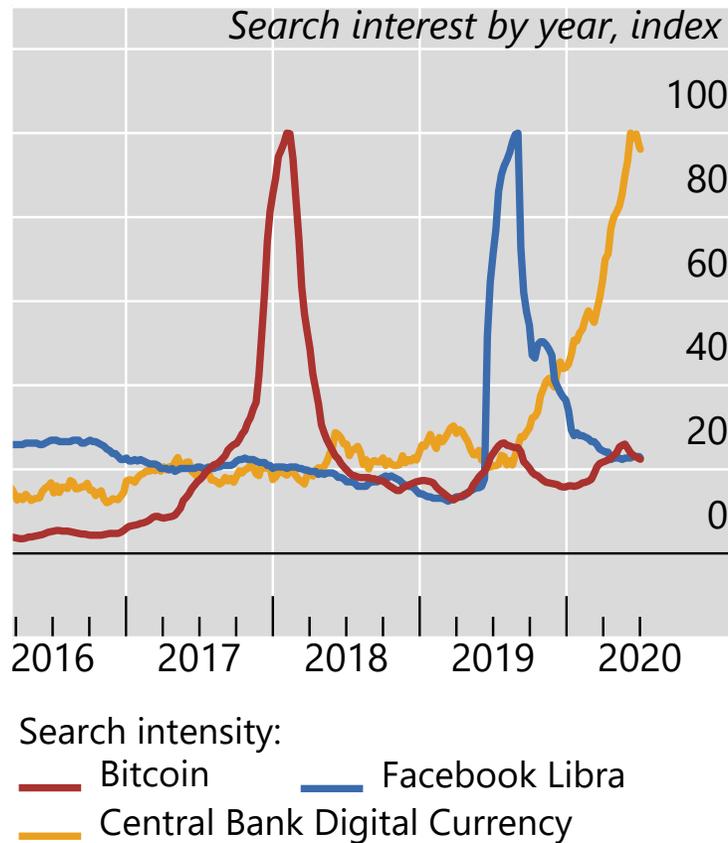
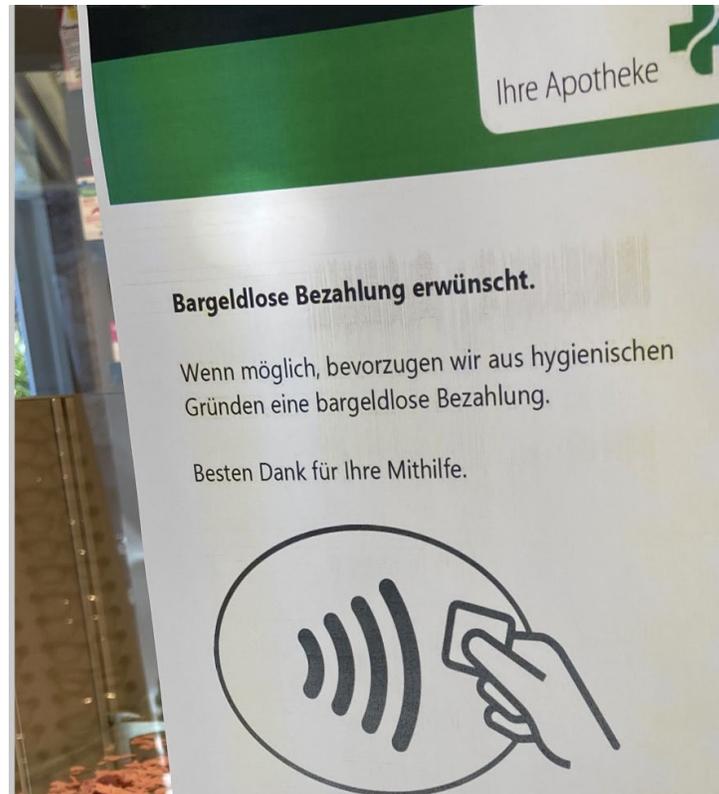


Bitcoin, Libra, and Covid19 have made policy makers warm to CBDC

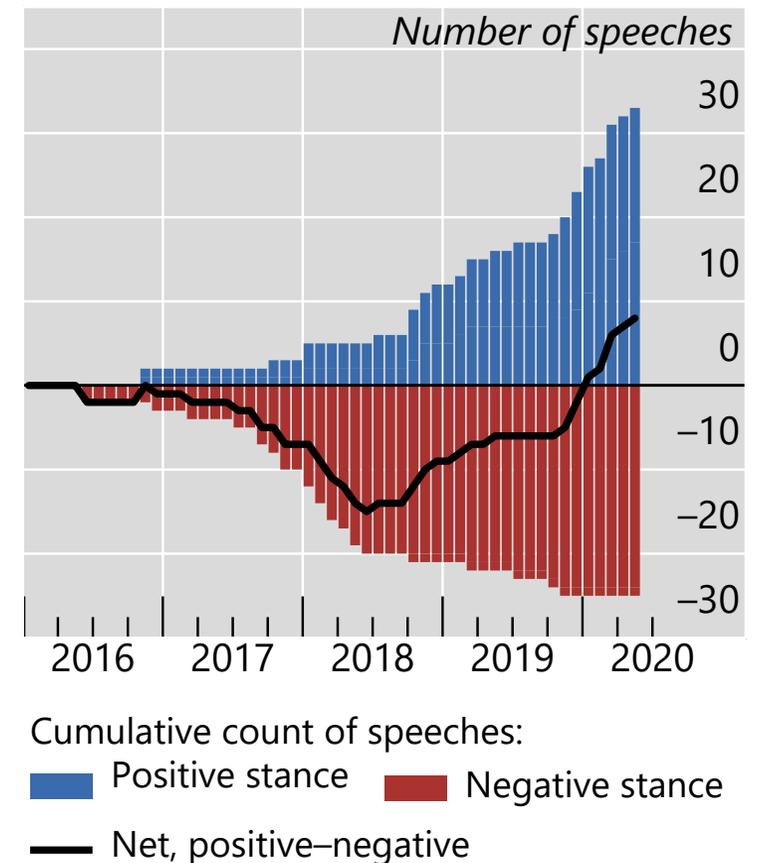
Private digital currencies put CBDC in the limelight



(Unwarranted) concerns that cash transmits Covid19 emerged



As a result, policymakers' stance on CBDCs turned positive



Source: Auer, R, G Cornelli and J Frost (2020): "Rise of the central bank digital currencies: drivers, approaches and technologies", *BIS Working Papers*, No 880, August.

The rise of CBDC: drivers, approaches, and technologies

- CBDC are in the limelight, but there is substantial heterogeneity across countries
 - some central banks are looking into retail CBDC development, others in wholesale, some see no need
 - among those researching and developing retail CBDCs, both approaches and designs differ
- **Today's presentation:**
 - **take stock of CBDC projects, stance on issuance, and drivers**
 - **discuss evolving thinking on retail CBDC design**
 - **discuss how and why central banks' approaches and technologies differ**
 - (not touching upon the macro/financial implications – see Andalfatto 18, Brunnermeier-Niepelt 20, Niepelt 20, Keister-Monnet 20)

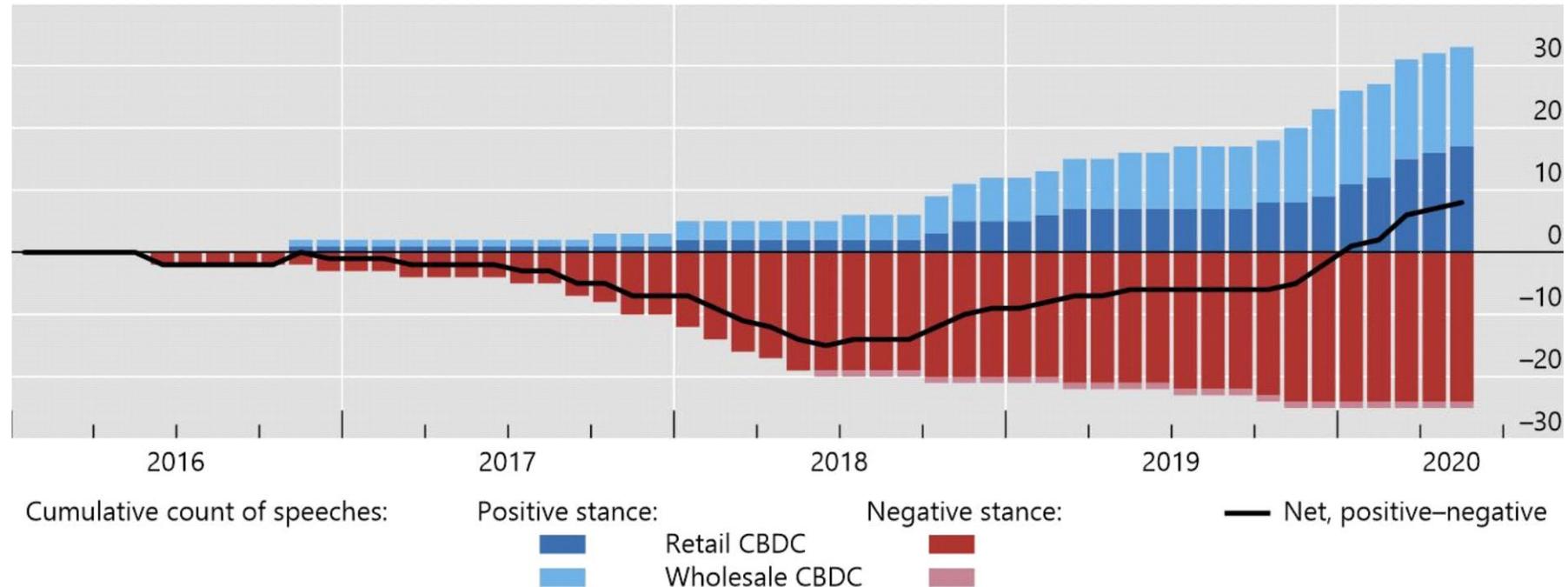
I. A new database on CBDCs

https://www.bis.org/publ/work880_data.xlsx
(update available on request)

Three sources of information on CBDCs

- Projects and design approaches (cross-section)
 - Reports by central banks on retail and wholesale CBDC research and pilots
 - Only official reports, not rumours
 - (For retail) technical characteristics: architecture, infrastructure, access, and interlinkages
- Central bank speeches (2013-2020)
 - Universe of 16000 BIS speeches
 - Search for keywords related to CBDCs
 - Measure stance – positive or negative
- General search interest, as measured by Google Trends and Baidu Trends (cross-section)

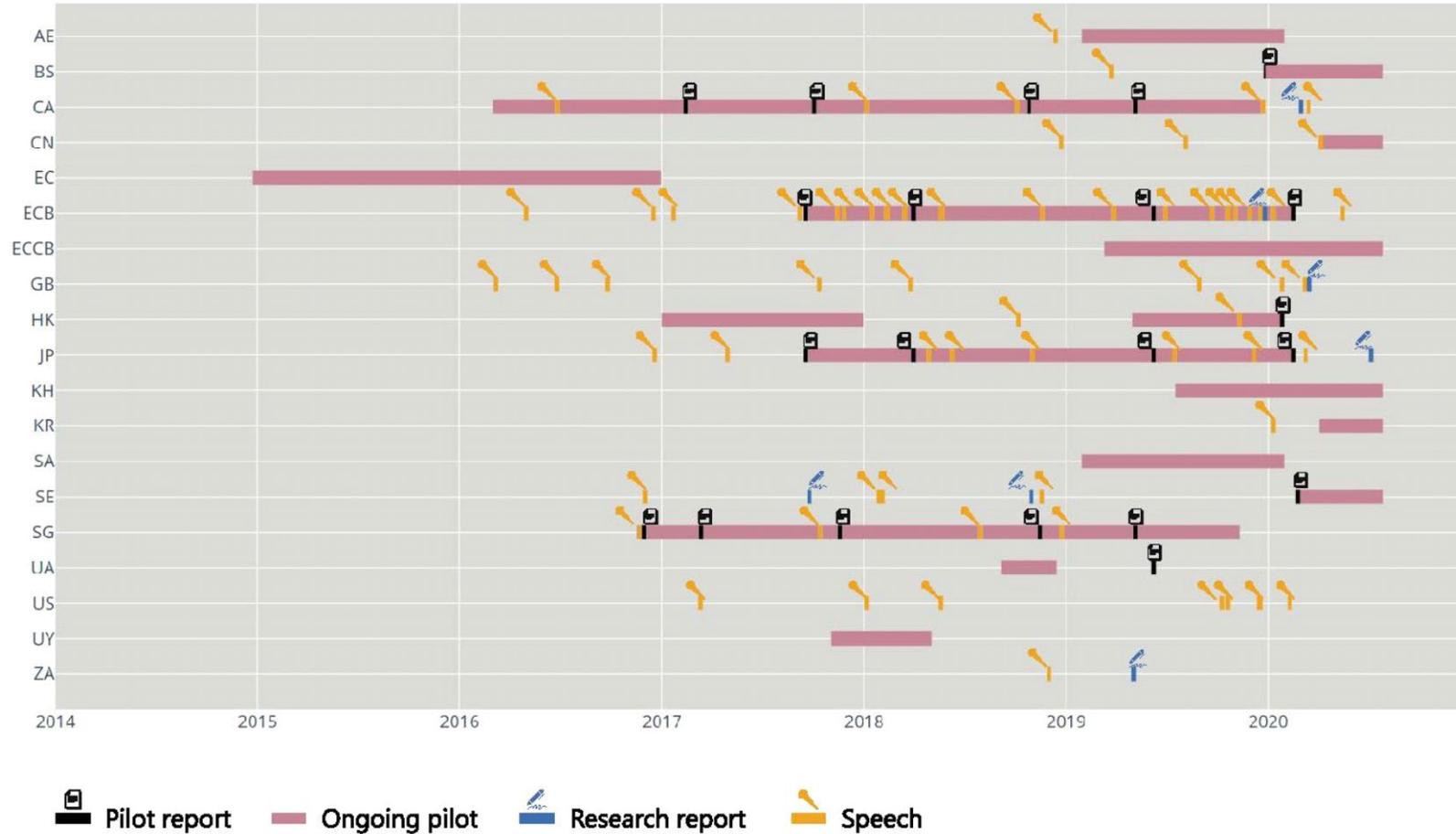
Speeches on CBDCs have turned more positive since late 2018



Search on keywords "CBDC", "digital currency" and "digital money". The classification is based on authors' judgment. The score takes a value of -1 if the speech stance was clearly negative or in case it was explicitly said that there was no specific plan at present to issue digital currencies. It takes a value of +1 if the speech stance was clearly positive or a project/pilot was launched or was in the pipeline. Other speeches (not displayed) have been classified as neutral.

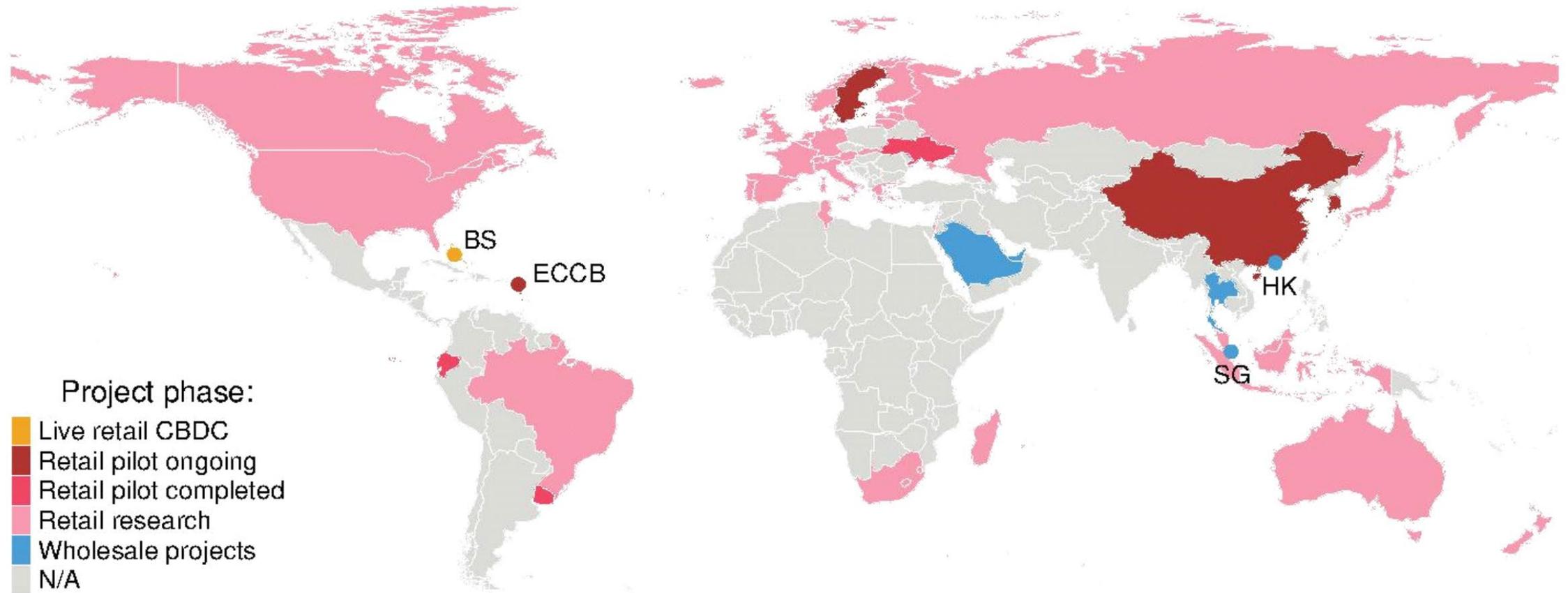
Sources: [centralbanking.com](https://www.centralbanking.com); [Central Bankers' Speeches](#); Central bank websites; authors' calculations.

CBDC projects have proliferated since 2016



Sources: [Central Bankers' Speeches](#); Central Banks' websites.

CBDCs development is now taking place around the globe



BS = The Bahamas; ECCB = Eastern Caribbean central bank; HK = Hong Kong SAR; SG = Singapore.

The use of this map does not constitute, and should not be construed as constituting, an expression of a position by the BIS regarding the legal status of, or sovereignty of any territory or its authorities, to the delimitation of international frontiers and boundaries and/or to the name and designation of any territory, city or area.

Source: Auer, R, G Cornelli and J Forst (2020): "Rise of the central bank digital currencies: drivers, approaches and technologies", *BIS Working Papers*, No 880, August.

CBDC project index (CBDCPI)

- To gauge the status of CBDCs, we generate a CBDC project index (CBDCPI)
- Three breakdowns:
 - **Overall project index:** 0=no announced project, 1=research, 2=pilot, 3=live CBDC
 - **Retail project index:** 0=no announced retail project, 1=research on retail CBDC, 2=retail CBDC pilot, 3=live retail CBDC
 - **Wholesale project index:** 0=no announced retail project, 1=research on wholesale CBDC, 2=wholesale CBDC pilot, 3=live wholesale CBDC
- The overall project scores takes the maximum value of retail and wholesale CBDC projects

Which variables could explain CBDC research and development?

	Observations	Mean	Standard deviation	Min	Max
Dependent variables					
Overall CBDC project index	175	0.31	0.66	0	2
Retail CBDC project index	175	0.22	0.53	0	2
Wholesale CBDC project index	175	0.13	0.48	0	2
Independent variables					
Mobile cellular subscriptions (per 100 people)	169	109.24	39.54	12.60	320.55
Broadband subscriptions (fixed line, per 100 people)	167	13.60	13.38	0	47.16
Innovation output score (WIPO)	118	29.67	12.69	7.90	67.13
Fast payment system dummy	175	0.37	0.48	0	1
Government effectiveness	175	0.08	0.99	-2.24	2.19
Informal economy (% of GDP)	122	26.08	11.62	5.43	55.78
GDP per capita (USD)	168	16,652	21,423	301	110,344
Account ownership (% age 15+)	135	60.39	27.96	6.45	99.96
Financial development index ²	158	0.36	0.22	0.06	0.93
Search interest index (Google/Baidu) ³	175	0.11	1.13	-0.34	8.18
Remittances ⁴ to GDP	110	5.89	7.86	0.19	41.18
Trade openness ⁵	134	80.05	48.87	0	345.69
Central bankers' speech stance index ⁷	175	0.02	0.47	-0.13	1.68

Multivariate ordered probit regressions on CBDC project indices

	Overall CBDC project index		Retail CBDC project index		Wholesale CBDC project index	
Mobile cellular subscriptions (per 100 people)	0.013** (0.005)	0.015*** (0.006)		0.011** (0.005)		0.022** (0.010)
Innovation output score (WIPO)	0.045*** (0.010)		0.067*** (0.017)	0.082*** (0.019)		
Informal economy (% of GDP)		0.027* (0.015)	0.033* (0.018)	0.042*** (0.016)		-0.009 (0.026)
Financial development Index ²		3.909*** (0.867)			3.303*** (0.775)	4.287*** (1.299)
Trade openness ³		-0.003 (0.004)		-0.016** (0.007)	0.004* (0.003)	-0.001 (0.004)
Number of observations	118	105	110	100	132	105
Pseudo R ²	0.167	0.241	0.144	0.244	0.263	0.352

II. The evolving thinking on retail CBDC design

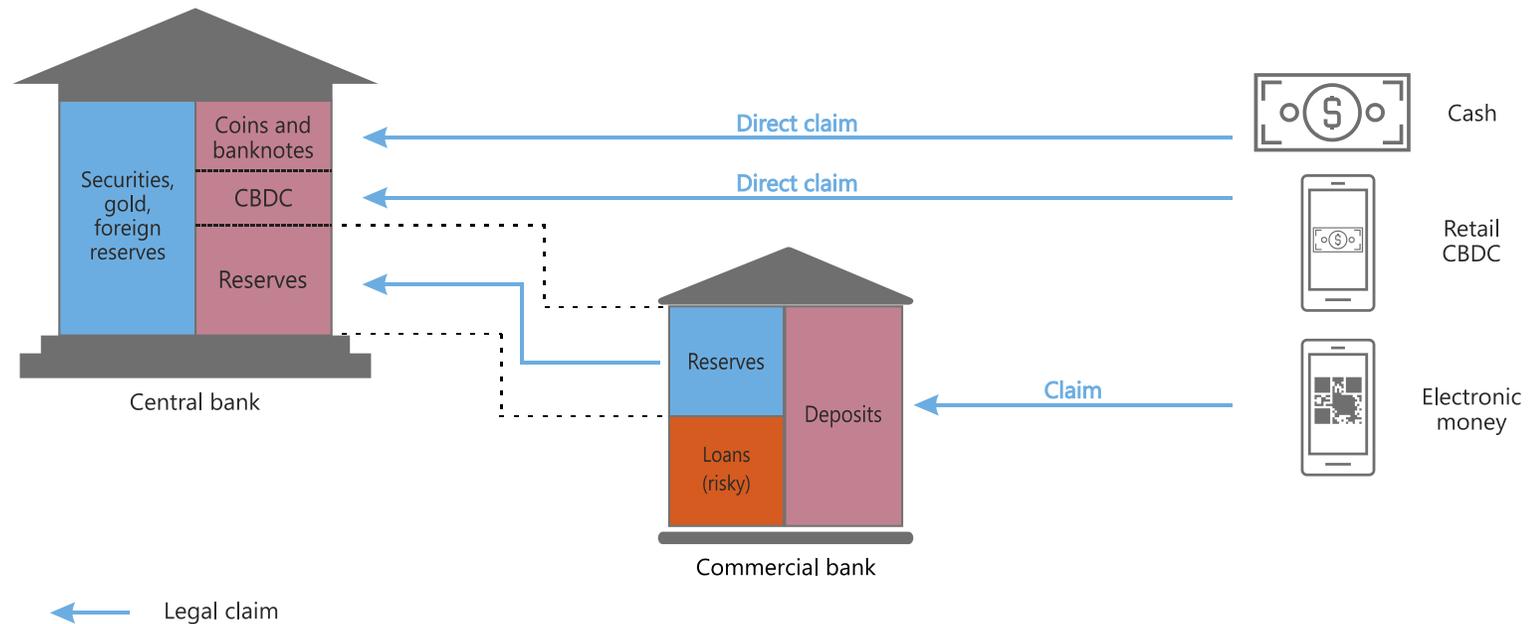
Draws on:

- Group of Central Banks (2020), Central bank digital currencies: foundational principles and core features, October
- Auer and Boehme (2020b) "CBDC architectures, the financial system, and the central bank of the future" VoxEU.org 29.10.2020 (extending March BIS QR)

Conceptualising retail CBDC

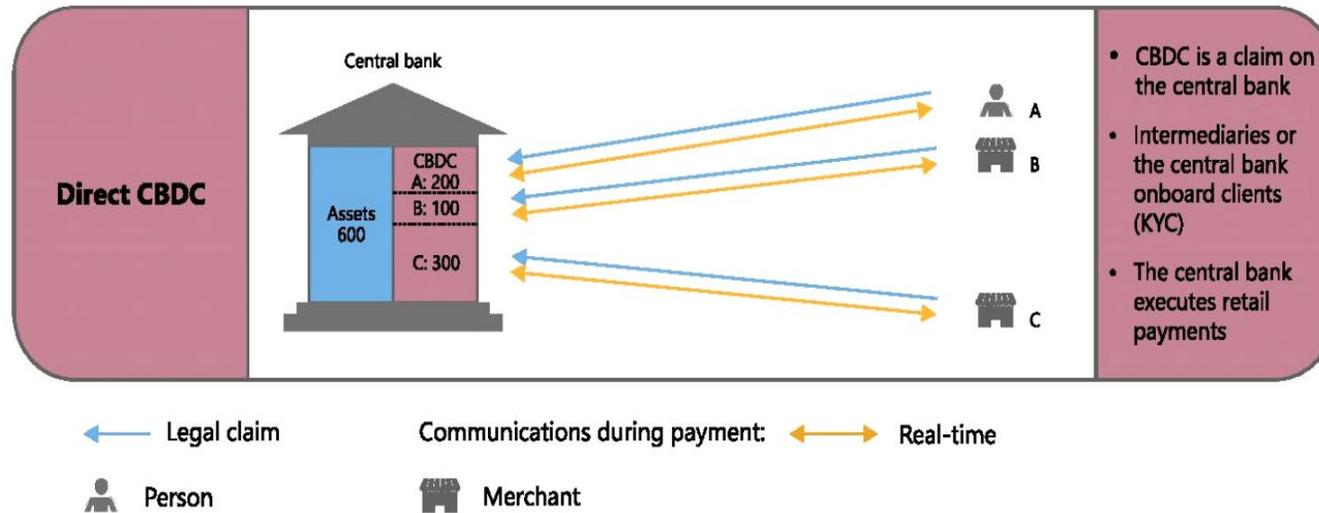
- Today's electronic money is a claim on an intermediary:
 - Balance sheet concerns
 - Technical outages
 - Access hurdles, privacy concerns
- **CBDC is a cash-like direct claim on the central bank available to the economy at large.** (Group of Central Banks (2020))
 - ("Synthetic CBDC" does not fit this definition)

The monetary system with a retail CBDC



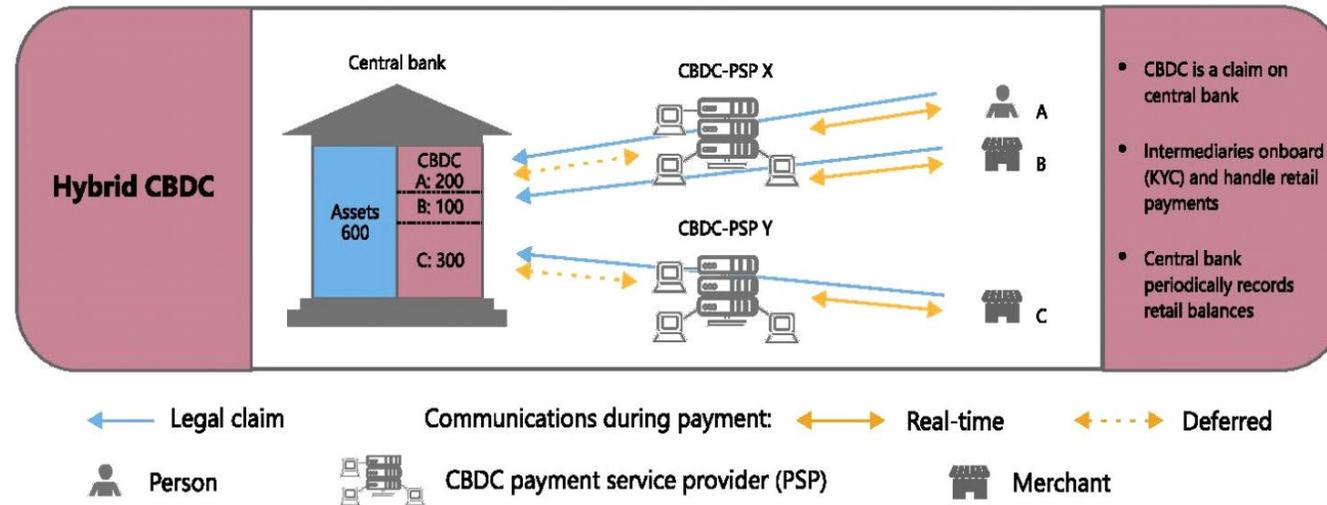
Source: Auer, R, and R Böhme (2020): "Central bank digital currency: the quest for minimally invasive technology", *BIS Working Papers*, forthcoming.

“Direct CBDC”: central bank-operated payments



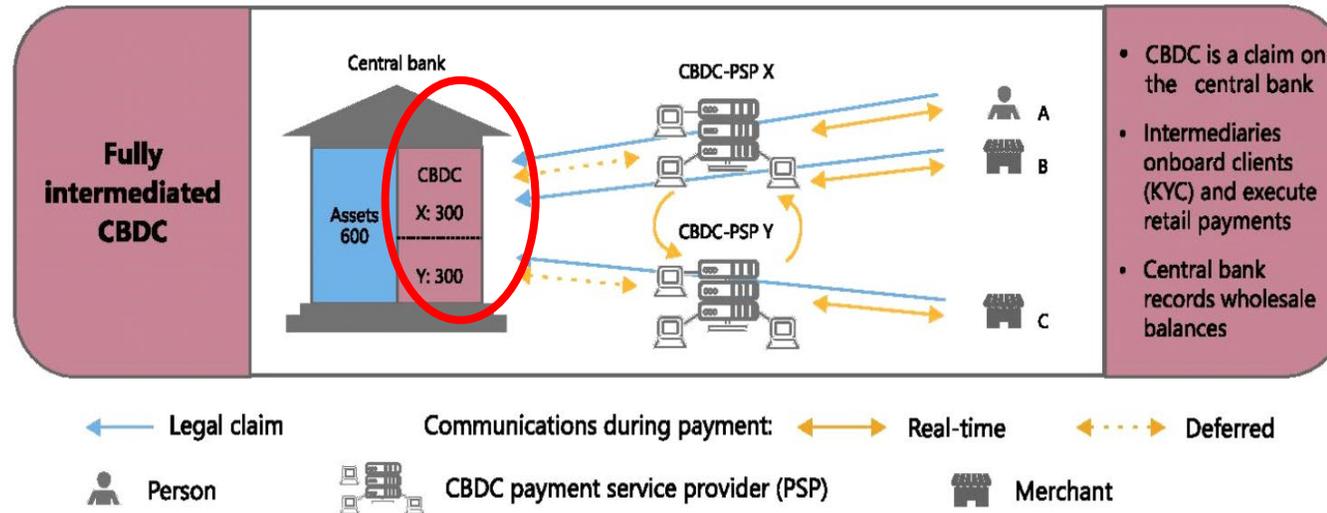
- Direct claims on the central bank
 - Private sector payment at most provides KYC
- Central bank operates payments:
 - How well-suited is the central bank for this activity?
 - Absence of risk-taking may impair real time payments

“Hybrid CBDC”: private sector payments with a central bank backup



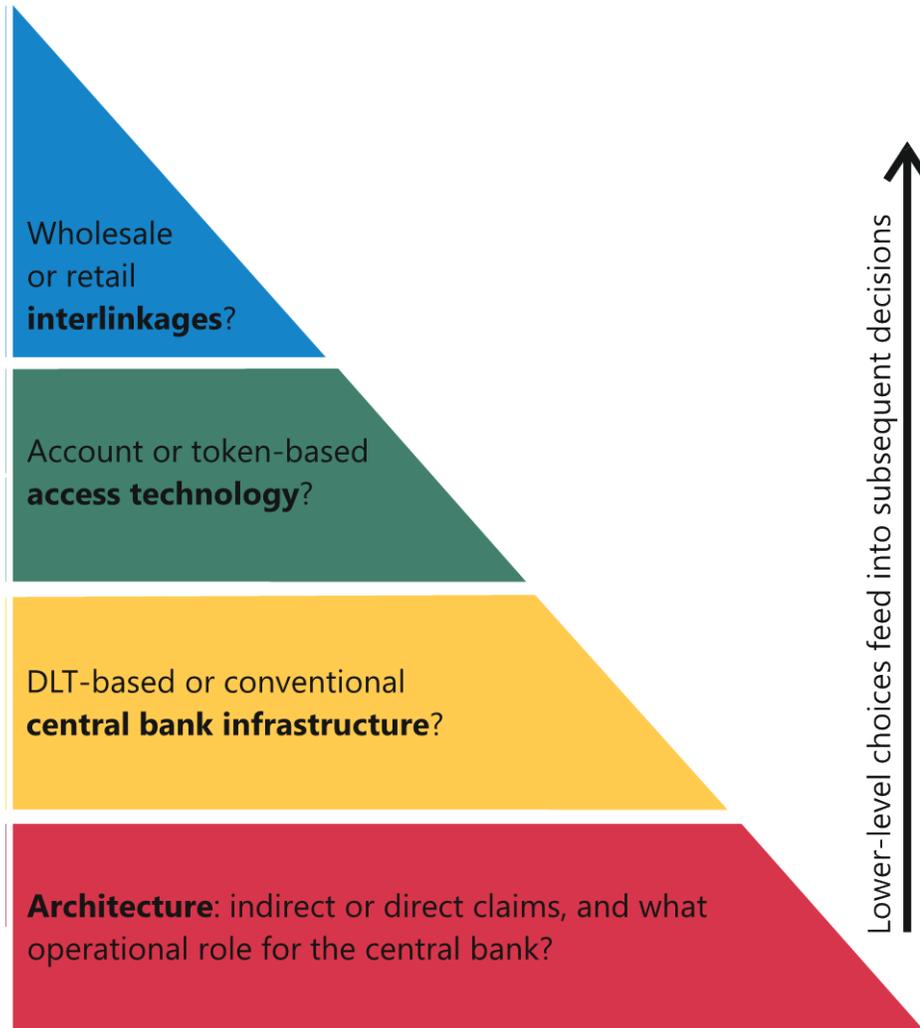
- Auer and Böhme (2020) propose hybrid approach:
 - Private sector payment providers perform onboarding, due diligence, and payments
 - The central bank has the technical means and legal power to switch retail client relations from a failing PSP to a working one

“Intermediated CBDC” : central bank knows wholesales balances only



- Direct claims on the central bank
- But central bank only operates a wholesale ledger
 - No privacy concerns for central bank
 - Associated need for financial supervision

Other design aspects: the CBDC pyramid



- Is CBDC designed for **use across borders?**
- **How much privacy** would a CBDC offer?
- Which **infrastructure** should a CBDC be run on?
- Direct, Hybrid, or Intermediated **operational architecture?**

III. Taking stock of technical CBDC design efforts

Design characteristics of the PBC's e-CNY (pilot)

Design aspect	PBC DC/EP design choices	Details
Inter-linkages	Retail & wholesale linkages	Tourists and business travellers may be able to use CBDC domestically in China with a foreign cell phone number.
Account or token-based access?	Mostly account-based , allowing for smart money interfaces	Different levels of user identification. Balances and transaction limits increase with the strength of the KYC requirements.
DLT-based or conventional CB infrastructure ?	PBC runs conventional infrastructure and DLT	PBC runs conventional infrastructure and DLT, private sector free to choose.
Architecture: indirect or direct claims, and what operational role for the central bank?	Hybrid CBDC	CBDC is a direct claim on the central bank, private sector intermediaries ("Authorised operators") execute payments, central bank periodically receives a backup copy of holdings and transactions.

Sources: Adapted from R Auer and R Boehme (2020), "The technology of retail central bank digital currency", *BIS Quarterly Review*, March, p85-100; Fan (2020) and conversations with PBC staff.

Sveriges Riksbank's e-krona (proof-of-concept)

Design aspect	Sveriges Riksbank e-krona design choices	Details
Inter-linkages	Only wholesale linkages	Token-based access would allow for retail linkages, i.e. use by tourists in small purchases. Interlinkages between the CBDC and the domestic wholesale payment system would ensure widespread usability in cross-border payments.
Account or token-based access?	Tiering of account and token-based access	Anonymous token-based options would be allowable for smaller payments, while account-based access would be required for larger purchases.
DLT-based or conventional CB infrastructure ?	DLT , but alternatives being considered	The proof-of-concept is based on a DLT-based infrastructure using R3's Corda, to be run with several notaries.
Architecture: indirect or direct claims, and what operational role for the central bank?	Hybrid CBDC, but alternatives being considered	The e-krona is a direct claim on the Riksbank. The Riksbank operates at least one of the notaries. Real-time payments are executed by intermediaries.

Sources: Adapted from R Auer and R Boehme (2020), "The technology of retail central bank digital currency", *BIS Quarterly Review*, March, p85-100; conversations with Sveriges Riksbank staff.

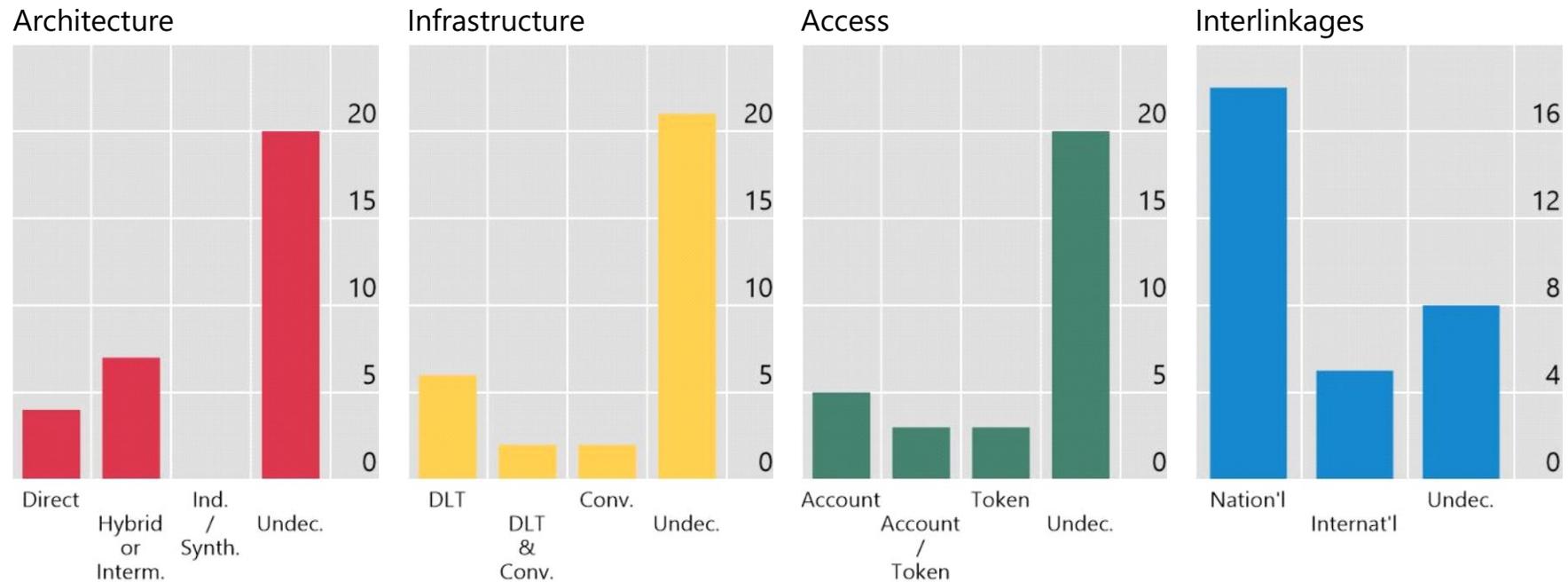
Bank of Canada's CBDC contingency plan

Design aspect	Bank of Canada CBDC design choices	Details
Inter-linkages	Retail & wholesale linkages	Token-based access would allow for retail linkages, i.e. use by tourists in small purchases. Interlinkages between the CBDC and the domestic wholesale payment system would ensure widespread usability in cross-border payments.
Account or token-based access?	Tiering of account and token-based access	Anonymous token-based options would be allowable for smaller payments, while account-based access would be required for larger purchases.
DLT-based or conventional CB infrastructure ?	Both DLT and conventional technology are being considered	All options will be considered.
Architecture: indirect or direct claims, and what operational role for the central bank?	Direct, Hybrid and Intermediated CBDC	The Bank of Canada is considering three architectures featuring direct claims: i) it provides the entire CBDC payment system, ii) it only issues and redeems CBDC, with private sector intermediaries providing end-user services, and iii) it only maintains a ledger of wholesale (not retail) transactions. A mix of options is also possible.

Sources: Adapted from R Auer and R Boehme (2020), "The technology of retail central bank digital currency", *BIS Quarterly Review*, March, p85-100; conversations with Bank of Canada staff.

Histograms on design choices of retail CBDCs

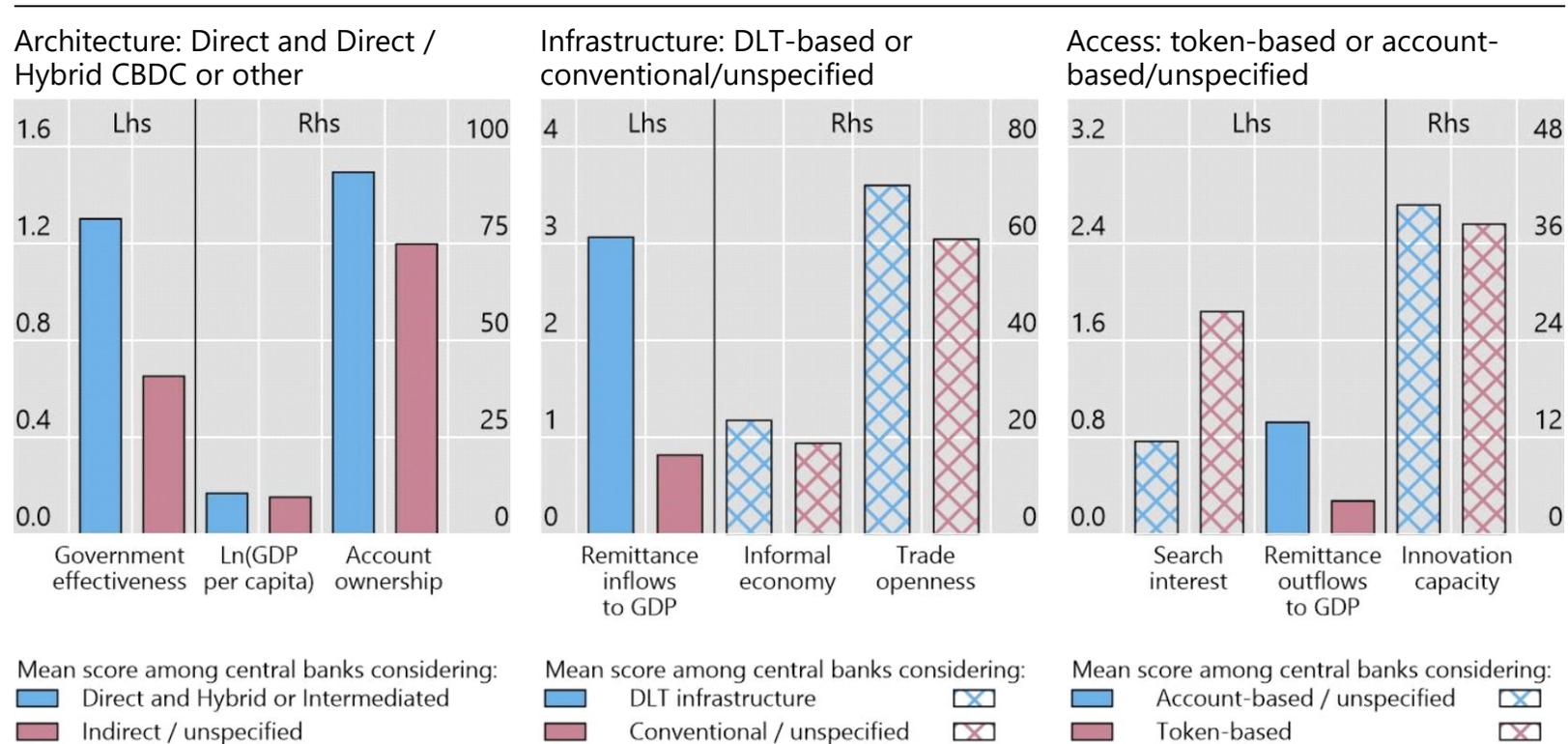
Number of retail CBDC projects investigating each design option



Intern. = Intermediated; Ind. = Indirect; Synth. = Synthetic; Undec. = undecided/unspecified or multiple options under consideration; DLT = distributed ledger technology; Conv. = Conventional; Nation'l = national use; Internat'l = international use.

Sources: Central bank websites; authors' calculations.

Jurisdictions with different characteristics choose different retail CBDC designs



Each bar visualises the cross-country average for the countries adopting the specific project feature. The solid fill denotes results significant at the 5/10% level in a probit univariate regression with robust standard errors.

Sources: WIPO (2018); Medina and Schneider (2019); IMF, *World Economic Outlook*; World Bank, *Remittance Prices Worldwide*, remittanceprices.worldbank.org; World Bank; Baidu; central bank websites; Datastream; GoogleTrends; authors' calculations.

Conclusion

- Around the world, CBDC design efforts are intensifying
 - Except in the Bahamas, issuance has not been decided upon
- A wide range of options are being considered, but tendency is:
 - To complement cash rather than replace it
 - Offer a solution with cash-like claims on central bank and an important role for the private sector (“Hybrid” design)
- International cooperation is key to foster exchange of knowledge and experiences
 - See ie CPMI/G20 task-force on cross-border payments

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- Group of Central Banks (2020), Central bank digital currencies: foundational principles and core features.

IV. Three case studies

V. Conclusion

Conclusion

- Interest in CBDCs is rising, and issuance is imminent in some economies
- Novel CBDC project index (CBDCPI) and speech, search interest scores provided with the paper as a public good for researchers, policy makers and the general public
- CBDCs more likely in countries with higher mobile use and innovation capacity
- Retail CBDCs more likely where the informal economy is larger, *ceteris paribus*
- Heterogeneity in approaches and designs across countries (architecture, infrastructure, access, interlinkages)
- Many central banks are considering CBDCs as a direct cash-like claim on the central bank, but where the private sector handles all customer-facing activity

Annex

Univariate ordered probit regressions on overall CBDC project index

Digital infrastructure						
Mobile cellular subscriptions (per 100 people)	0.010*** (0.004)					
Broadband subscriptions (fixed line, per 100 people)		0.042*** (0.008)				
Innovation capacity						
Innovation output score (WIPO)			0.047*** (0.009)			
Fast payment system (FPS) dummy				0.882*** (0.221)		
Institutional characteristics						
Government effectiveness					0.674*** (0.118)	
Informal economy (% of GDP)						-0.03*** (0.013)
Number of observations	169	167	118	175	175	122
Pseudo R ²	0.057	0.126	0.129	0.074	0.145	0.058

Univariate ordered probit regressions on overall CBDC project index (2)

Development and financial inclusion

Ln(GDP per capita)	0.439***					
	(0.092)					
Account ownership (% age 15+)		0.023***				
		(0.005)				
Financial development index ²			3.414***			
			(0.552)			

Public interest in CBDCs

Search interest index (Google/Baidu) ³				0.432***		
				(0.098)		

Cross-border transactions

Remittances ⁴ to GDP					-0.157**	
					(0.068)	
Trade openness ⁵						0.001
						(0.003)
Number of observations	168	135	158	175	110	134
Pseudo R ²	0.119	0.131	0.215	0.105	0.113	0.001

Univariate ordered probit regressions on retail CBDC project index

Digital infrastructure						
Mobile cellular subscriptions (per 100 people)	0.005** (0.002)					
Broadband subscriptions (fixed line, per 100 people)		0.037*** (0.008)				
Innovation capacity						
Innovation output score (WIPO)			0.046*** (0.010)			
Fast payment system dummy				0.678*** (0.227)		
Institutional characteristics						
Government effectiveness					0.522*** (0.114)	
Informal economy (% of GDP)						-0.027** (0.013)
Number of observations	169	167	118	175	175	122
Pseudo R ²	0.016	0.108	0.135	0.047	0.10	0.038

Univariate ordered probit regressions on retail CBDC project index (2)

Development and financial inclusion

Ln(GDP per capita)	0.352***					
	(0.09)					
Account ownership (% age 15+)		0.018***				
		(0.005)				
Financial development index ²			2.616***			
			(0.519)			

Public interest in CBDCs

Search interest index (Google/Baidu) ³				0.258***		
				(0.067)		

Cross-border transactions

Remittances ⁴ to GDP					-0.138**	
					(0.069)	
Trade openness ⁵						-0.007**
						(0.004)
Number of observations	168	135	158	175	110	134
Pseudo R ²	0.086	0.09	0.149	0.052	0.101	0.031

Univariate ordered probit regressions on wholesale CBDC project index

Digital infrastructure						
Mobile cellular subscriptions (per 100 people)	0.01** (0.004)					
Broadband subscriptions (fixed line, per 100 people)		0.037*** (0.01)				
Innovation capacity						
Innovation output score (WIPO)			0.037*** (0.01)			
Fast payment system dummy				1.023*** (0.3)		
Institutional characteristics						
Government effectiveness					0.762*** (0.193)	
Informal economy (% of GDP)						-0.059** (0.025)
Number of observations	169	167	118	175	175	122
Pseudo R ²	0.071	0.119	0.101	0.108	0.191	0.147

Univariate ordered probit regressions on wholesale CBDC project index (2)

Development and financial inclusion

Ln(GDP per capita)	0.479***					
	(0.128)					
Account ownership (% age 15+)		0.03***				
		(0.009)				
Financial development index ²			3.532***			
			(0.739)			

Public interest in CBDCs

Search interest index (Google/Baidu) ³				0.526***		
				(0.117)		

Cross-border transactions

Remittances ⁴ to GDP					-0.219**	
					(0.097)	
Trade openness ⁵						0.005*
						(0.003)
Number of observations	168	135	158	175	110	134
Pseudo R ²	0.145	0.185	0.267	0.218	0.119	0.037

Univariate probit on retail CBDC project features

	Architecture 1: Direct and Hybrid or Intermediated 0: Indirect / unspecified			Infrastructure 1: DLT infrastructure 0: Conventional / unspecified			Access 1: Token-based 0: Account-based / unspecified		
Government effectiveness	0.599** (0.299)								
Ln(GDP per capita)	0.600** (0.249)								
Account ownership (% age 15+)	0.033** (0.015)								
Remittance inflows to GDP				0.205** (0.096)					
Informal economy (% of GDP)				0.02 (0.023)					
Trade openness ²				0.006 (0.007)					
Search interest index (Google/Baidu) ³							0.157 (0.131)		
Remittance outflows to GDP							-1.873** (0.828)		
Innovation output score (WIPO)							-0.008 (0.022)		
Number of observations	31	31	27	28	27	31	31	26	28
Pseudo R ²	0.103	0.150	0.148	0.118	0.027	0.0191	0.046	0.186	0.005