Simulating the Adoption of a rCBDC

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About FNA

FNA is a leader in advanced network analytics and simulation.

FNA's software is used to uncover hidden connections and anomalies in large, complex datasets, to predict the impact of stress events, and to optimally configure financial systems and infrastructures.

FNA is trusted by the world's largest central banks, government authorities, commercial banks and financial infrastructures.

- Monetary Authority of Singapore
- US Department of Defense
- Payments Canada
- Hong Kong Monetary Authority
- The World Bank
- CLS Group
- RTGS.global
- ICE Clear Credit
- The Clearing House
- Bank for International Settlements
- Giesecke + Devrient
- UK Finance
- Banco de la República-Colombia
- Fnality
- Bank of England

About today

- Main takeaways
- Why should central banks simulate rCBDC?
- Agent-based simulation of rCBDC adoption
- rCBDC Spanish market adoption
- Further work

Main Takeaways

Main takeaways

- Simulating rCBDC adoption can help central banks to iterate design options.
- Without attractive design features or stimulus policies, we found low adoption of rCBDC.
- Reverse waterfall functionality, government payments, and positive remuneration spread can increase rCBDC adoption.
- Balance limits, top-up limits effective to restrain rCBDC adoption.
- In general, rCBDC won't compete with cash but with deposit-related payment instruments—unless the government fosters targeted use of rCBDC

Why should central banks simulate rCBDC?

CBDC - Many Stakeholders with Many Interrelated Concerns

100+ countries are exploring CBDC, of which 26 are in development, and 15 are making pilots*

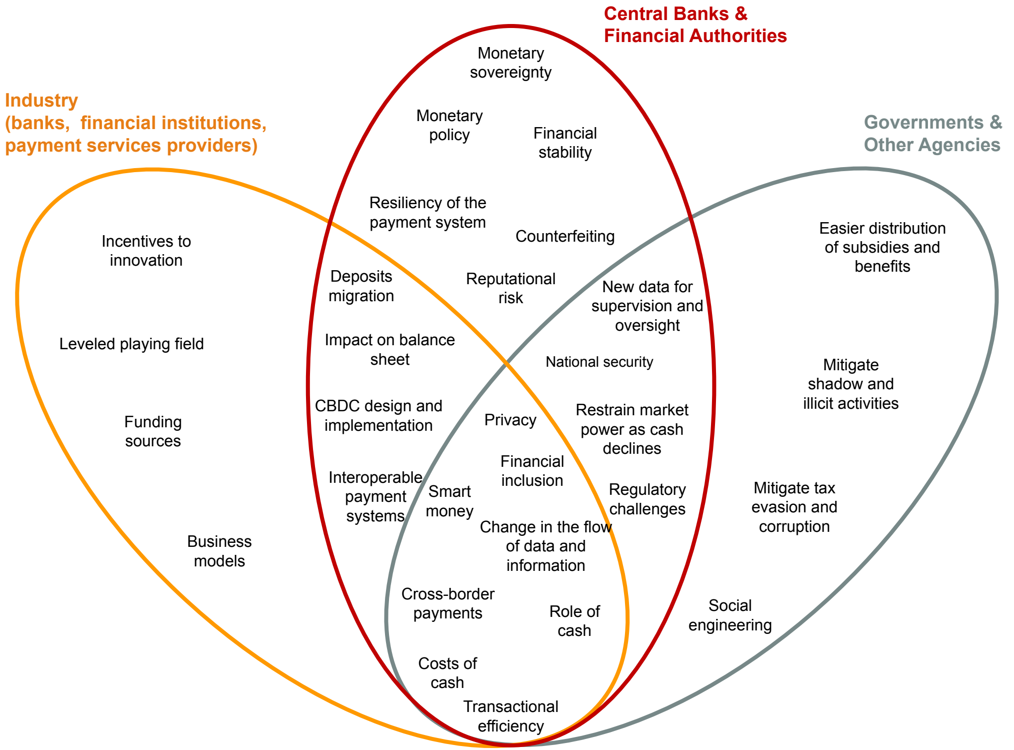
What model are we looking for?

A model of selected macro-financial effects from deploying a CBDC

A parsimonious and tractable model that enables scenario analysis

A modular, flexible and extendable modelling approach

To add new features and answer new questions opportunely



Our Goals

Shed light on crucial macro-financial and payments questions

Measure the impact on the economy, financial system and payment ecosystem

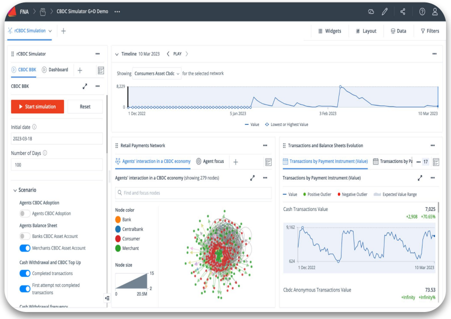
Analyse and substantiate the design of CBDCs

Encourage research on CBDC

(*) Sources: Atlantic Council (https://www.atlanticcouncil.org/cbdctracker/) and CBDC Tracker (https://cbdctracker.org)

Learning by simulation - rCBDC simulation is the key to modelling the impact of CBDC introduction on the economy and the payment ecosystem

FNA



Design | Validate | Optimize

- Learning by doing and simulation with FNA's out-of-box **maximum virtual product** to reduce rCBDC project risk and accelerate the time to value
- It enables **effective communication** and **shared understanding** among stakeholders by **visualising insights** through **interactive** user interfaces
- It allows central banks and market participants to **design a safe and efficient CBDC** by testing **multiple policy** inputs and **tailored CBDC** configurations

Learning by doing and simulation	Substantiates qualitative analysis with quantitative insights	Is modular - and configurable for specific features of each jurisdiction
Is data agnostic - and configurable on publicly available and proprietary data	Is technology agnostic - and compatible with any infrastructure underpinning a CBDC	Provides value beyond the design phase - and crucial for continuous monitoring and stress testing

Agent-based simulation of rCBDC adoption

Anything in common?

Forest fires

Ants

Retail payments

Yes. To understand them, it is better to simulate.

Anything in common?


Forest fires


Ants


Retail payments

Yes. They are complex adaptive systems.

- **Large number of individuals (i.e., agents)…**
- **That interact and adapt or learn…**
- With the **emergent (aggregate) behavior** neither explained nor predicted by individual behavior…
- Which commonly show several features, such as
  - **Path dependence** (i.e., particularly sensitive to changes in initial conditions)
  - **Non-linearity** (i.e., size of input change is unrelated to size of output change)
  - **Self-organization** (i.e., without an authority, the system tends to organize)
  - May display **phase transitions** (i.e. tipping points)
  - Do not operate under equilibrium

This is why top-down approaches are not very helpful to understand the adoption of an rCBDC—or other type of digital currency.

(*) In bold, this is the definition of Holland (2006)

Anything in common?

Forest fires

Ants

Retail payments

One good way to model them is Agent Based Models (ABM).

They comply with the four key assumptions of ABM:

- **Each agent is autonomous**: no central agent organizes the system top-down (i.e., self-organization)
- **Agents are interdependent**: agents are influenced by other agents and by the environment
- **Agents follow simple rules**: simple behavior by the agents leads to non-simple emergent behavior
- **Agents are adaptive and backward-looking**: agents adapt by learning from their history

Agent-Based Models in Money & Banking

2006

Congestion and Cascades in Payment Systems

FRBNY

Walter Beyeler
Kimmo Soramäki
Robert Glass
Morten Bech

2008

An agent-based model of payment systems

BoE

Marco Galbiati
Kimmo Soramäki

2008

Exploring ABM for the analysis of payment systems

BoI

Luca Arciero
Claudia Biancotti
Leandro D'Aurizio
Claudio Impenna

2016

Macroprudential policy in ABM of the UK housing market

BoE

Rafa Baptista
J Doyne Farmer
Marc Hinterschweiger
Katie Low
Daniel Tang
Arzu Uluc

2018

ABM of system-wide implications of funding risk

ECB

Grzegorz Hałaj

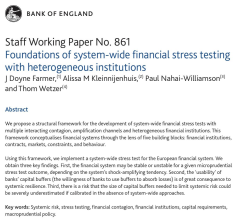
2019

System-wide stress simulation

BoE

David Aikman
Pavel Chichkanov
Graeme Douglas
Yordan Georgiev
James Howat
Benjamin King

Agent-Based Models in Money & Banking

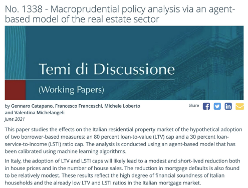

BANK OF ENGLAND

Staff Working Paper No. 861

Foundations of system-wide financial stress testing with heterogeneous institutions

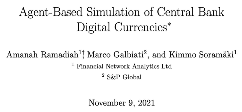
J Doyne Farmer,[1] Alissa M Kleinnijenhuis,[2] Paul Nahai-Williamson[3] and Thom Wetzer[4]

Abstract


No. 1338 - Macroprudential policy analysis via an agent-based model of the real estate sector

Temi di Discussione

(Working Papers)


Agent-Based Simulation of Central Bank Digital Currencies*

Amanah Ramadiah[1†], Marco Galbiati[2], and Kimmo Soramäki[1]

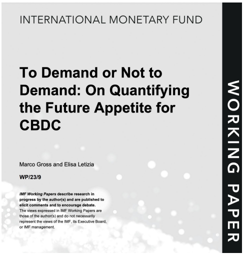
[1] Financial Network Analytics Ltd

[2] S&P Global

November 9, 2021


UNIVERSITY OF TWENTE.

Adoption and Implications of CBDC: An Agent-Based Modelling Approach

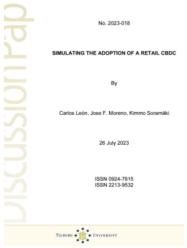

INTERNATIONAL MONETARY FUND

To Demand or Not to Demand: On Quantifying the Future Appetite for CBDC

Marco Gross and Elisa Letizia

WP/23/9

WORKING PAPER


No. 2023-018

SIMULATING THE ADOPTION OF A RETAIL CBDC

By

Carlos León, Jose F. Moreno, Kimmo Soramäki

26 July 2023

ISSN 0924-7815

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2020

Foundations of system-wide financial stress testing with heterogeneous institutions

BoE

J Doyne Farmer

Alissa M Kleinnijenhuis

Paul Nahai-Williamson

Thom Wetzer

2021

Macroprudential policy analysis via ABM of the real sector

BoI

Gennaro Catapano

Francesco Franceschi

Michele Loberto

Valentina Michelangeli

2021

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U. of Twente

Menno Martens

2023

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IMF

Marco Gross

Elisa Letizia

2023

Simulating the Adoption of a rCBDC

FNA

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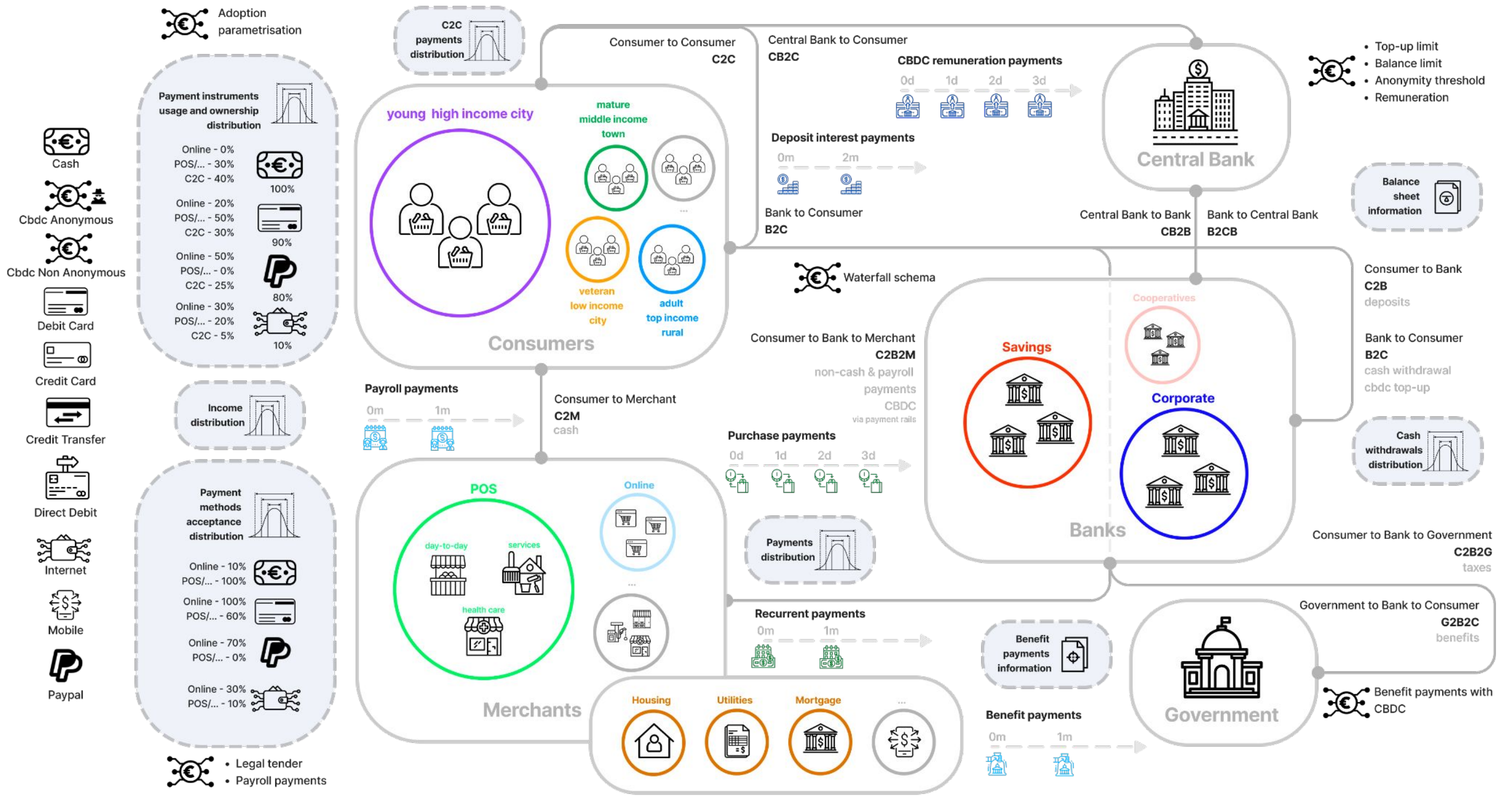
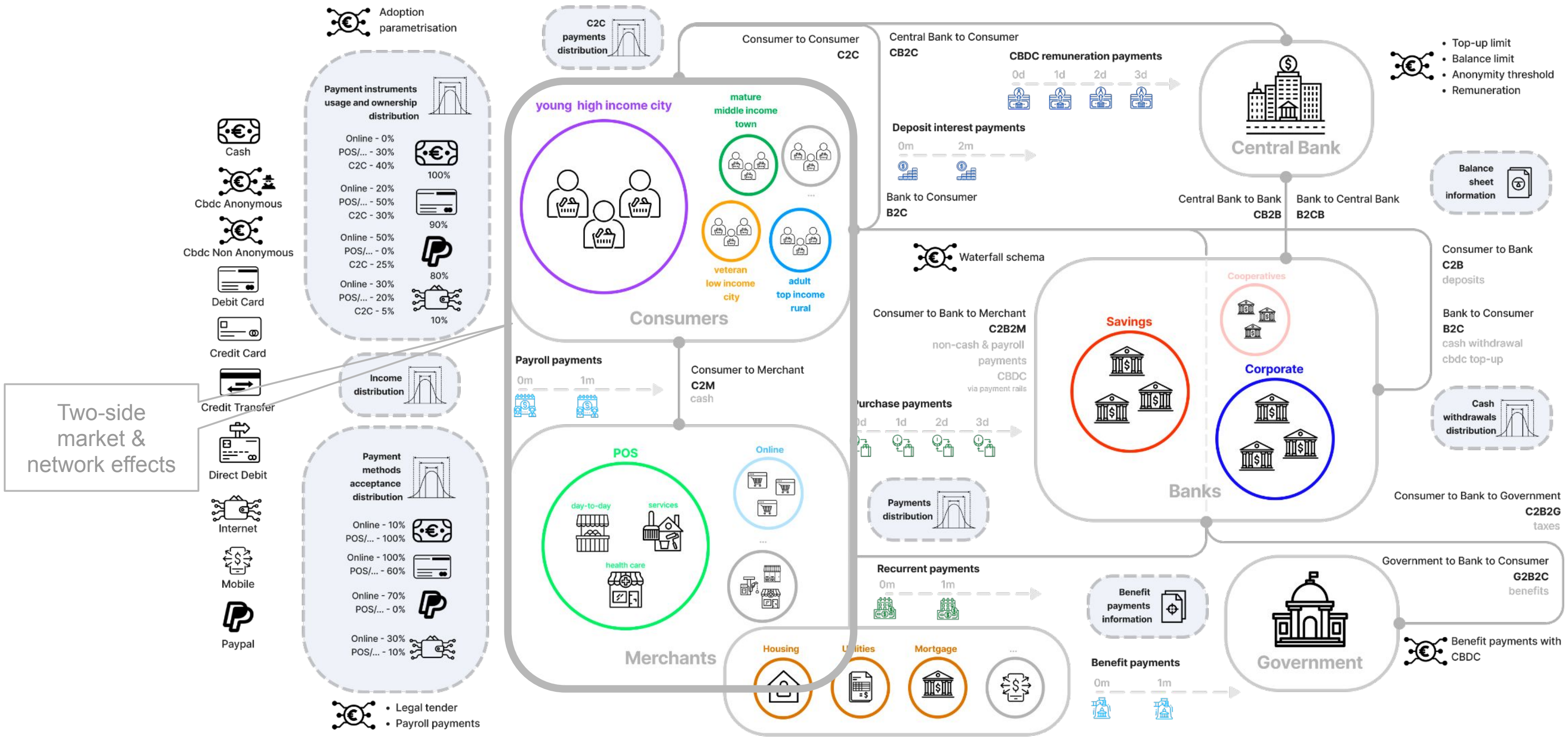
rCBDC ABM: consumer, merchant and bank personas provide heterogeneous decision-making and get us closer to the payment ecosystem



rCBDC ABM: consumer, merchant and bank personas provide heterogeneous decision-making and get us closer to the payment ecosystem



CBDC Simulation Inputs

Payments statistics, surveys, diaries
Distribution of number and amount of retail payments

Income distribution
Income distribution in your economy, e.g GDP per capita, Gini distribution, household surveys

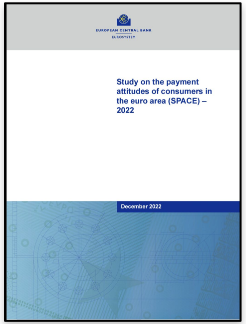
Payment instruments usage
The proportion of transactions that are settled in different payment instruments

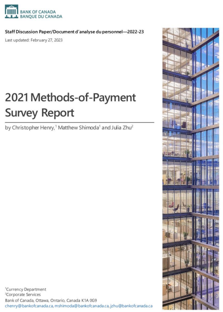
Payment instruments acceptance
Merchants' acceptance ratio of payment instruments

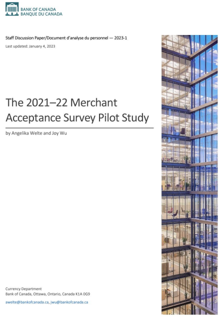
Banks' statistics
Aggregated balance sheet information, assets returns, deposits interest rate

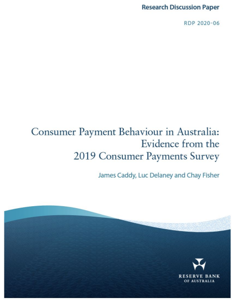
Policy instruments
CBDC top up, balance and anonymity limits, CBDC two-tier interest rate, scenarios configuration

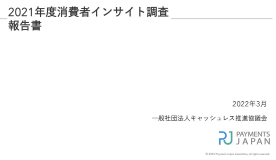
CBDC Simulation Inputs - What info do you need?

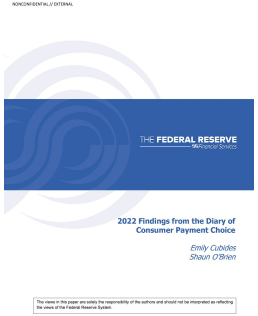


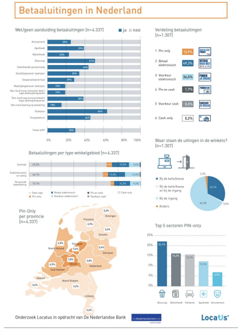


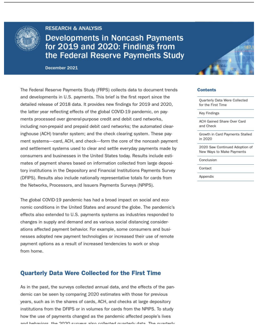


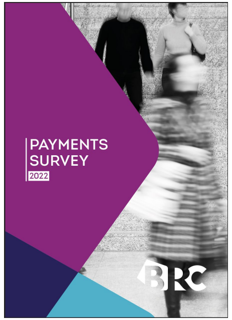












Main Inputs – to calibrate and configure

Example

Consumer personas

- Age: Young (18-24), Adult (25-44), Mature (45-64), Veteran (64-)
- Income: Low (0-1500), Middle (1500-3000), High (3000-6000), Top (6000-)
- Location: Rural, City, Town

→ Payment instruments access and usage; Monthly income range; Withdrawal value and frequency

Example

Merchant personas

- Supermarkets
- Entertainment
- Restaurants and delivery
- E-commerce
- Services
- Housing (R)
- Health care
- Utilities (R)

→ Payment instruments acceptance; (R) Recurrent merchants

Payment instruments

- Debit card
- Credit card
- Direct Debit
- Mobile
- Cash
- Credit transfer
- Internet
- Paypal

→ **Retail payments data**

Distribution of payments value per merchant (and consumer) persona

Distribution of payments number per merchant (and consumer) persona

Payment instrument usage weight per consumer (and merchant) persona

rCBDC design and simulation configuration options

rCBDC
Design options

- Anonymity
- Remuneration
- Balance limit
- Top-up limit
- Government incentives
- Legal tender
- Consumer personas usage affinity

Simulation
Configuration

- Multiple banks
- Bank personas
- Balance sheet modelling
- P2P payments
- Recurrent Payments

Example

Bank personas

Corporate
Consumer
Credit cooperatives
Others

CBDC Simulation Scenarios

Merchant adoption scenarios
Legal tender scenario
Two-side market adoption
Merchants payments with CBDC?

Consumer adoption scenarios
Privacy and anonymity
Government or Central bank incentives
Merchant incentives

CBDC balance sheet scenarios
CBDC waterfall behaviour
Merchants CBDC holdings
Banks CBDC holdings

Disintermediation scenarios
CBDC balance and topup limits
CBDC two-tier (or not) remuneration rate

CBDC topup scenarios
Income/salary transfer to CBDC
Cash-like CBDC topups

Commercial bank balance sheet scenarios
Driven by margin
Driven by solvency
Central Bank facilities

CBDC Simulation Outputs

Adoption rate
The pace at which CBDC is acquired and used by the public (financial inclusion effect)

Composition of consumers' wealth
The amount of asset, cash, CBDC, deposit in consumers' portfolios

Diffusion of payment instruments
The proportion of transactions that are settled in card, cash, or CBDC

Banking disintermediation
The amount of bank deposits that are migrated to CBDC.

Banks balance sheet
The composition of asset side (e.g., reserves, cash) and liability side (e.g., deposits)

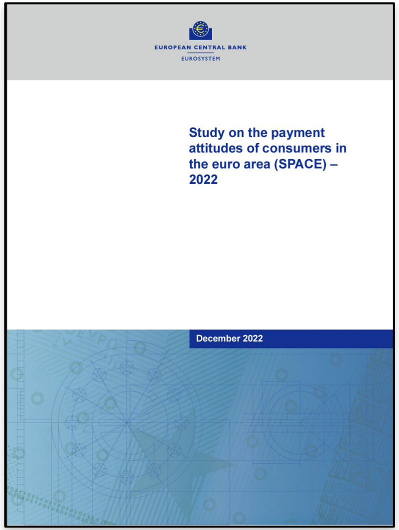
Scenario analysis
Comparing the impact of different design choices and initial conditions

rCBDC Spanish market adoption

ECB Space Survey Data 🇪🇸

Merchant personas 26

	Medicine	Home	Street
	Clothes	Travel	Insurance (R)
Durables	Day-to-day	Charity	Loans
Entertainment	Transport	Vending Machines	Rent / Mortgage
Outhome services	Petrol	Home services	Taxes
Luxury	Financial	Restaurants	Phone / Internet
Public	Subscriptions	Utilities	Other


EUROPEAN CENTRAL BANK
EUROSYSTEM

Study on the payment attitudes of consumers in the euro area (SPACE) – 2022

December 2022

Consumer personas 20

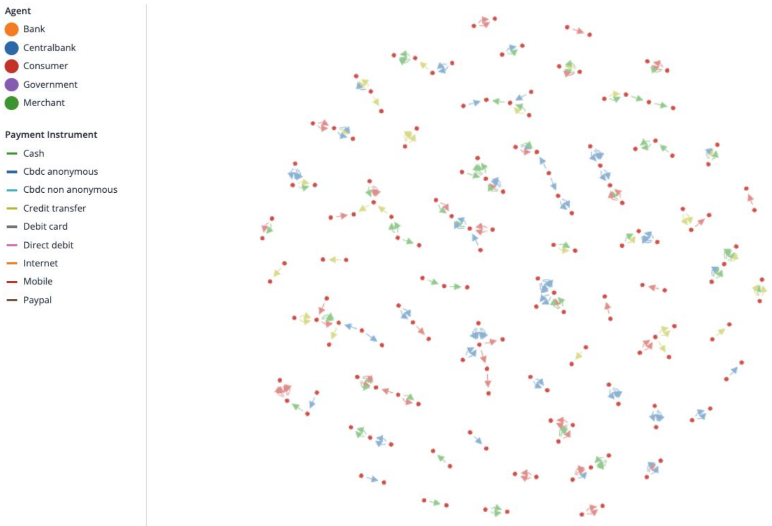
Age: Young (18-30), Adult (31-50), Mature (51-70), Veteran (71-)

Income: Low (0-750), Middle (751-1500), High (1501-2500), Very High (2501-4000), Top (4001-)

Payment instruments

Cash	Credit transfer	Mobile
Cards	Direct Debit	Internet
Paypal	CBDC anon.	CBDC non-an.

C2M and C2C networks



Extracted from the 180th day of the basic scenario simulation.

Scenarios

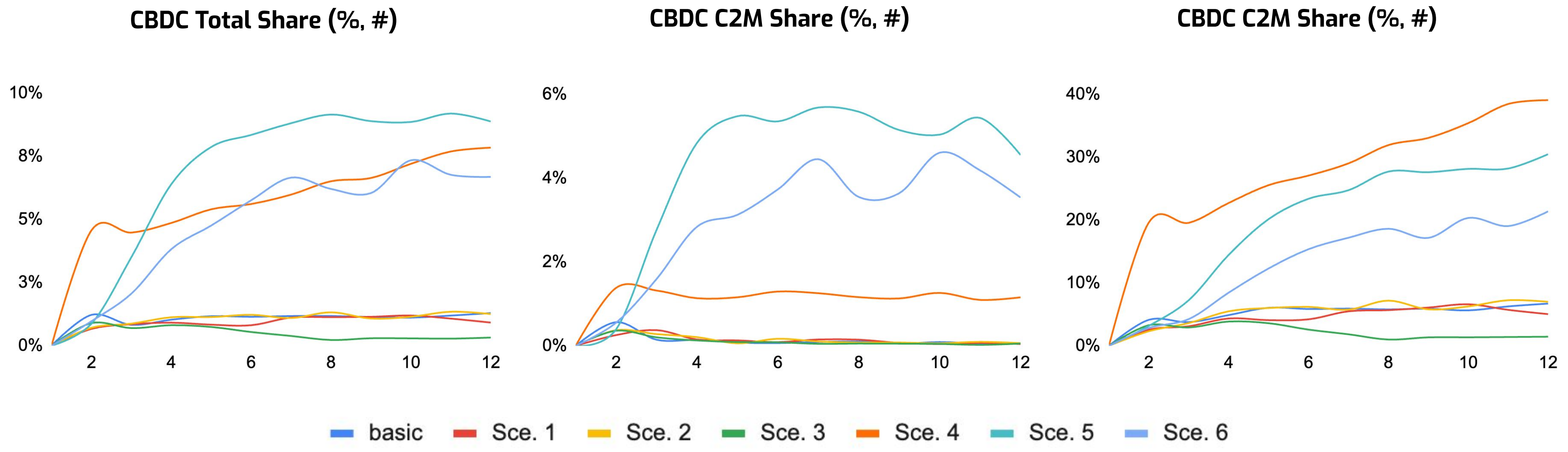
Design options	Baseline	Basic	Sce. 1	Sce. 2	Sce. 3	Sce. 4	Sce. 5	Sce. 6
Legal tender	NA	**Yes**	Yes	Yes	Yes	Yes	Yes	Yes
Balance limit	NA	**€3,000**	€3,000	€3,000	€3,000	€3,000	€3,000	**€1,000**
Top-up limit	NA	**NA**	**€500**	NA	NA	NA	NA	NA
Anonymity threshold	NA	**∞**	∞	**€200**	∞	∞	∞	∞
Reverse Waterfall	NA	**Yes**	Yes	Yes	**No**	Yes	Yes	Yes
Government benefits	NA	**NA**	NA	NA	NA	**Yes**	NA	NA
Remuneration spread	NA	**NA**	NA	NA	NA	NA	**Yes**	**Yes**

Adoption Scenarios Comparison

Scenario	Cash	rCBDC		Cards	Credit transfer	Direct debit	Internet	Mobile	Paypal
		anonymous	non-anon.						
Baseline	24.77%	0.00%	0.00%	46.93%	5.34%	6.80%	0.03%	13.41%	2.71%
Basic	25.08%	1.29%	0.00%	45.87%	5.19%	6.41%	0.02%	13.73%	2.40%
1	23.34%	0.91%	0.00%	47.06%	5.03%	6.60%	0.01%	14.29%	2.75%
2	25.64%	1.23%	0.02%	46.46%	4.70%	6.68%	0.00%	12.76%	2.51%
3	27.20%	0.32%	0.00%	44.50%	3.91%	6.48%	0.01%	15.08%	2.50%
4	10.93%	7.84%	0.00%	49.06%	5.76%	7.59%	1.14%	13.98%	3.70%
5	29.62%	8.88%	0.00%	39.61%	4.09%	5.48%	0.00%	10.41%	1.92%
6	28.67%	6.68%	0.00%	41.00%	4.27%	5.99%	0.02%	11.41%	1.95%

Payments made during the last month of the simulation, as per cent of the number of payments.

Adoption Scenarios Comparison



Main takeaways

- Simulating rCBDC adoption can help central banks to iterate design options.
- Without attractive design features or stimulus policies we found low adoption of rCBDC in the Spanish retail payments ecosystem.
- Reverse waterfall functionality, government payments, and positive remuneration spread can increase rCBDC adoption.
- Balance limits, top-up limits effective to restrain rCBDC adoption.
- In general, rCBDC won't compete with cash but with deposit-related payment instruments—unless the government fosters targeted use of rCBDC

Future Work

Future work

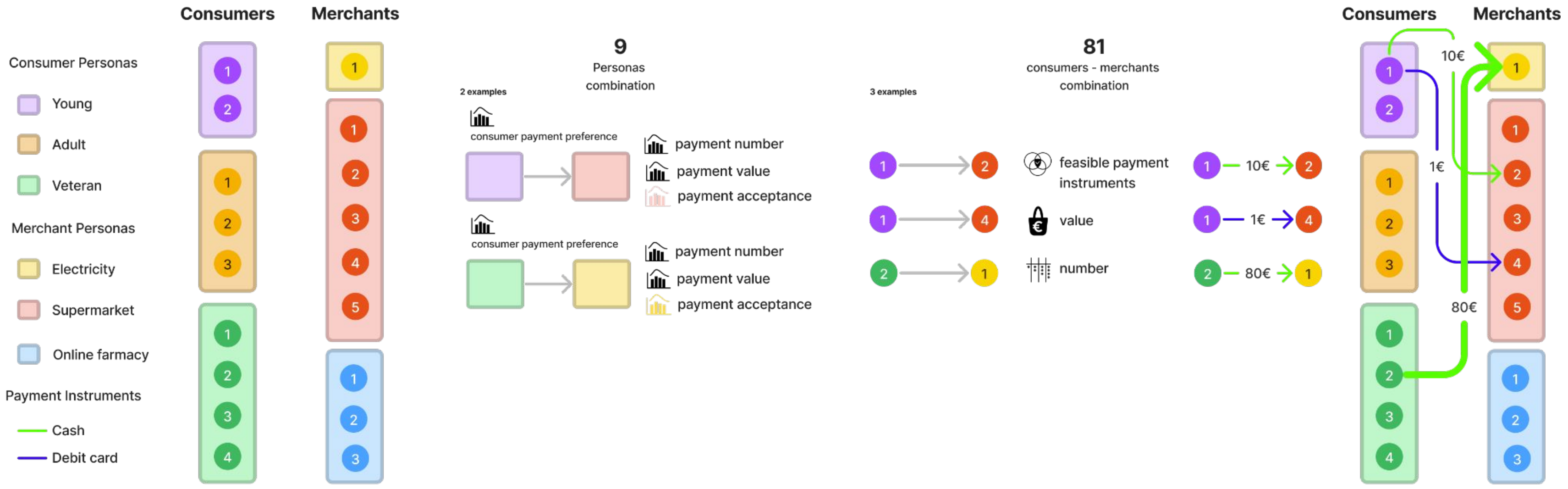
- Explore more scenarios with different combinations of design options and stimulus policies.
- Study the adoption of rCBDCs in different jurisdictions.
- Analyze results by consumer and merchant personas.
- Explicitly model commercial banks' balances and make them adaptive decision-makers.
- Enhance the model by calculating confidence intervals, using data about the costs of holding forms of money, and testing other network-generating models.
- Model M2M payments.

Thank you

Agent-based simulation of rCBDC adoption

Details (Appendix)

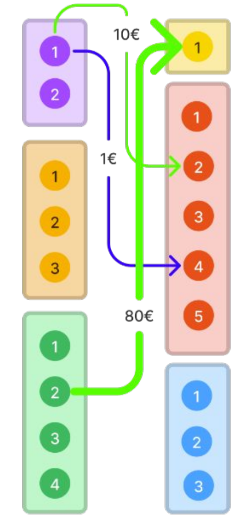
The consumer and merchant decision making process – C2M network generation



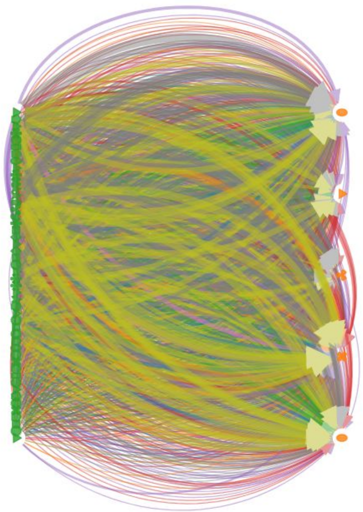
The consumer and merchant decision making process – C2M network generation

Example

CBDC Simulation Actual Result



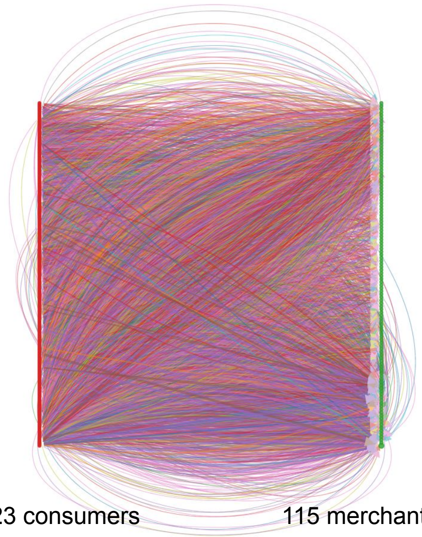
By consumer and merchant persona



48 consumer personas

7 merchant personas

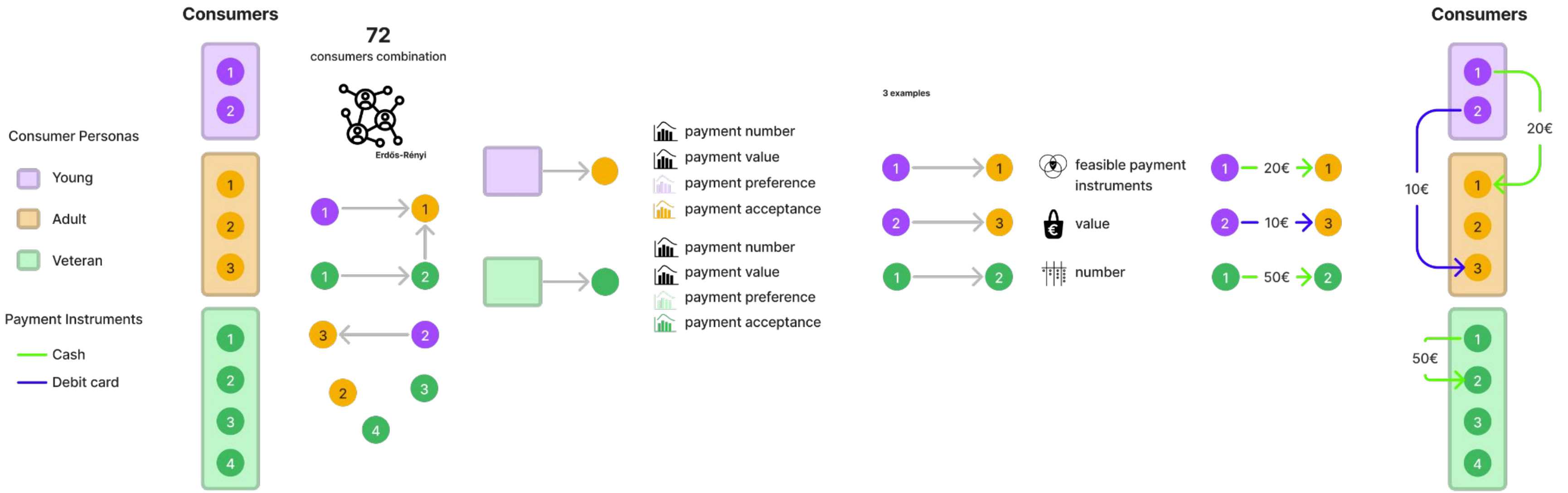
By agent



523 consumers

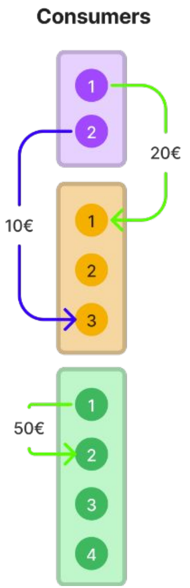
115 merchants

The consumer and consumer decision making process – C2C network generation



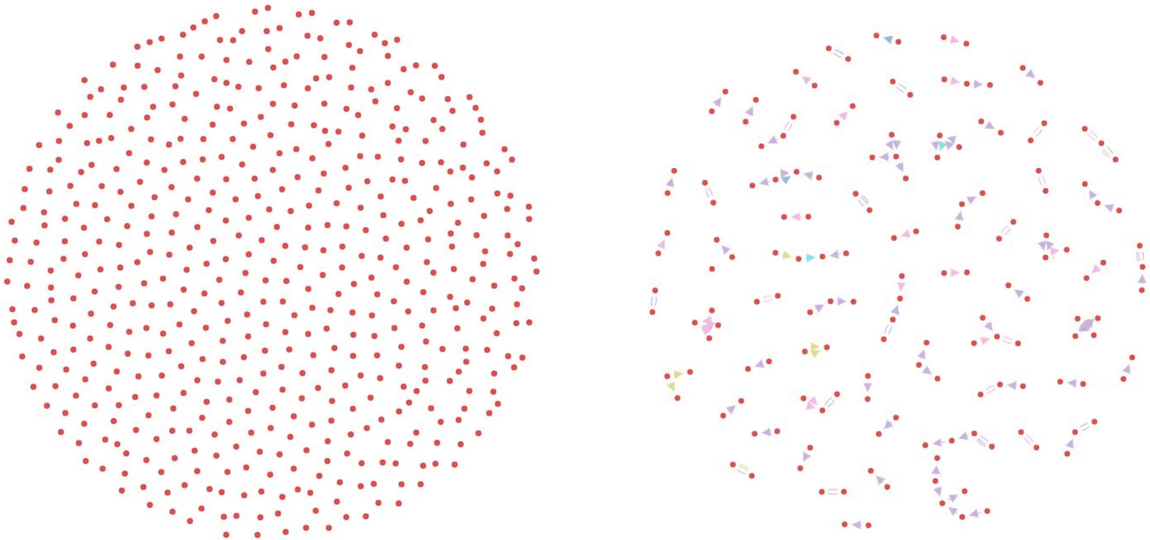
The consumer and merchant decision making process – C2C network generation

Example



CBDC Simulation Actual Result

By agent



523 consumers
159 connected consumers

Consumers initialisation

Initialisation Info

young high income city

Income distribution	3000€ - 6000€
Cash holdings distribution	min 10€, median 20€, mean 25€, max 100€
Benefit payments information	1% income

	Accessibility Probability		Accessibility Probability
✓ Cash	100%	✓ Credit Transfer	99%
✗ Cbdc Anonymous	0%	✓ Direct Debit	99%
✗ Cbdc Non Anonymous	0%	✓ Internet	98%
✓ Debit Card	99%	✓ Mobile	98%
✓ Credit Card	99%	✓ Paypal	98%

Initialisation Mechanics

Simulation 1st day

Income ➔ 4350€
Cash ➔ 25€
Benefits ➔ 43.5€
Salary ➔ 4306.5€

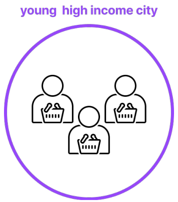
➔

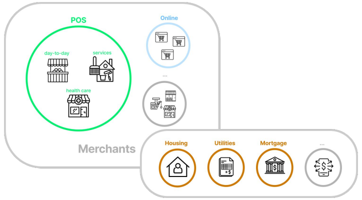
Cash Account ➔ 25€
Deposit Account ➔ 4325€

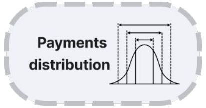
Monthly payments

Consumer recurrent, merchant payroll, and banks deposit interest payments

Initialisation Info







By recurrent merchant persona

min	median	mean	max
50€	200€	250€	400€

value

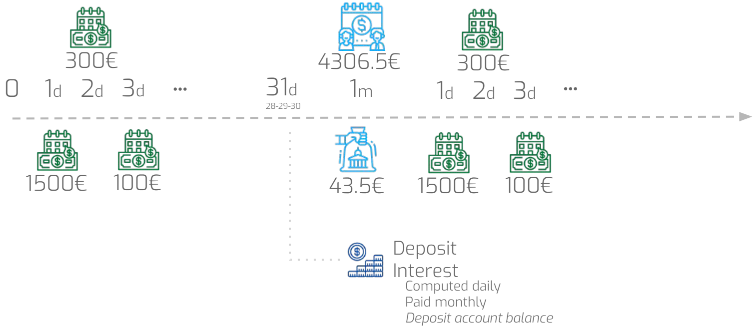
min	median	mean	max
1	2	2	5

number per month

Benefits ➔ 43.5€
Salary ➔ 4306.5€

Mechanics

Payroll Payer ➔ POS merchant 3
Recurrent payments*
➔ day: 2, value: 300€, merchant: utilities 1
➔ day: 3, value: 100€, merchant: utilities 3
➔ day: 1, value: 1500€, merchant: housing 1
TOTAL: 1900€



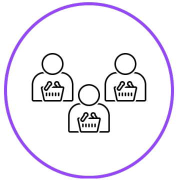
* Prioritised payments. No default allowed. It means consumers always pay and save money for making these payments.

Daily purchase payments

Selected payment instrument

Payment Info

young high income city



Cash 5%
Debit Card 20%
Credit Card 5%
Credit Transfer 20%
Direct Debit 10%
Internet 25%
Mobile 5%
Paypal 10%

Priority = 1

✗ Cash
✓ Cbdc Anonymous
✓ Cbdc Non Anonymous
✓ Debit Card
✓ Credit Card
✗ Credit Transfer
✗ Direct Debit
✓ Internet
✗ Mobile
✓ Paypal

Online 1
Acceptance

By merchant persona and consumer** persona

min	median	mean	max
10€	40€	50€	2000€

value per transaction

min	median	mean	max
1	2	2	5

number per day

Assets ➔ 4350€
- ➔ Deposits: 4325€
- ➔ Cash: 25€

Recurrent payments ➔ 1900€
Budget ➔ 2450€

Mechanics

per consumer and merchant persona

Online

Payments
- ➔ value: 20€, merchant: online 1
  - ➔ value: 40€, merchant: online 5

Feasible Payment Instruments*

Debit Card 20%
Credit Card 5%
Internet 25%
Paypal 10%

➔

Budget check
- ➔ 20€ ≤ 2450€ (budget) ✓

Payment instrument*
- ➔ 20€ ≤ 4325€ (deposits) ✓

Internet

➔

Transaction
- ➔ *from:* consumer Y-HI-C 1
- ➔ *to:* merchant online 1
- ➔ *value:* 20€
- ➔ *payment instrument:* internet
- ➔ *status:* completed
- ➔ *type:* purchase

Assets C ➔ 4330€
- ➔ Deposits: 4305€
- ➔ Cash: 25€

Assets M ➔ +20€
- ➔ Deposits: +20€
- ➔ Cash: 0€

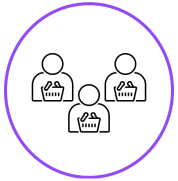
* This mechanics also applies to recurrent payments.

Daily purchase payments

Multiple payment instruments transfer

Payment Info

young high income city



Cash 5%
Debit Card 20%
Credit Card 5%
Credit Transfer 20%
Direct Debit 10%
Internet 25%
Mobile 5%
Paypal 10%

Day-to-Day

Priority = 2

✓ Cash
✓ Cbdc Anonymous
✓ Cbdc Non Anonymous
✓ Debit Card
✓ Credit Card
✗ Credit Transfer
✗ Direct Debit
✗ Internet
✗ Mobile
✓ Paypal

Day-to-day 1
Acceptance

By merchant persona
p.e. Online

	min	median	mean	max
value per transaction	10€	40€	50€	200€
number per day	1	1	2	6

Assets ➔ 50€
➔ Deposits: 25€
➔ Cash: 25€
Recurrent payments ➔ paid
Budget ➔ 50€

Mechanics*

per consumer and merchant persona

Payments

➔ value: 40€, merchant: day-to-day 2
➔ value: 2€, merchant: day-to-day 5

Feasible Payment Instruments

Debit Card 20%
Credit Card 5%
Cash 5%
Paypal 10%

➔

Budget check

➔ 40€ ≤ 50€ (budget) ✓

Payment instrument

➔ 40€ ≤ 25€ (deposits) ✗

Debit Card

➔

Transaction 1
➔ *from:* consumer Y-HI-C 1
➔ *to:* merchant day-to-day 2
➔ *value:* 25€
➔ *payment instrument:* debit card
➔ *status:* completed
➔ *type:* **purchase**

Transaction 2
➔ *from:* consumer Y-HI-C 1
➔ *to:* merchant day-to-day 2
➔ *value:* 15€
➔ *payment instrument:* **cash**
➔ *status:* completed
➔ *type:* **purchase**

Assets C ➔ 10€
➔ Deposits: 0€
➔ Cash: 10€

Assets M ➔ +40€
➔ Deposits: +25€
➔ Cash: +15€

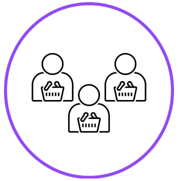
* This mechanics also applies to C2C payments.

Daily purchase payments

Money transfer

Payment Info

young high income city



		Credit Transfer	20%
Cash	5%	Direct Debit	10%
Debit Card	20%	Internet	25%
Credit Card	5%	Mobile	5%
		Paypal	10%

Online

Priority = 1

✗ Cash	✗ Credit Transfer
✓ Cbdc Anonymous	✗ Direct Debit
✓ Cbdc Non Anonymous	✓ Internet
✓ Debit Card	✗ Mobile
✓ Credit Card	✓ Paypal

Online 1
Acceptance

By merchant persona
p.e. Online

min	median	mean	max
10€	40€	50€	2000€

value per transaction

min	median	mean	max
1	2	2	5

number per day

Assets ➔ 350€
- ➔ Deposits: 325€
- ➔ Cash: 25€

Recurrent payments ➔ paid

Budget ➔ 350€

Mechanics*

per consumer and merchant persona

Online

Payments

➔ value: 350€, merchant: online 1

➔ value: 100€, merchant: online 5 ✗

Feasible Payment Instruments

Debit Card	Credit Card	Internet	Paypal
20%	5%	25%	10%

➔

Budget check

➔ 350€ ≤ 350€ (budget) ✓

Payment instrument

➔ 350€ ≤ 325€ (deposits) ✗

Debit Card

➔

Transaction 1
- ➔ *from:* consumer Y-HI-C 1
- ➔ *to:* consumer Y-HI-C 1
- ➔ *value:* 25€
- ➔ *payment instrument:* cash
- ➔ *status:* completed
- ➔ *type:* **deposit top-up**

Transaction 2
- ➔ *from:* consumer Y-HI-C 1
- ➔ *to:* merchant online 1
- ➔ *value:* 350€
- ➔ *payment instrument:* debit card
- ➔ *status:* completed
- ➔ *type:* purchase

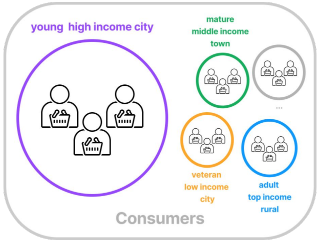
Assets C ➔ 0€
- ➔ Deposits: 0€
- ➔ Cash: 0€

Assets M ➔ +350€
- ➔ Deposits: +350€
- ➔ Cash: 0€

* This mechanics also applies to C2C payments.

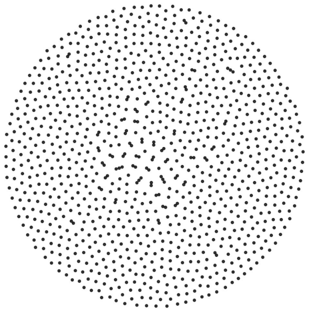
C2C Network

Consumer Y-HI-C 1

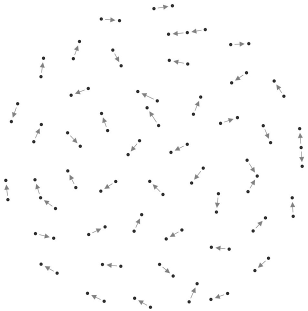


Consumers number ➔ 1000
Network density ➔ 0.00005

All



Connected



Erdős-Rényi network model

for consumer in consumers:
➔ if consumer ≠ Y-HI-C 1:
➔ if random.uniform(0, 1) ≤ **network density**:
➔ add consumer to my c2c network

Daily C2C payments

Payment Info

young high income city

Cash	5%
Debit Card	20%
Credit Card	5%
Credit Transfer	20%
Direct Debit	10%
Internet	25%
Mobile	5%
Paypal	10%

adult top income rural

✓ Cash
✗ Cbdc Anonymous
✗ Cbdc Non Anonymous
✓ Debit Card
✓ Credit Card
✗ Credit Transfer
✗ Direct Debit
✓ Internet
✗ Mobile
✓ Paypal

C2C payments distribution

	min	median	mean	max
value per transaction	10€	40€	50€	2000€
number per day	1	2	2	5

Assets ➔ 4350€
➔ Deposits: 4325€
➔ Cash: 25€
Recurrent payments ➔ 1900€
Budget ➔ 2450€

Mechanics*

per consumer bounded by her c2c network

Payments

➔ value: 10€, consumer: A-TI-R 2
➔ value: 25€, consumer: Y-HI-C 5

Feasible Payment Instruments*

Cash	Debit Card	Credit Card	Internet	Paypal
5%	20%	5%	25%	10%

➔

Budget check

➔ 10€ ≤ 2450€ (budget) ✓

Payment instrument*

➔ 10€ ≤ 4325€ (deposits) ✓

Paypal

➔

Transaction

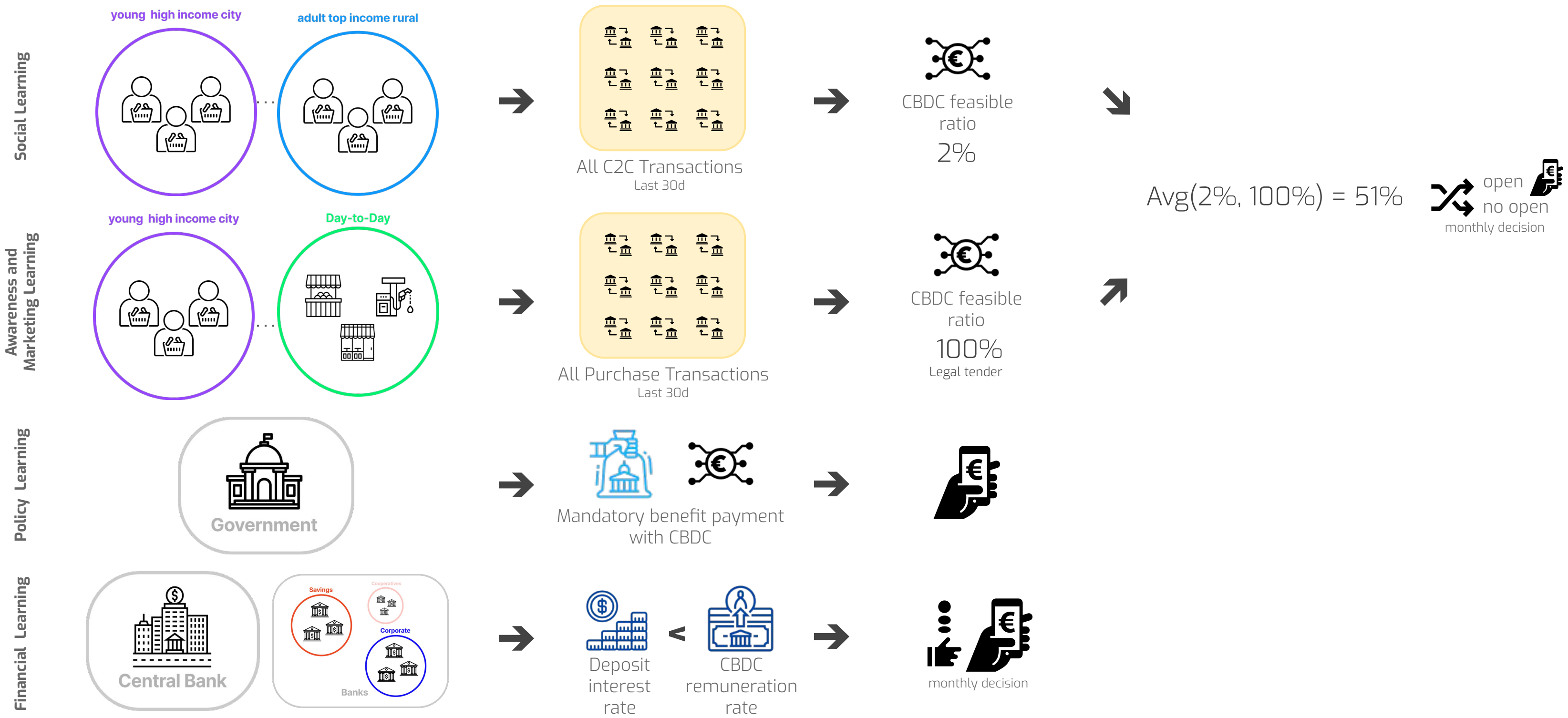
➔ *from:* consumer Y-HI-C 1
➔ *to:* consumer A-TI-R 2
➔ *value:* 10€
➔ *payment instrument:* paypal
➔ *status:* completed
➔ *type:* purchase

Assets Y-HI-C 1 ➔ 4340€
➔ Deposits: 4315€
➔ Cash: 25€

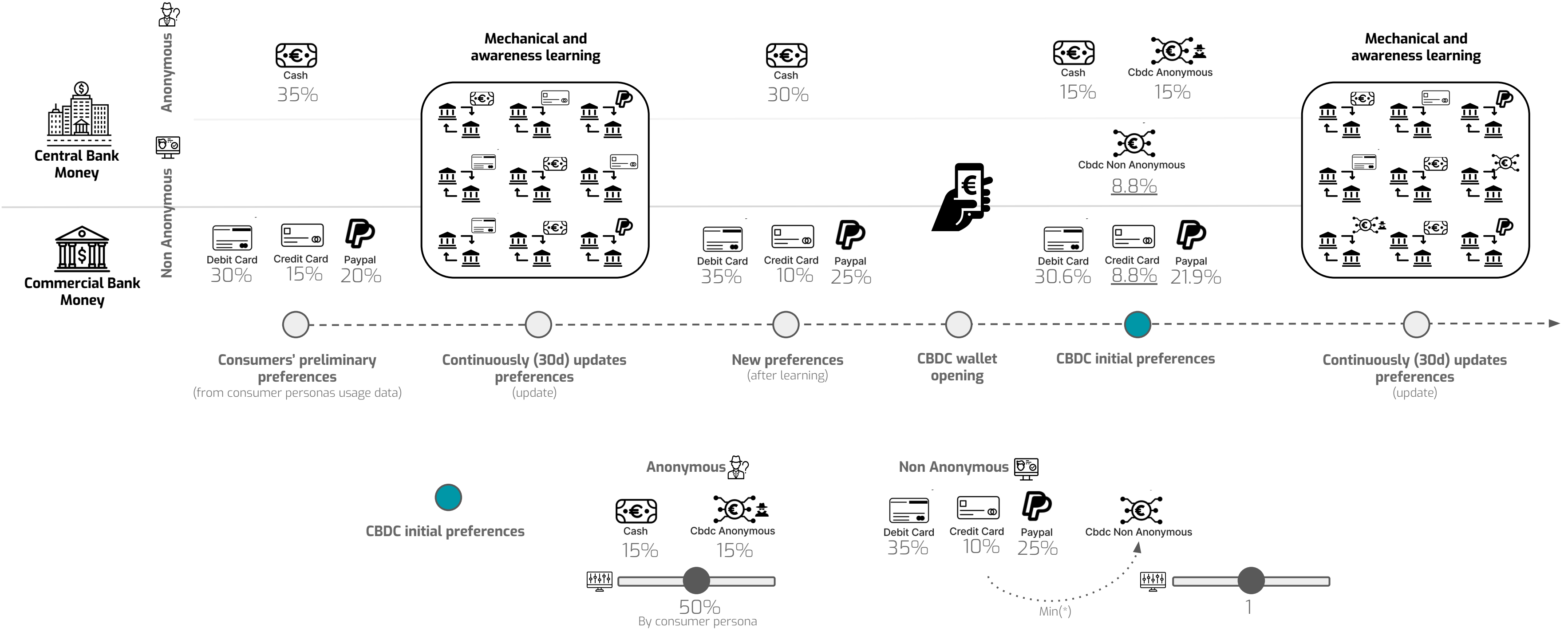
Assets A-TI-R 2 ➔ +10€
➔ Deposits: +10€
➔ Cash: +0€

* Multiple payment instruments and money transfer mechanics also apply here.

Consumers opening a CBDC wallet



Payment instruments preferences and CBDC adoption



CBDC details

First top-up*

Assets → 4350€
→ Deposits: 4325€
→ Cash: 25€

→

CBDC → 555.43€
→ Deposits: 4325€ × **12.55%** = 542.93€
→ Cash: 25€ × **50%** = 12.5€

Cbdc Anonymous 15% → **50%** Of anonymous payment instruments

Cbdc Non Anonymous 8.8% → **12.55%** Of non anonymous payment instruments

Top-ups*

Frequency → As cash withdrawal
→ Daily
→ Weekly
→ Consumer persona

Completed with CBDC value (last frequency transactions)

and or

First attempt with CBDC failed value (last frequency transactions)

+ Benefits mandatory scenario + Payroll decision scenario - Negative remuneration

Anonymity

Threshold → 0€
→ completely non anonymous

Threshold → ∞€
→ completely anonymous

Threshold → 200€

→ if transaction value > 200€ → Cbdc Non Anonymous

→ if transaction value ≤ 200€ → Cbdc Anonymous

*Limits

Balance limit
→ max CBDC account balance value
→ waterfall behaviour (e.g. salary > limit)

Top-up limit
→ max top-up value
→ subject to balance limit

Remuneration

Daily remuneration to avoid **default** in the **negative remuneration** scenario

0 1d 2d 3d ... 31d (28-29-30) 1d 2d 3d ...

Deposit interest rate < CBDC remuneration rate + Payroll decision scenario →