Starbucks' wallet and in-app transactions such as Uber or Airbnb. Due to data unavailability, the annual number and value of online/mobile e-wallet transactions made in Canada that were not paid using a credit card are not included in the figures and empirical analyses in this paper.

Paper remittance Bill payments accompanied by a paper bill stub, generally initiated via an automated banking machine (ABM) or at a bank branch. Annual data are taken from the ACSS database and therefore do not include on-us transactions (i.e., transactions between bank accounts at the same financial institution).

Prepaid card Credit card company or store-branded prepaid product, either reloadable or for one-time use, that can be used in physical points-of-sale or online stores. Due to data unavailability, the annual number and value of prepaid transactions made in Canada are not included in the figures and empirical analyses in this paper.

Wire transfer A payment processed in the Large Value Transfer System (LVTS). Consumers can initiate a wire payment by visiting a bank branch, whereas businesses can initiate wires online. Annual wire transaction data are taken from the LVTS database.

A.3 Description of payment system attributes

Access Access describes what entities can participate in the payment system. Access can be as narrow as only banks to as wide as non-financial corporations.

Cover-1 A credit risk model that ensures that the single largest credit exposure in the system is covered with ex-ante financial resources.

Cover-all A credit risk model that ensures that every single exposure is covered ex-ante with financial resources.

Defaulter pay system A system in which every payment is covered with collateral. In this case, any shortfalls caused by a default will be absorbed by the collateral that the defaulter had pledged ex-ante, leaving the surviving participants free from absorbing losses. By construction, cover-all systems are defaulter pay systems.

DNS Deferred net settlement. In a DNS system, payment obligations are settled at a later time than when they are submitted. The time and frequency of this settlement varies depending on the system rules and procedures. Payments are netted across each other, as a result of which collateral requirements are lower. However, due to the delay in settlement, exposures might build up intra-day and present credit risk in the system if a participant becomes unable to settle its end-of-day balances. For DNS systems, payments may not be received until later when they are settled.

LSM Liquidity saving mechanism. LSMs can be employed in a payment system to allow participants to trade off settlement delay for optimizing liquidity costs. Most common LSMs include queueing and payment offsetting, where payments are stored for a period of time and netted with other payments before being settled. Some LSMs allow participants to prioritize payments in a queue to ensure urgent payments in a queue are settled faster than non-urgent payments. LSMs have a direct impact on the required liquidity in a system, as they allow participants to recycle liquidity via the netting in the queue. In addition, LSMs impact the timeliness of payments. The longer a payment sits in the queue, the longer it takes to settle. Hence, there exists a clear trade-off with LSMs between higher (lower) liquidity costs versus lower (higher) potential for delays in payment finality.

RTGS Real time gross settlement. In a pure RTGS, payments are settled once submitted and immediately received by the recipient. As a result, there is no possibility of netting payments against each other, which means that collateral requirements are generally larger in RTGS systems than in DNS systems. In addition, since payments are settled immediately, the potential of credit risk is greatly reduced and in most cases eliminated.

Survivor pay collateral pool A collateral pool to which all participants together contribute, which implies that all the surviving participants share the losses in case of a default.

Type of transactions supported The type of transactions supported by a system is often determined by the design of the system, regulatory requirements and the rules set by the operators. Types of transactions include interbank payments, end-user payments, settlement of ancillary systems as well as payments to the central bank.

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