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Working Paper

Retail central bank digital currency: Has its time come?

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Appendix

Table A1: ISO Country Codes for G20 Economies and Euro Area

Country	ISO Code
Argentina	ARG
Australia	AUS
Brazil	BRA
Canada	CAN
China	CHN
Germany	DEU
Euro Area	EUR
France	FRA
United Kingdom	GBR
Indonesia	IDN
India	IND
Italy	ITA
Japan	JPN
Korea	KOR
Mexico	MEX
Russia	RUS
Saudi Arabia	SAU
Turkey	TUR
United States	USA
South Africa	ZAF

Source: International Organization for Standardization (ISO) (see www.iso.org/obp/ui/#search).

Table A2: Bank Regulation and Supervision-Based Governance Index

Question	Score
What body/agency supervises banks for prudential purposes? (Q12_1.)	Central bank = 2; single agency = 1; other (for example, multiple agencies) = 0.
Has a banking supervisory agency mandate been written? (Q12_4.)	Yes = 1; no = 0.
Are financial system responsibilities included in the mandate? (Q12_4.)	Yes = 1; no = 0.
Is an integrated financial supervisory agency covering all significant financial institutions? (Q12_24 was Q12_21 in 2007.)	Memorandum of understanding = 1; other (for example, banking agency) = 0.
Is a banking supervisor responsible for macroprudential supervision? (Q12_25 was Q12_22 in 2007.)	Yes = 1; no = 0.
What body is responsible for financial consumer protection laws/regulations? (Q14_1 folded into Q12_3.)	Other (for example, single agency) = 1; central bank = 0.

Notes: Answers used to construct Figure 4 in the paper. QXX_YY refers to the question in section XX and number YY in the data source. Data for Argentina, China, India, Indonesia, South Africa and the euro area was used to construct an index of trust by summing the index values from individual characteristics and converting them into a range from zero to 100 so that the change between 2020 and 2011 could be evaluated and plotted against the change in trust from the OECD survey. Individual trust levels for 2011 and 2020 separately are plotted in Figure A2. Therefore, the vertical axis label does not, strictly speaking, apply for the countries listed above. Full OECD data is plotted separately in Figure A3.

Table A3: An Illustrative Regression of Governance Characteristics and Macroprudential Interventions

Dependent variable: Delta_agg_score
Observations: 19 after adjustments

Variable	Coefficient	Std. error	T-statistic	Prob.
C	-0.67	0.33	-2.03	0.06
Mapp_select	0.11	0.05	2.24	0.04
EME	1.69	0.41	4.15	0.00
R-squared	0.59	Mean dependent var.		0.58
Adjusted R-squared	0.54	S. D. dependent var.		1.30
F-statistic	11.62	Durbin-Watson stat.		1.48
Prob. (F-statistic)	0.00			

Notes: Delta_agg_score is the *change* in the Bank Regulation and Supervision-Based Governance Index; mapp_select is the sum of four elements from the International Monetary Fund's (IMF's) Integrated Macroprudential Policy (iMaPP) Database (see www.elibrary-areaer.imf.org/Macroprudential/Pages/iMaPPDatabase.aspx). They are: C6.LCG or limits on growth or the volume of aggregate credit, the household-sector credit, or the corporate-sector credit by banks, and penalties for high-credit growth; C7.LoanR or loan restrictions that are more tailored than those captured in limits on credit growth, including loan limits and prohibitions, which may be conditioned on loan characteristics (for example, the maturity, size, loan-to-value [LTV] ratio and type of interest rate of loans), bank characteristics (for example, mortgage banks) and other factors; C9.LTV or limits to the LTV ratios, including those mostly targeted at housing loans but also including those targeted at automobile loans, and commercial real estate loans; and C10.DSTI or limits to the debt-service-to-income ratio and the loan-to-income ratio, which restrict the size of debt services or debt relative to income, including those targeted at housing loans, consumer loans and commercial real estate loans (the higher the score, the greater the protection from financial instability via macroprudential policies). EME is a dummy variable set to one for the G20 economies that are emerging market economies according to the IMF's definition. They include: ARG, BRA, CHN, IDN, IND, MEX, RUS, SAU, TUR and ZAF (using the three-letter ISO country codes). Estimation is via ordinary least squares.

Table A4: Variable Names

Access_s	Uptake_d	Environment	Inputs
Transaction_s	Inclusion_d		Process
Fulfillment_s	Digpay_d	Trust_dig	Outputs
Mnemonics			

Note: The above table includes variable names used in some statistical, graphical and/or tabular analysis to translate some of the drivers listed in Figure A3.

Table A5: World Values Survey (Selected Simple Correlations, 2017–2020)

Variables	**Correlation (p-value)**
Trust in people, individual responsibility	-0.15 (0.58)
Trust in people, government responsibility	-0.57 (0.02)
Care in trust, government responsibility	0.56 (0.02)
Favourable future in technology, confidence in banks	0.55 (0.05)
Favourable future in technology, confidence in major companies	0.54 (0.06)
Favourable future in technology, confidence in government	0.56 (0.05)
Unfavourable future in technology, trust in people	-0.76 (0.00)
Unfavourable future in technology, individual responsibility	0.79 (0.00)

Sources: Data from World Values Survey Wave 7 (2017–2020) (see www.worldvaluessurvey.org/WVSDocumentationWV7.jsp). The simple correlations are calculated by the author for the G20 economies.

Note: The European Union is represented by data for France, Germany and Italy.

Table A6: Factor Loadings for Financial Inclusion Variable

Variable	**Loadings**
Accp	0.84
Finexp	-1.00
Fintrust	-0.85
Borrowfp	0.41
Borrowp	0.77

Source: World Bank Global Findex Database 2017 (see https://globalfindex.worldbank.org/).

Note: Loadings are from principal component estimation, via maximum likelihood, for the variables shown and the nine EMEs listed in Figure A4. The sample is from 2011 to 2017. "Accp" is the percent of the population's poorest (15 years of age and older) with a bank account; "finexp" is the percent of those 15 years of age and older without an account because it is too expensive; "fintrust" is the percent of those 15 years of age and older without an account because of a lack of trust in financial institutions; "borrowfp" is the percent of those 15 years of age and older who borrowed from a financial institution; and "4orrow" is the percent of those 15 years of age and older who borrowed any money in the past year.

Table A7: Payment Alternatives and Digital Gap (Population versus Poorest)

Country	Credit card gap	Debit card gap	Internet usage gap	Digital payment gap	Remittances received	Trend and bank share/total financial assets (%)	National identity card
ARG	-	+	+	-	-	-/33.05	Y
AUS	-	+	-	-	NA	-/39.20	
BRA	-	-	+	-	+	+/32.61	Y
CAN	-	ND	+	ND	NA	-/59.38	
CHN	+	+	+	0	+	0/51.50	
DEU	0	-	-	-	NA	-/37.25	
EMU	0	-	-	-	NA	-/57.25	
FRA	0	-	-	-	NA	-/45.07	
GBR	-	ND	+	+	NA	-/61.51	
IDN	0	-	+	+	-	+/50.33	Y
IND	0	+	+	0	+	-/45.22	Y
ITA	-	-	-	-	NA	-/47.77	
JPN	ND	ND	+	+	NA	0/43.57	
KOR	-	-	-	-	NA	-/30.71	
MEX	-	-	+	0	-	-/49.71	Y
RUS	ND	-	+	0	+	-/51.44	Y
SAU	0	+	+	0	NA	-/71.27	
TUR	+	+	+	+	-	0/22.15	Y
USA	+	+	+	+	NA	0/29.91	
ZAF	-	-	0	-	-	-/29.91	Y

Source: Author's calculations.

Notes: Countries are identified by their three-letter ISO code. ND = no data; NA = not available; 0 = no change; Y = yes; plus sign = rising; minus sign = falling. Gaps are defined in the notes to Figure A4. The plus or minus signs refer to changes over the 2011 and 2017 surveys. The bank shares indicators are for the year 2019.

Table A8: Selected Features of Payments Systems (G20)

Country	System(s)	Settlement	Manager	Processing	Pricing	Finality
ARG	5	1	CB, PA	1	V, 0	1
AUS	2	2	CB, O	2	V	2
BRA	5	3	CB, PA, O, B	3	F	2
CAN	3	0	PA, O	1	F	1
CHN	5	1	CB, PA	5	F, 0	1
FRA	3	2	CB, PA	2	F	2
DEU	3	1	CB, PA	1	F, V	1
IND	8	1	CB, PA, B	3	V, S, F	1
IDN	2	1	CB	1	F	1
ITA	2	1	CB	1	F	1
JPN	4	3	CB, B	3	V, F	2
KOR	3	1	CB, PA	2	F	1
MEX	3	0	CB, B	2	F	2
RUS	2	2	CB, B	2	V	2
SAU	1	1	CB	1	F	1
ZAF	1	1	CB	1	F	1
TUR	5	1	CB, B, O, PA	1	F	1
GBR	5	1	CB, PA	1	F	1
USA	8	2	CB, PA, B	4	F	2
EUR	3	1	CB, PA	2	F	1

Source: Author's calculation from 2021 data from the Bank for International Settlements (BIS) *Red Book* (see www.bis.org/statistics/payment_stats.htm).

Notes: CB = central bank; B = bank; O = other; PA = payment association. Number of "systems" refers to the number of arrangements in each country for settlement (the varieties are real-time gross settlement, multilateral settlement, bilateral settlement, other gross settlement and batch settlement). "Settlement" refers to the number of real-time settlement systems in place. "Processing" refers to the number of processing methods (the varieties are manual, automatic clearinghouse and real-time transmission). "Pricing" refers to whether there is full cost recovery (F), variable cost (V), symbolic cost (S) or none (0). "Finality" represents the number of systems where final settlement is in real time.

Table A9: Simple Correlations between Measures of Cashless Measures

Correlation			
T-statistic			
Probability	**Emoneyrel**	**Card_debitrel**	**Card_creditrel**
Emoneyrel	1.00		

Card_debitrel	**-0.42**	1.00	
	-4.04	-----	
	0.00	-----	
Card_creditrel	**-0.23**	-0.03	1.00
	-1.93	-0.34	-----
	0.06	0.73	-----
Cards	**-0.29**	**0.21**	**0.56**
	-2.57	**2.34**	**7.10**
	0.01	**0.02**	**0.00**

Source: 2021 data from the BIS *Red Book* (see www.bis.org/statistics/payment_stats.htm).

Notes: Simple correlation between the variables shown over the 2012–2018 sample. Statistically significant correlations are in bold. Emoneyrel is the relative importance, as a percent of total cashless payments, of e-money transactions; card_debitrel is the relative importance, as a percent of total cashless payments, of debit card transactions; card_creditrel is the relative importance, as a percent of total cashless payments, of credit card transactions; cards is the total number of debit and credit cards per inhabitant.

Table A10: Selected Correlations between Cashless Use Measures and Economic Governance Indicators

Governance	Cashless	Cashlesspp	Cards
Econfree		0.40 (0.00)	0.27 (0.00)
Legal		0.40 (0.00)	0.22 (0.00)
Finopen		0.54 (0.00)	
Taxcomp		0.35 (0.00)	
Contracts	0.13 (0.01)	0.45 (0.00)	0.18 (0.00)

Sources: Data for cashless, cashlesspp and cards is from the BIS *Red Book* (see www.bis.org/statistics/payment_stats.htm). The governance indicators are from the Fraser Institute's Economic Freedom of the World 2021 Annual Report (see www.fraserinstitute.org/sites/default/files/economic-freedom-of-the-world-2021.pdf).

Notes: Simple correlations with p-values in parentheses. Econfree = economic freedom summary index; legal = legal system and property rights; finopen = financial openness; taxcomp = tax compliance; contracts = legal enforcement of contracts. "Cards" is the total number of debit and credit cards per inhabitant; "cashless" is the total volume of cashless payments (in US$ millions); "cashlesspp" is the total volume of cashless payments per inhabitant.

Table A11: Payment Instruments Preferred for Payment

Year	Cash	Credit	Debit	Other
2016	27%	24%	42%	7%
2017	24%	29%	42%	5%
2018	22%	29%	42%	6%
2019	23%	29%	42%	7%
2020	18%	33%	43%	6%

Payment Instrument Use by Age	Cash	Credit	Debit	ACH	Check	Other
18 to 24	20%	21%	51%	3%	0%	5%
25 to 34	11%	28%	33%	14%	4%	10%
35 to 44	16%	31%	29%	12%	3%	9%
45 to 54	17%	25%	33%	13%	4%	8%
55 to 64	23%	28%	26%	11%	8%	5%
65 and older	26%	25%	19%	13%	13%	4%

Cash Use by Age Group	2016	2017	2018	2019	2020
18 to 24	32%	34%	34%	33%	20%
25 to 34	24%	23%	18%	18%	11%
35 to 44	32%	26%	19%	20%	16%
45 to 54	33%	34%	27%	25%	17%
55 to 64	34%	34%	31%	32%	23%
65 and older	33%	34%	33%	33%	26%

Share of Payment Use by Year					
Year	Cash	Credit	Debit	ACH	Other
2012	47.1%	17.3%	24.4%	11.2%	
2018	26%	23%	28%	11%	11%
2019	26%	24%	30%	11%	9%
2020	19%	27%	28%	12%	14%

Source: Federal Reserve Bank of Atlanta, Diary of Consumer Payment Choice, 2021 and 2012 editions (see www.atlantafed.org/banking-and-payments/consumer-payments/diary-of-consumer-payment-choice). Data is for the United States.

Note: ACH = automated clearing house.

Table A12: Number of Significant Cyberattacks (2006–2020)

Country	Number of cyberattacks
USA	156
GBR	47
IND	23
DEU	21
KOR	18
AUS	16
CHN	15
SAU	15
JPN	13
CAN	12
FRA	11
RUS	8
TUR	6
IDN	5
ITA	4
BRA	2
MEX	1
ZAF	1
ARG	0

Sources: World Economic Forum (2021, 54) (see www3.weforum.org/docs/WEF_The_Global_Risks_Report_2021.pdf); Center for Strategic and International Studies (see www.csis.org/programs/strategic-technologies-program/significant-cyber-incidents).

Table A13: Technological Disasters

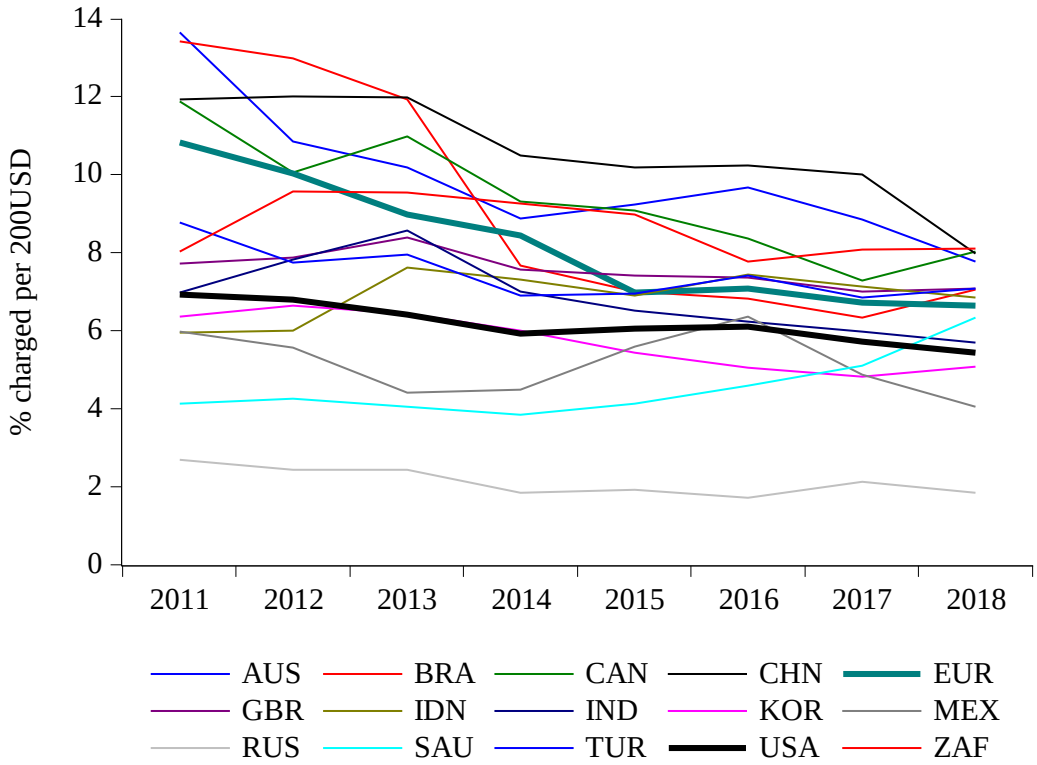
Year	Number	Country	Number
1980	19	ARG	45
1981	20	AUS	26
1982	17	BRA	163
1983	22	CAN	41
1984	29	CHN	951
1985	44	FRA	60
1986	55	DEU	34
1987	75	IND	753
1988	90	IDN	240
1989	105	ITA	83
1990	94	JPN	49
1991	40	KOR	62
1992	59	MEX	150
1993	91	SAU	49

1994	100	ZAF	183
1995	81	RUS	47
1996	97	TUR	161
1997	103	GBR	53
1998	108	USA	232
1999	129		
2000	137		
2001	119		
2002	143		
2003	148		
2004	140		
2005	147		
2006	111		
2007	105		
2008	92		
2009	67		
2010	90		
2011	84		
2012	65		
2013	65		
2014	65		
2015	85		
2016	62		
2017	69		
2018	47		
2019	48		
2020	23		

Source: Data is from the International Disaster Database (see www.emdat.be/), compiled by the Centre for Research on the Epidemiology of Disasters.

Note: Technological disasters are defined primarily as transport and industrial accidents together with “miscellaneous” other accidents that do not easily fit into the two categories.

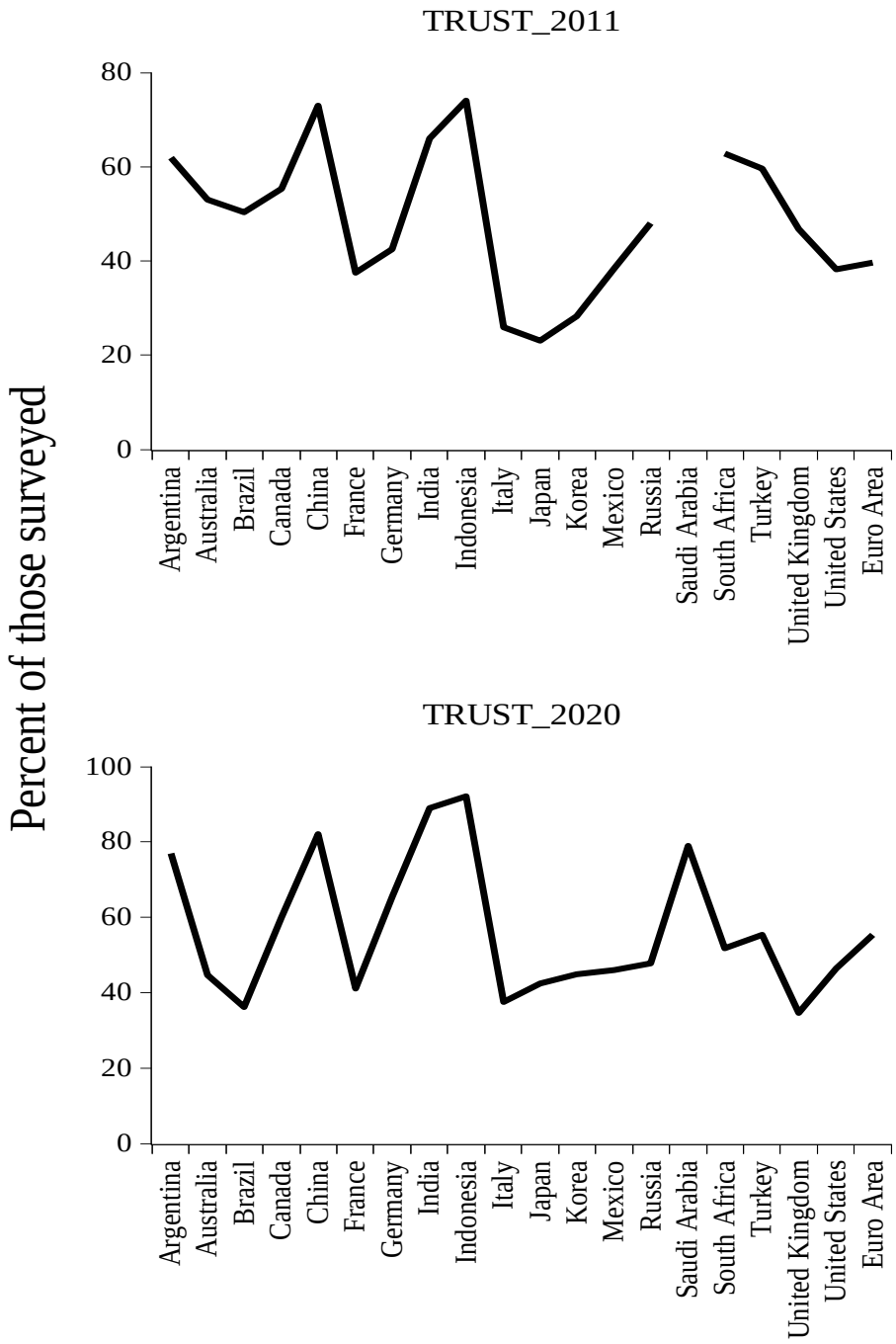
Figure A1: Remittances Costs



Source: Data is from the World Bank's World Development Indicators (see https://datatopics.worldbank.org/world-development-indicators/).

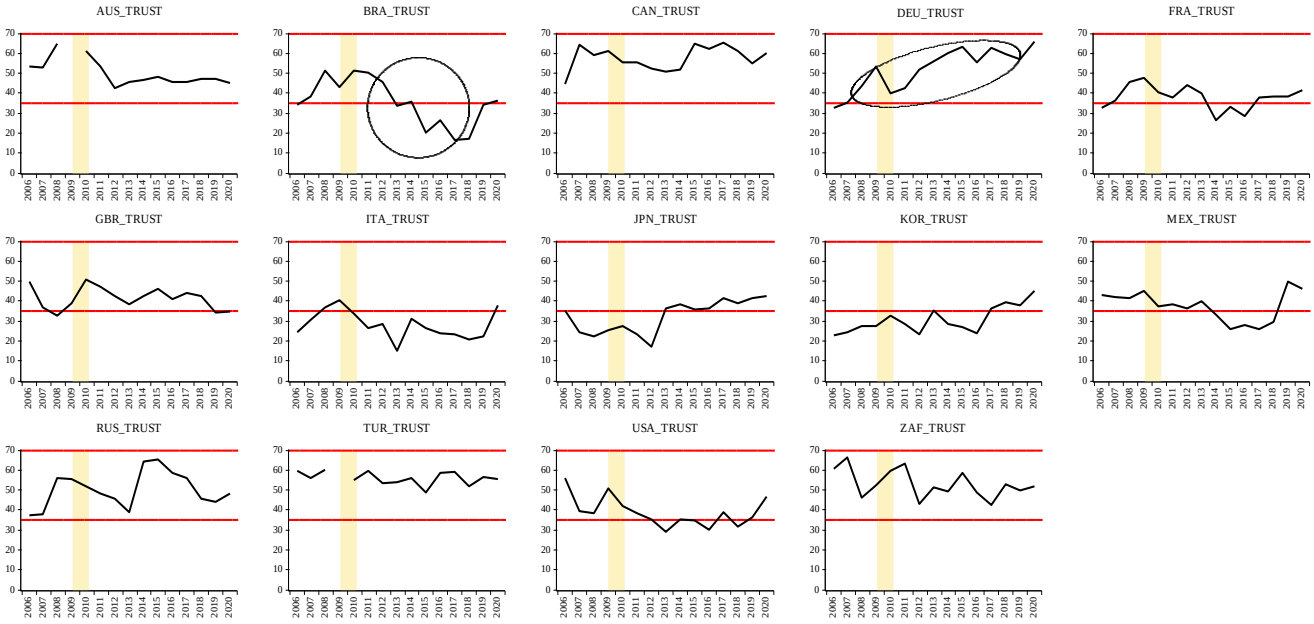
Notes: Data is annual. Countries are identified by their three-letter ISO code (EUR = euro area).

Figure A2: Index of Trust



Source: See www.oecd.org/gov/trust-in-government.htm.

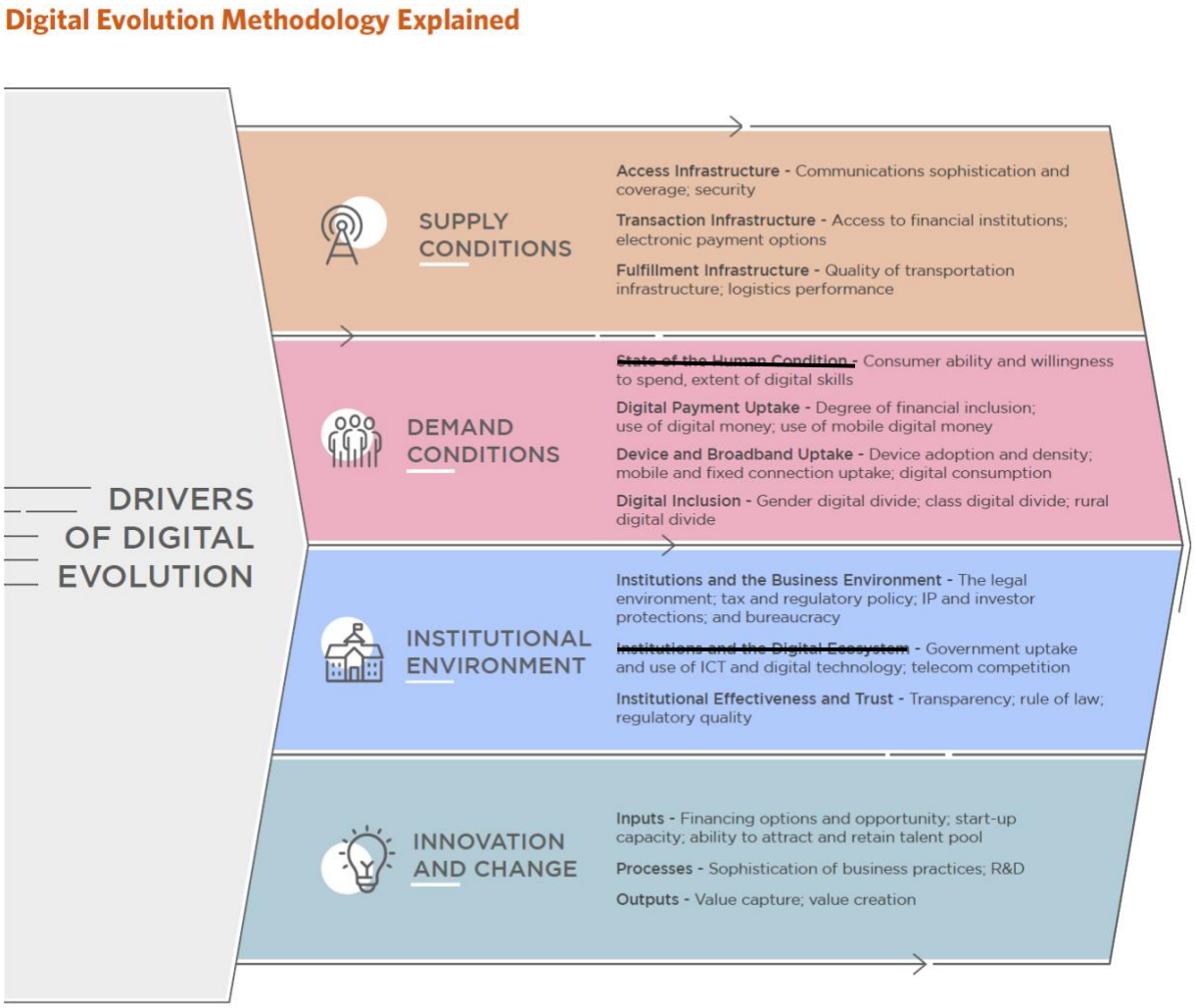
Figure A3: Trust over the Years (2006–2020)



Source: For data and definitions, see www.oecd.org/gov/trust-in-government.htm.

Notes: The shaded areas are for the years of the global financial crisis. Data is from the OECD Trust in Government survey in which respondents were asked whether they trust their governments. Gaps in the data reflect missing observations. Circles and ellipses highlight notable trends in the countries concerned. Countries are identified by their three-letter ISO codes. Values are percent of those *surveyed*.

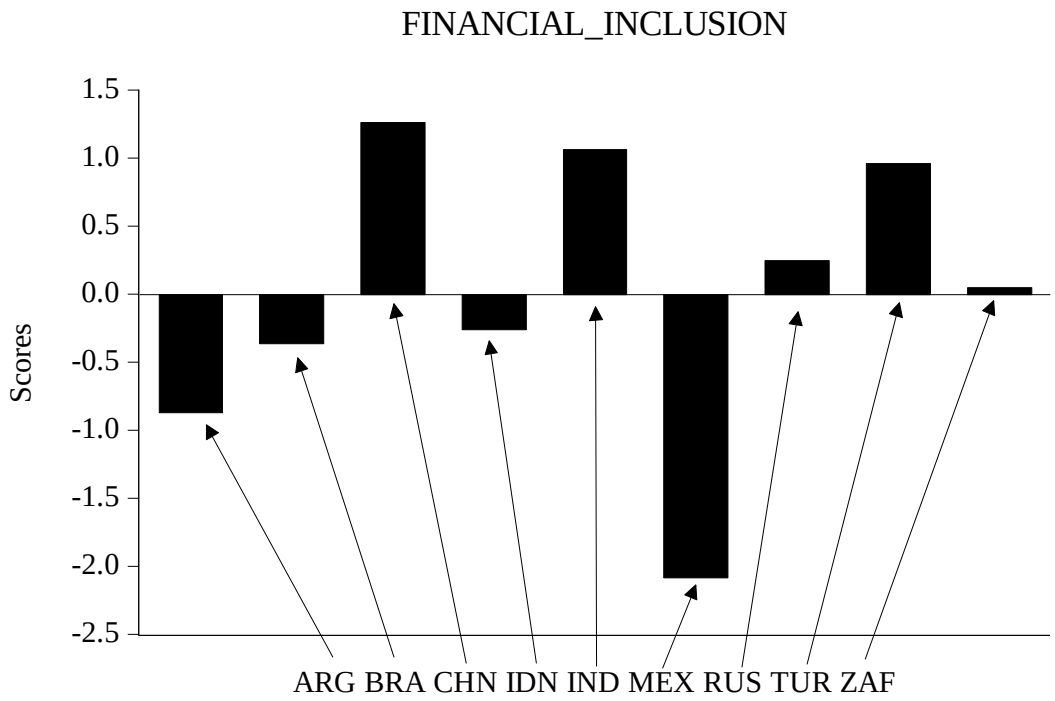
Figure A4: Digital Evolution



Source: Chakravorti et al. (2020, 19).

Figure A5: Financial Inclusion and Digital Exposure (Selected Developments and Summary Findings)

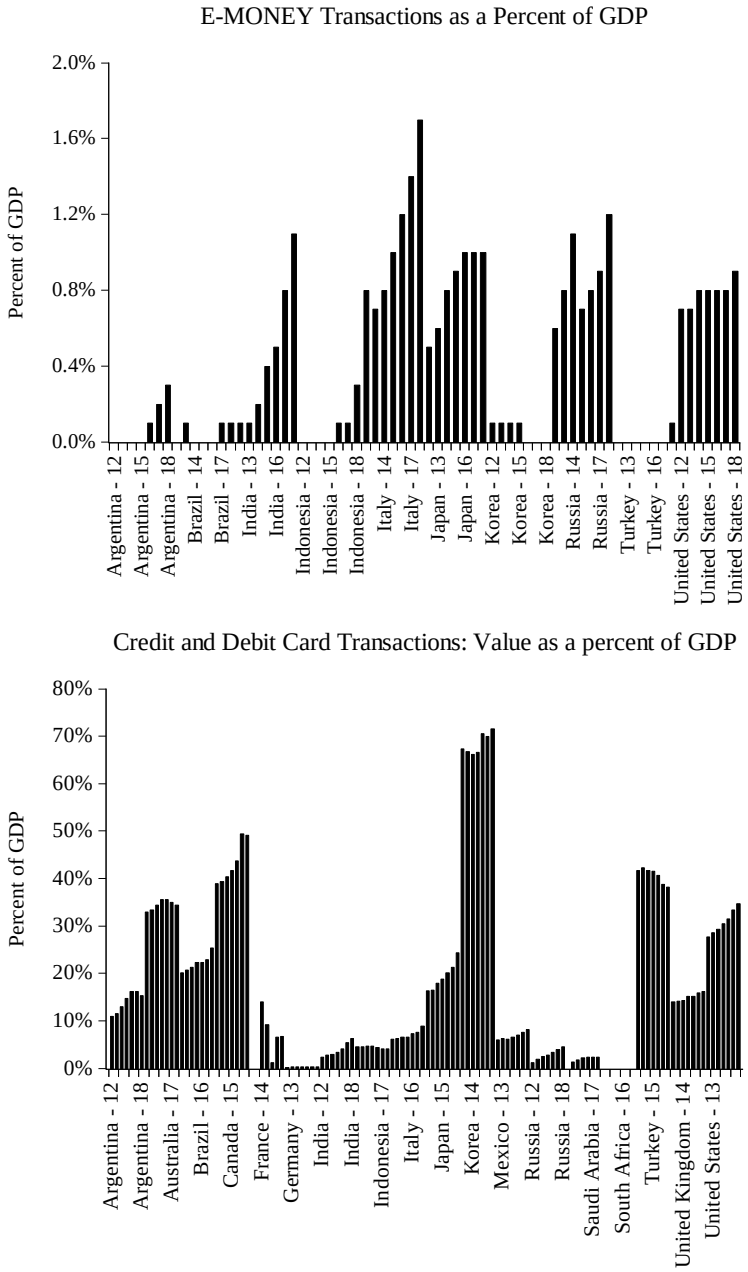
Financial inclusion indicator: EME



Source: World Bank Global Findex Database 2017 (see https://globalfindex.worldbank.org/).

Notes: Countries are identified by their three-letter ISO code. Scores are for the year 2017. The scores aggregate four characteristics for which a *gap* is calculated as the difference in population (15 years and older) versus poorest 40 percent of the population (15 years and older) who owned a debit card, owned a credit card, used the internet to pay bills or to buy something online in the past year, or made or received digital payments in the past year. A positive score signals an improvement in financial inclusion while a negative score means a deterioration in financial inclusion in the 2017 survey.

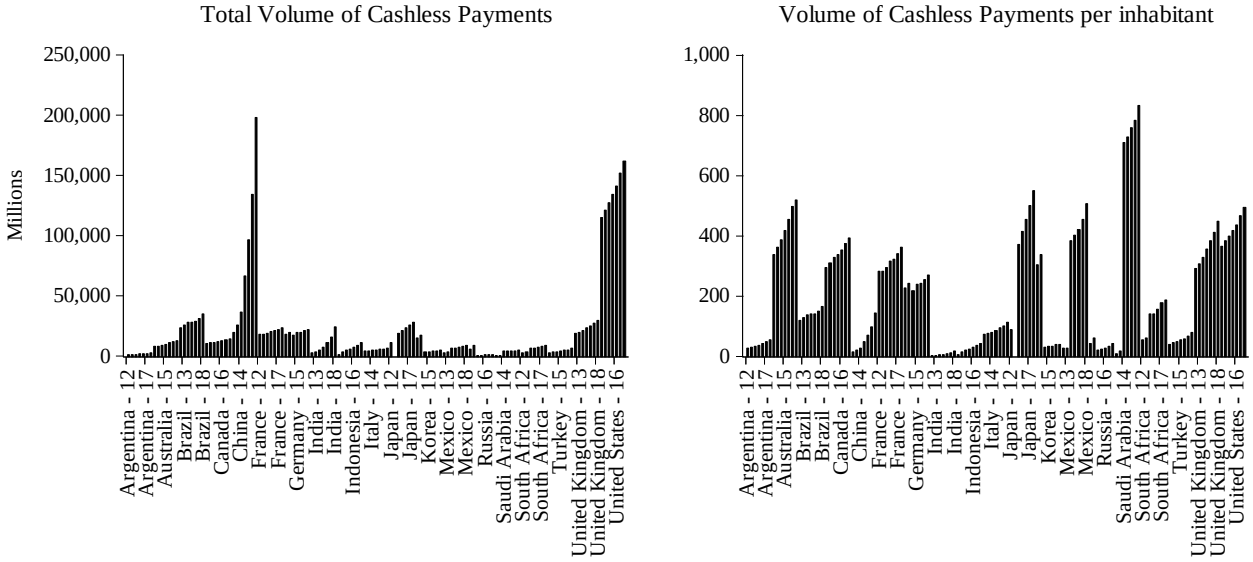
Figure A6: Cashless Payments (Selected Data)



Source: Data is annual and from the BIS *Red Book*, a publication of the Committee on Payments and Market Infrastructures (see www.bis.org/statistics/payment_stats.htm).

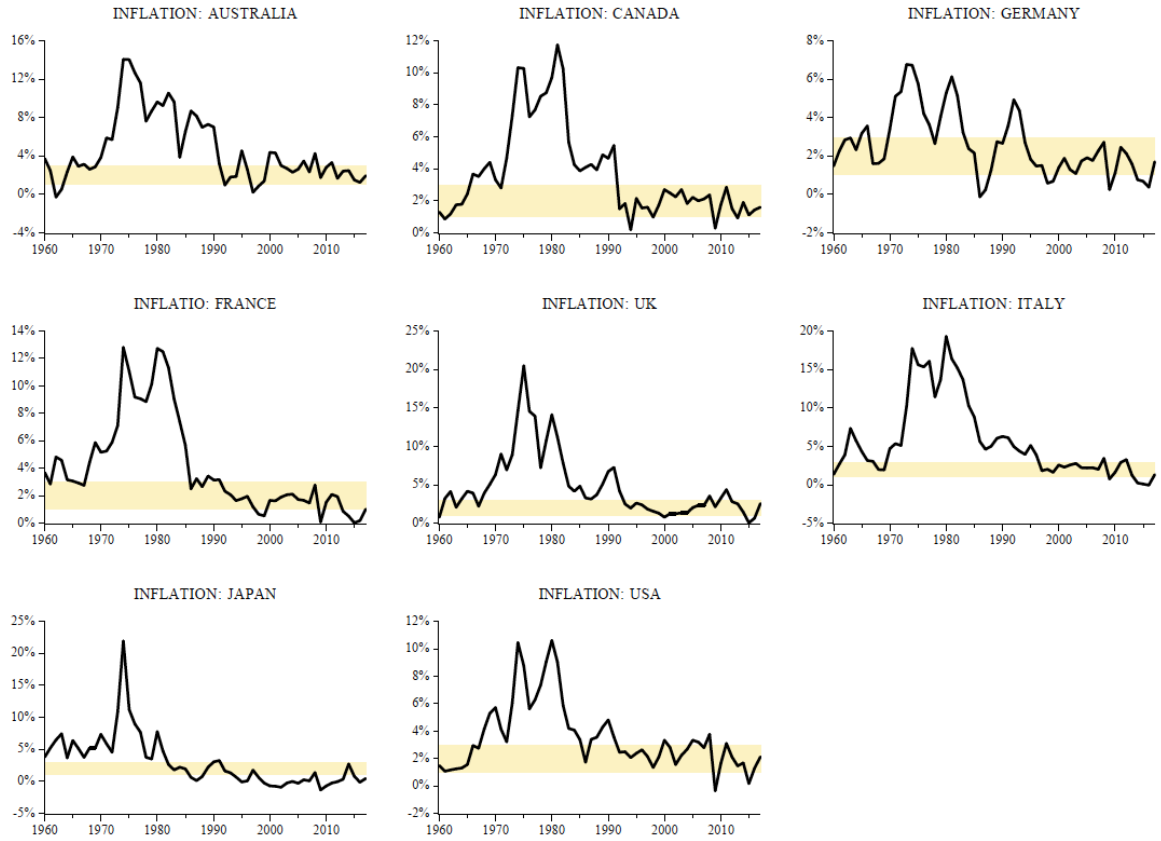
Notes: The bars are for the countries shown over the 2012–2018 period. For each country, a particular year is identified (for example, 2013 for the United States).

Figure A7: Cashless Transactions: Volume and per Inhabitant Measures



Source: Data for 2021 from the BIS *Red Book* (see www.bis.org/statistics/payment_stats.htm).

Figure A8: Inflation Rates in Select Advanced Economies (1960–2017)



Source: Annual data from Jordà-Schularik-Taylor Macrohistory Database (see www.macrohistory.net/database/).

Notes: Annual inflation in Consumer Price Index. The shaded area identifies the 1–3 percent inflation target range popular in several inflation-targeting advanced economies.