Digital Finance, Development, and Climate Change

- Work in progress –

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What we do

The main idea:

Contradictory effects of Digital Finance

- Test the role of : ….
  - Mobile money
  - Bitcoin

… on development, in Sub-Saharan African countries,

… *through their impact on CO2 emissions*

- It is important because …
  - Policy implications : picking the right tool among those available for financial development
  - If we show an impact, it follows that the ecological cost of means of payment (or savings instruments) has to be included in the policy makers' cost - advantage analysis

* "leapfrogging" the banking system (Aron, 2017)

* SS Africa could jump directly from cash to digital finance, without incurring the cost of installing a complete banking industry infrastructure: *positive* impact

Particularly interesting in Africa because mobile money has boomed in the 2010s

The **positive** effects of Digital finance :
Comes from previous arguments (efficiency of payments, etc.)
But also through :
a disminished transportation cost of people and of cash, the avoidance of building/maintaining a banking infrastructure
→ Thus Digital Finance can help reduce CO2 emissions

The **negative** effects come from its own contribution to CO2 emissions

Which effect is the strongest?

Mobile Money and development

- **Increases GDP growth & HDI:**
- Beck et al, 2015: theoretical model and test on Kenya: MM improves growth by ≈ 0.4 b.p
- Also, several works of Asongu et al (e.g., 2017): **ICT sector** overall positive impact on HDI
- **More efficient payments and more secure savings (Aron & Muelbauer, 2019)**
- **Better aid transfers**
- Thompson, 2017: MM avoid long chains of project actors, where aid incur high transaction costs and is susceptible to elite capture and corruption.
- Interhouseholds aid improved with mobile money following climatic events (Aker et al, 2016 in Kenya following droughts)

Bitcoin and development

- **Avoid distrust towards domestic currencies & provide an international means of payments**
- Ammous 2015, Nguyen 2016: survey of arguments for indicating better GDP growth prospects for developing countries:
- more efficient remittances transfers and aid distribution, [cf. Salvador, 2021]
- fosters international trade
- Permits international supralegal contracts
- **A negative impact through monetary policy?**
- **Correlation with GDP and HDI**
- Obviously, it is plausible that the correlation reflects inverse causality. Parino et al (2018) shows that the nb. of BTC client downloads is correlated with GDP (ρ = 0,63 to 0,71) and with HDI (ρ = 0,77 to 0,80)

Limits of Digital Finance w.r.t. development

- Limited by literacy and access to electricity (and of course to smartphone or computer devices)
  - Ex: only 33% literacy in Mali, 2017.
  - Electricity: 93% Gabon, 15% Burkina Faso
  - Mobile phone accounts: from 15% (Erytrea) to > 100% (Ghana)
- **Contribution to climate changes through CO_2 emissions** in the world.
- Comparison :
- ICT : 6% tot. CO_2 2007 → 14% 2040 (Belkhir et al 2018)
- Per transaction (De Vries 2018 etc.):
  - VISA : 0,4 g CO_2, bank card : 3g
  - Cheque 15 g
  - 40€ of cash : 22 g
  - Bitcoin: 233 to 363 **kg**

DATA SET

- **yearly data 2010–2018, 46 countries, 414 observations**
- Dependent variable: Human Development Index (HDI), from UN.
- Mobile Money and Financial Services: IMF
- Bitcoin client download stats: Sourceforge
- CO2: Edgar JRC (European Commission)
- All others: World Bank

COUNTRIES

Sub-Saharian African (SSA) countries

We deliberately restrict the study to SSA countries for two reasons.

- First, those countries are among those to _suffer the most from projected climate change_ (Burke et al., 2015).
- Second, these countries are also the place where _digital finance is experiencing the sharpest increase_ in the 2010s (Aron & Muellbauer, 2019)

VARIABLES

Digital Finance variables:

✓ Bitcoin clients download statistics.

✓ Mobile Money (Number of registered mobile money accounts /1000 adults, number of active mobile money accounts/1000 adults, value of mobile money transactions as % GDP, number of mobile money transactions/1000 adults)

CO_2 emission variables:

✓ Fossil CO_2 totals by country (in M tons), which include sources from fossil fuel use (combustion, flaring), industrial processes (cement, steel, chemicals, and urea) and product use,

✓ Variants: Fossil CO_2 per 1000$ of GDP by country, CO_2 from electricity and heat

Control variables

✓ Education quality,

✓ Foreign aid,

✓ Private domestic credit,

✓ Foreign direct investment.

MODEL

HYPOTHESIS

- Close to Asongu *et al.* (2017, 2019)
  - Assess whether Mobile Phone mitigates the impact of CO_2 on HDI
  - However, the sign of CO_2 variables is unstable
  - The results are mixed
- *Our paper differs in that*:
  - Our interest variable is Digital Finance
  - We study non-linear effect of CO_2 on HDI
  - Interact Digital Finance with the square term
  - Explicitly assess the p-value for marginal effects

- H1: **Bitcoin** helps mitigating the potentially negative impact of CO_2 emissions on development

- H2: **Mobile Money** helps mitigating the potentially negative impact of CO_2 emissions on development

- With country i and year t:

$$HDI_{it} = \beta_0 + \beta_1 DF_{it} + \beta_2 CO2_{it} + \beta_3 CO2_{it}^2 + \beta_4 \left(CO2_{it}^2 \times DF_{it}\right)$$

$$+ \sum_{c=1}^{C} \gamma_c W_{it} + \alpha_i + \varepsilon_{it}$$

- With W a set of control variables, α the country fixed-effect. Robust std. err., country-level cluster.

- We expect non-linearity for CO2 ($\beta_2 > 0$ and $\beta_3 < 0$), and expect β_4 to be significant.

- We **assess our results with the overall marginal effect** of CO2 on HDI:

$$\frac{\partial HDI}{\partial CO2} = \beta_2 + 2\beta_3 \overline{CO2} + 2\beta_4 \overline{CO2} \cdot \overline{DF}$$

- Do not reject H1 (H2) when this effect is significant and >0 <u>and</u> β_1 effect of BTC (MM) significant and >0

- Endogeneity: Hausman test
  - Instrumental Variable vs OLS Panel
  - If p>0.05 : OLS Panel is preferable

Preliminary tests results

VARIABLES	Reg.1 HDI	Reg.2 HDI	Reg.3 HDI	Reg.4 HDI	Reg.5 HDI	Reg.6 HDI
CO_2_t	0.008***	0.008***	0.006***	0.009***	0.004***	0.005**
	[0,001]	[0,002]	[0,001]	[0,001]	[0,001]	[0,002]
c.CO2_t#c.CO2_t	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000**
	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]
aid		-0.001***		-0.001***		0.001
		[0,000]		[0,000]		[0,001]
credit		-0.000		-0.000		0.002**
		[0,000]		[0,000]		[0,001]
edu		-0.001*		-0.001**		0.000
		[0.001]		[0,000]		[0,000]
fdi		-0.000		-0.000		-0.000
		[0,000]		[0,000]		[0,000]
cumulBTC			0.000**	-0.000*		
			[0,000]	[0,000]		
c.cumulBTC#c.CO2_t#c.CO2_t			-0.000	0.000**		
			[0,000]	[0,000]		
NRMMA (Number of Registered Mobile Money Transactions per 1000 adults					0.000***	0.000***
					[0,000]	[0,000]
c.NRMMA#c.CO2_t#c.CO2_t					0.000***	0.000***
					[0,000]	[0,000]
Constant	0.422***	0.471***	0.437***	0.472***	0.462***	0.406***
	[0,016]	[0,027]	[0,015]	[0,026]	[0,016]	[-0.044]
Observations	352	237	352	237	188	134
R-squared	0.307	0.474	0.364	0.488	0.667	0.701
Number of cnum	44	42	44	42	35	29
Country Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
CO2 marginal effect (at means)	0.00736***	0.00819***	Na	0.00912***	0.0036***	0.00441**
Margin st. err.	0.00125	0.00151		0.0014	0.00111	0.00187
Margin p-value	3.66e-09	5.61e-08		6.92e-11	0.00121	[0,0186]
Hausman endog. test chi2	6.209	7.370	5.501	7.880	1.034	4.482
P-value	0.0449	0.195	0.139	0.247	0.793	0.612

Robust standard errors in parentheses   *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	Reg.7	Reg.8	Reg.9	Reg.10	Reg.11	Reg.12
	HDI	HDI	HDI	HDI	HDI	HDI
$CO2\_t$	0.009***	0.008***	0.006**	0.007**	0.007**	0.009***
	[0.003]	[0.002]	[0,002]	[0,003]	[0,003]	[0,003]
$c.CO2\_t\#c.CO2\_t$	-0.000**	-0.000	-0.000**	-0.000**	-0.000***	-0.000***
	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]
Aid		0.000		0.001		-0.000
		[0.001]		[0.001]		[0.001]
Credit		0.003***		0.002**		0.001
		[0,001]		[0,001]		[0,001]
Edu		-0.000		0.000		0.000
		[0.000]		[0.000]		[0.000]
Fdi		0.000		0.000		-0.000
		[0.000]		[0.000]		[0.000]
NAMMA(Number of Active Mobile Money Transactions per 1000 adults)	0.000***	0.000				
	[0,000]	[0,000]				
$c.NAMMA\#c.CO2\_t\#c.CO2\_t$	-0.000***	-0.000**				
	[0,000]	[0,000]				
NMMT(Number of Mobile Money Transactions per 1000 adults)			0.000***	0.000***		
			[0,000]	[0,000]		
$c.NMMT\#c.CO2\_t\#c.CO2\_t$			-0.000*	-0.000**		
			[0,000]	[0,000]		
VMMT(Value of Mobile Money Transactions - % of GDP)					0.001***	0.000***
					[0,000]	[0,000]
$c.VMMT\#c.CO2\_t\#c.CO2\_t$					-0.000	-0.000***
					[0,000]	[0,000]
Constant	0.387***	0.321***	0.438***	0.369***	0.416***	0.382***
	[0,032]	[0,051]	[0,032]	[0,051]	[0,041]	[0,048]
Observations	134	97	165	114	168	119
R-squared	0.613	0.673	0.534	0.644	0.496	0.589
Number of cnum	28	23	32	28	33	28
Country Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
CO2 marginal effect (at means)	0.00857***	Na	0.00510***	0.00608***	Na	0.00771***
Margin st. err.	0.00257		0.00197	0.00233		0.00259
Margin p-value	0.000845		0.00973	0.00902		0.00287
Hausman endog. test chi2	2.664	12.95	0.154	11.01	0.159	10.14
P-value	0.446	0.0734	0.926	0.0512	0.984	0.119
Robust standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1					

Turning Points Analysis

Table 1 regression number	(1)	(2)	(3)	(4)	(5)	(6)
Digital finance variable	**No**	**No**	**CumulBTC**	**CumulBTC**	**NRMMA**	**NRMMA**
CO_2 turning point	527	521.4	477.1	455.8	458.4	462
Whithin sample range	No	No	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes	No	Yes
Observations	352	237	352	237	188	134
Number of countries	44	42	44	42	35	29

Table 1 regression number	(7)	(8)	(9)	(10)	(11)	(12)
Digital finance variable	**NAMMA**	**NAMMA**	**NMMT**	**NMMT**	**VMMT**	**VMMT**
CO_2 turning point	599.1	646.4	146.7	115.3	130.4	124.5
Whithin sample range	No	No	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes	No	Yes
Observations	134	97	165	114	168	119
Number of countries	28	23	32	28	33	28

Results

- We show a non-linear impact of CO2 on HDI, with turning points mostly within observed range

- **We reject H1**: Bitcoin helps mitigating the potentially negative impact of CO2 emission on development.
  - Because, Bitcoin's direct effect is negative, and its contribution in mitigating the negative impact of CO2 emission is very low.

- **We do not reject H2**: Mobile money helps mitigating the potentially negative impact of CO2 emission on development.

- Robust to:
  - 1 lag RHS variables ;
  - other CO2 variable ;
  - other computations for margins

Discussion

- Need to better take into account the fact that BTC is an externality for SSA countries (low countries contributions)

- Concerning mobile money, the scarcity of some metals used in mobile or smartphones production should also be taken into account – though this aspect is beyond the scope of this article.

Many thanks for your attention