Best Before? Expiring Central Bank Digital Currency and Loss Recovery[1]

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[1]Views expressed do not necessarily reflect official positions of the Bank of Canada.

Introduction

An important advantage of physical cash: Payment can be made when internet is down.

- Remote locations
- Natural disasters
- Cyberattacks or technical failures
- Temporary lack of connectivity

Want similar offline capability in electronic cash substitute. Argues for device based storage.

The Double-Spending Problem

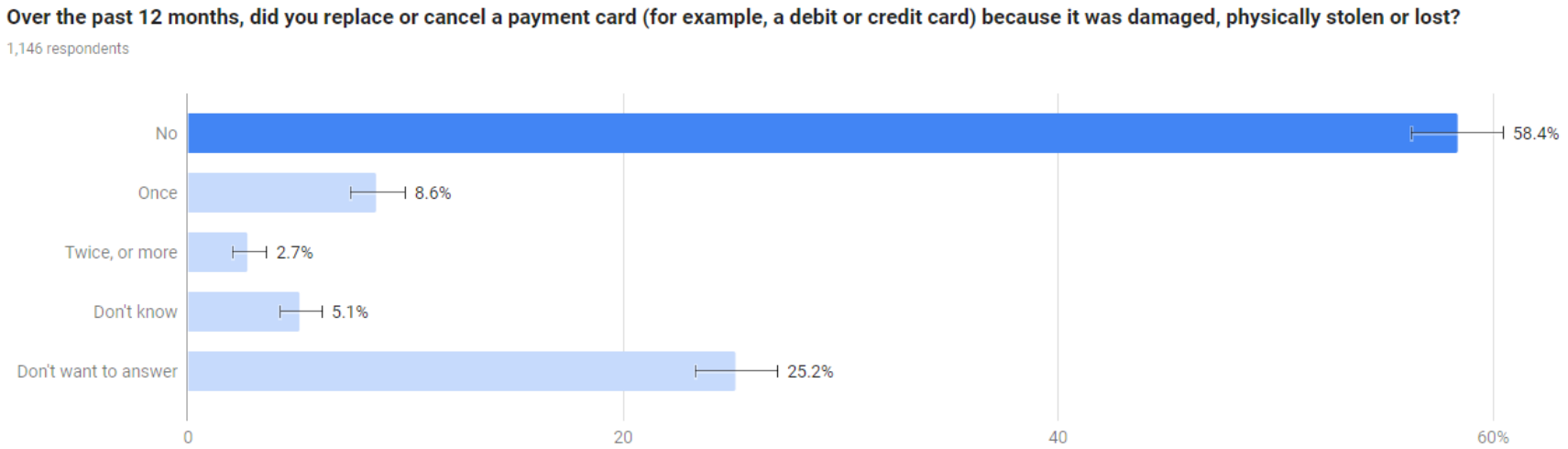
Why not store a backup of the money?

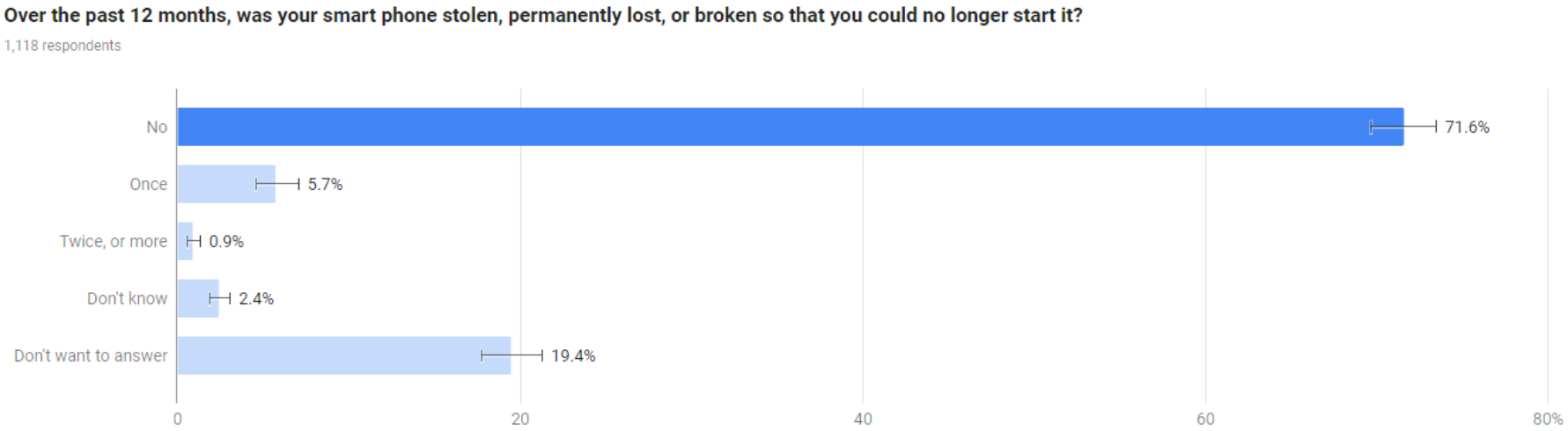
- Customer will want to spend his offline balances, claim his device was lost, and go back to reuse his online balance.
- Ruling out double-spending requires
  - storing balances uniquely in (tamper-resistant) device, and
  - separation of funds that may be spent with device

Consequence: Loss of device implies loss of funds...

Risk of Loss: Some survey evidence in the US

Probability of losing balance during a year:
on card ±16%, on phone ±8%
(source: authors' online survey)

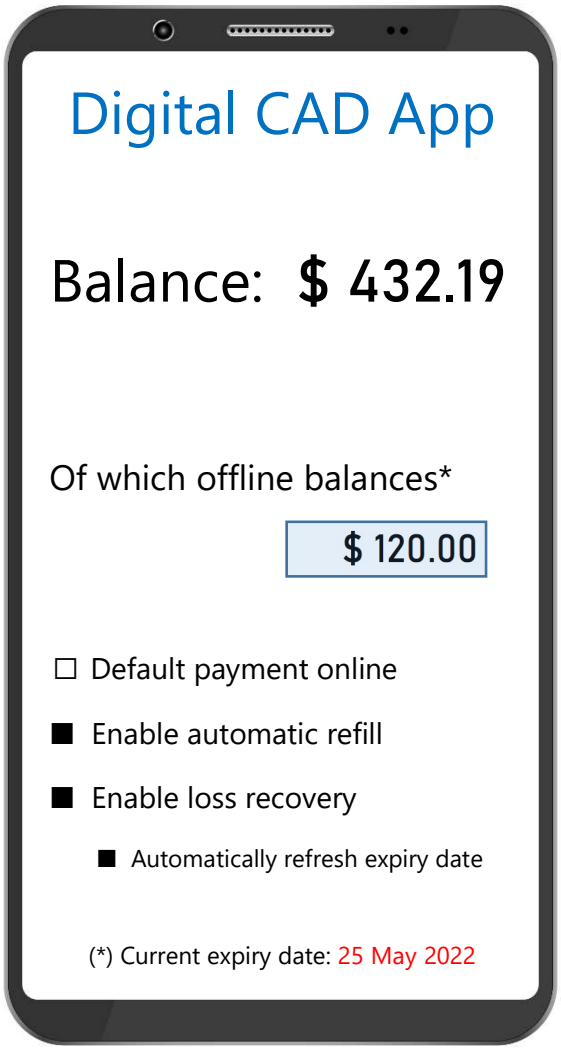




Loss recovery to reduce the risk

- Can we reduce the cost of losses in case of a digital cash substitute?
- **This paper:** Yes, we can do so seamlessly with an expiry date
- Automatically reimburse consumers for expired offline balances
- Some interesting economic questions:
  - Information sharing between devices and the central bank?
  - How to optimally set the expiry date?

Idea in a nutshell



How Much Information to Share?

Ok. Expired cash gets reimbursed.

But who "lost" the cash?

We consider two information models:

- **"Higher privacy"**
  - Syncing payer's device with unspent cash does not reveal whether and where payer spent offline balances
  - Onus is on payees to deposit balances before expiry date
- **"Lower privacy"**
  - Syncing device reveals whether and where payer spent offline balances.
  - Payee still needs to deposit balances before expiry date
  - If payer's device reveals offline balances were used to pay a payee without being deposited, then that payee is reimbursed

Summary of results

- Loss recovery based on introducing an expiry date could have a substantial positive impact on consumer demand for offline digital currency balances.
- More information-sharing between consumers and the central bank can improve loss recovery but has an ambiguous impact on social welfare and may actually reduce it.
- The cost of setting a longer than optimal expiry date is small; setting an expiry date that is too short has a large negative impact.

Small model

Goal: Illustrate trade-offs of expiry date in an outage event.

Cash: ("offline money") a bearer instrument that can be used for offline payments

- e.g., stored-value in a payment card or smartphone chip

Cash allows for payments during outages, but is subject to losses.

Timeline: $t = 0$

At $t = 0$, the consumer decides how much cash to hold

- Online balances pay interest i but offline ones do not

A random preference shock realized:

- Consumer may want to consume 1 or 2 units

Timeline: $t = 1$

Two independent random shocks realized

- An outage disrupting network connection may occur
- Consumer may loses offline money.

The consumer buys the good from the producer

- Use online deposit if no outage, only offline cash if outage
- Consumption bounded by balances

Consumer can deposit the offline cash back if no outage

Timeline: $t = 2, 3$

At $t = 2$:

- Outage ends if there is one
- Producer may lose offline cash with probability η
- withdraw/deposit cash and online payments arrive

At $t = 3$, everybody enjoys counting their money

No expiry date (physical cash)

If paid with online payments, competitive producers charge

$$p_d = 1$$

If paid with cash payments, competitive producers charge

$$p_c = \frac{1}{1-\eta}$$

Producers need to be reimbursed for potential cash losses; thus consumer's default payment instrument is online.

Parameter restriction $\nu > p_c$ to ensure that there are gains from trade in using cash to purchase during an outage.

No expiry date (physical cash)

Cash holdings

Hold cash to purchase 1 or 2 units if the benefit exceeds the cost.

- Benefit comes from consumption in the outage
- Cost includes forgone interest and costs from a loss

Bring enough for the second unit is more demanding

- Only with some probability one wants to consume 2

Social welfare (expected # units consumed per consumer)

Cash expires quickly (shelf life: 1 period)

Offline cash expires in period 2 before producer can deposit

- Automatically reimburse to the consumer

Producers reject cash and no transactions occur during outages...

Social welfare (expected # units sold per consumer)

- Same as no-cash

High privacy and slow expiration (shelf life: 2 periods)

Acceptance: All offers as if there is no expiration date.

Cash holdings:
May hold more cash because the cost of loss is reduced

- One can get the money back but with some delay

Social welfare improves under certain parameters

Low privacy and slow expiration (shelf life: 2 periods)

Consumer's device reveals where he spends the money

After an outage, would consumers be willing to reconnect?

- Consumers who spent all offline cash do not reconnect
- Consumers who have unspent cash reconnect iff $i \geq \eta$.

Two situations:

- If $i \geq \eta$, some producers charge lower "cash" prices because of reimbursement for cash losses: *may improve social welfare*
- If $i < \eta$, increase in cost of precautionary cash holdings... *reduce social welfare*

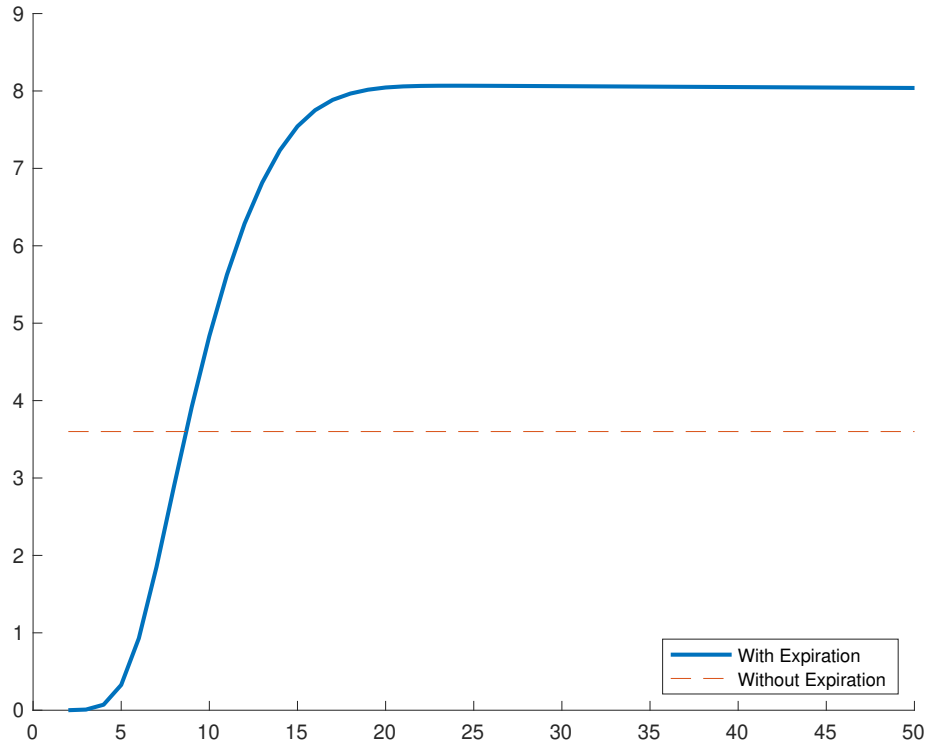
Calibration

Parameter	**Daily value**	**(annualized)**
Discount factor (β)	0.99990	0.96
Risk aversion (σ in $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$)	0.70	
Loss probability consumer (δ)	0.0004858	0.162
Loss probability producer (η)	0.0004858	0.162
Outage probability (λ)	0.00061	0.20
– Length: Poisson distribution	6.375	0.0175

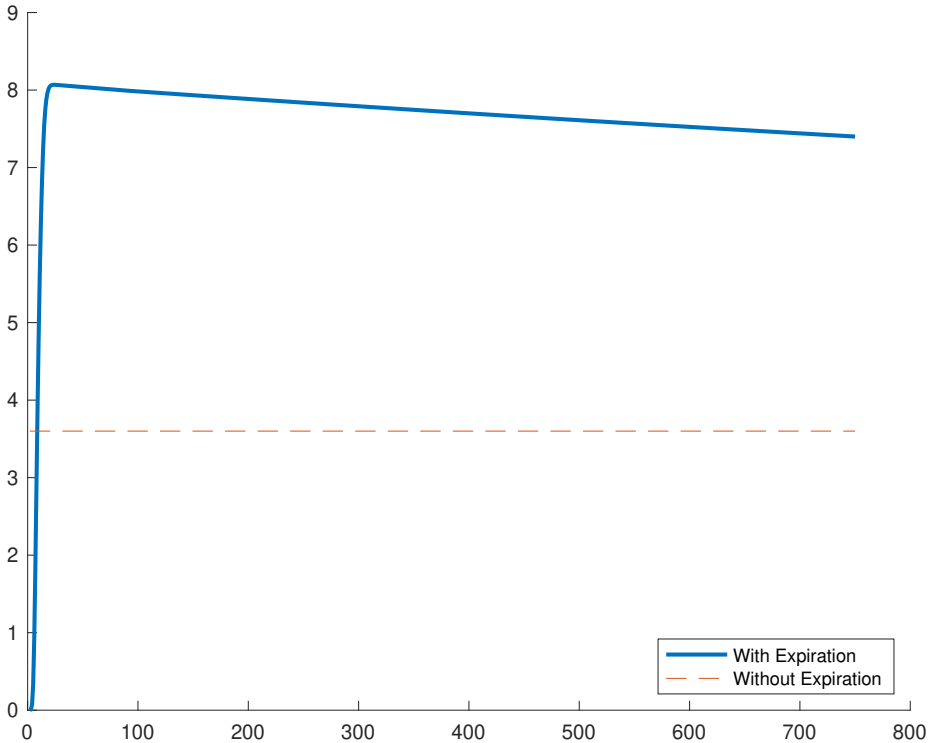
Conduct online survey: 16.2% (8.4%) people lost or damage card (phones) in the previous year

Cash holdings with expiry date and privacy

Shorter expiration dates (0-50 days)

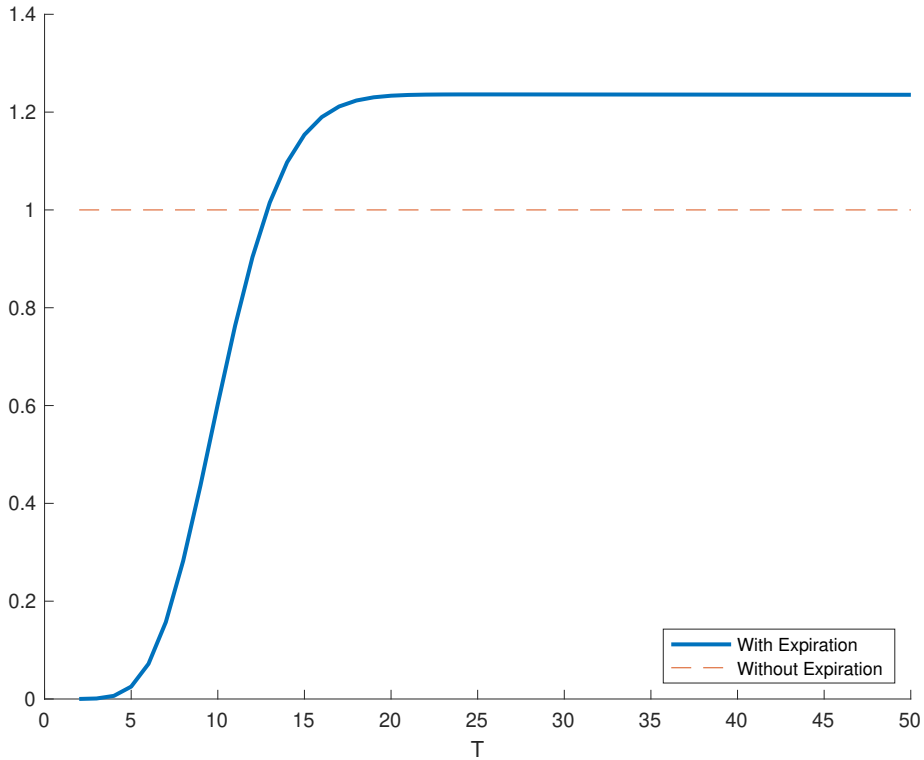


Longer expiration dates (0-750 days)



Consumer welfare with expiry date and privacy

Shorter expiration dates (0-50 days)



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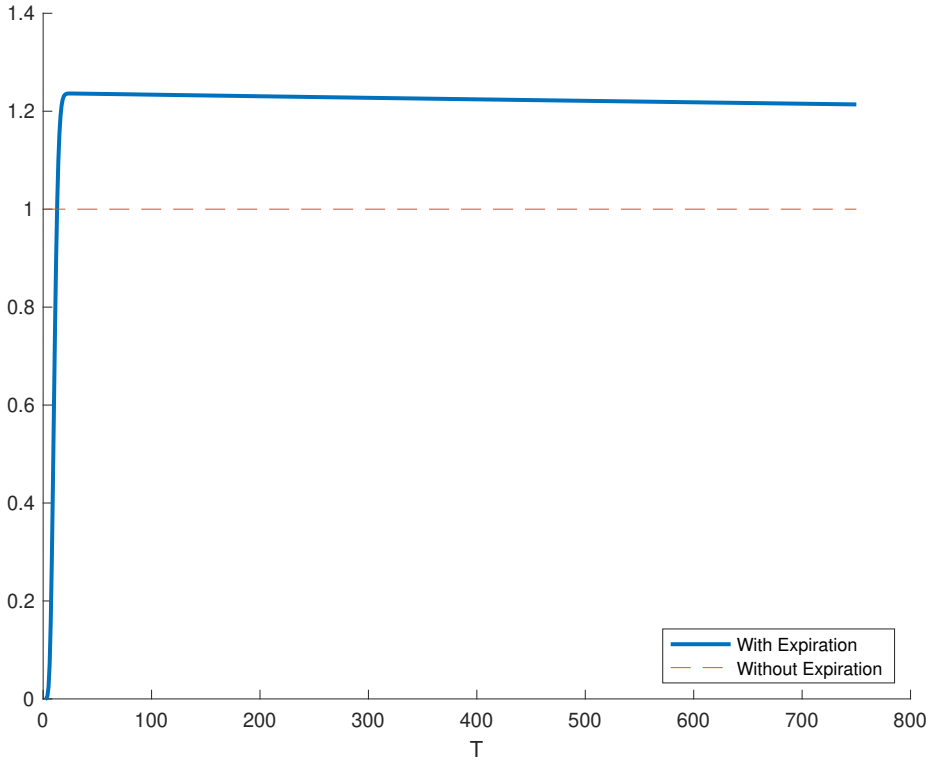

Concluding remarks

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- The cost of setting a longer than optimal expiry date is small; setting an expiry date that is too short has a large negative impact.
- More information sharing between consumers and the central bank can improve loss recovery but has an ambiguous impact on social welfare.