4th **Annual National Bank of Cambodia Macroeconomic Conference**

Technological Progress and its Impacts on Access to Finance

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NATIONAL BANK OF CAMBODIA

Riel. Stability. Development.

Focus on:

"Dynamic Stage of Technological Progress and Financial Loan Portfolio in Cambodia: *Convergence or Divergence?*"

## *What I am going to talk very briefly today:*

- Why this project does matter?

- What others have found?

- What and how I have found?

- Concluding remarks and policy recommendations

(1) Access to financial products and services (financial inclusion) such as
- transactions, payments, saving,
credit and insurance - is a key to promote economic growth in Cambodia.

(2) Nearly 80 % of Cambodian population, living in rural areas, can access to credit and not many people to transactions, payments and insurance.

"Four themes of financial and technological progress in Cambodia"
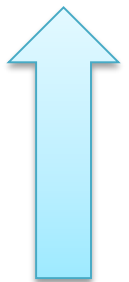
(3) To access to financial inclusion, we still depend on traditional ways at micro / firm levels (Offices, staffs, ATMs, bank account, credit / debit cards, etc). => High cost => rural areas & the poorest households?

(4) Yet, 2/3 of population is adult that can access to mobile phone (90%) and internet (48%). => Technological innovation in Cambodia: how its impacts?

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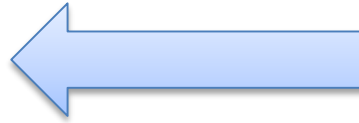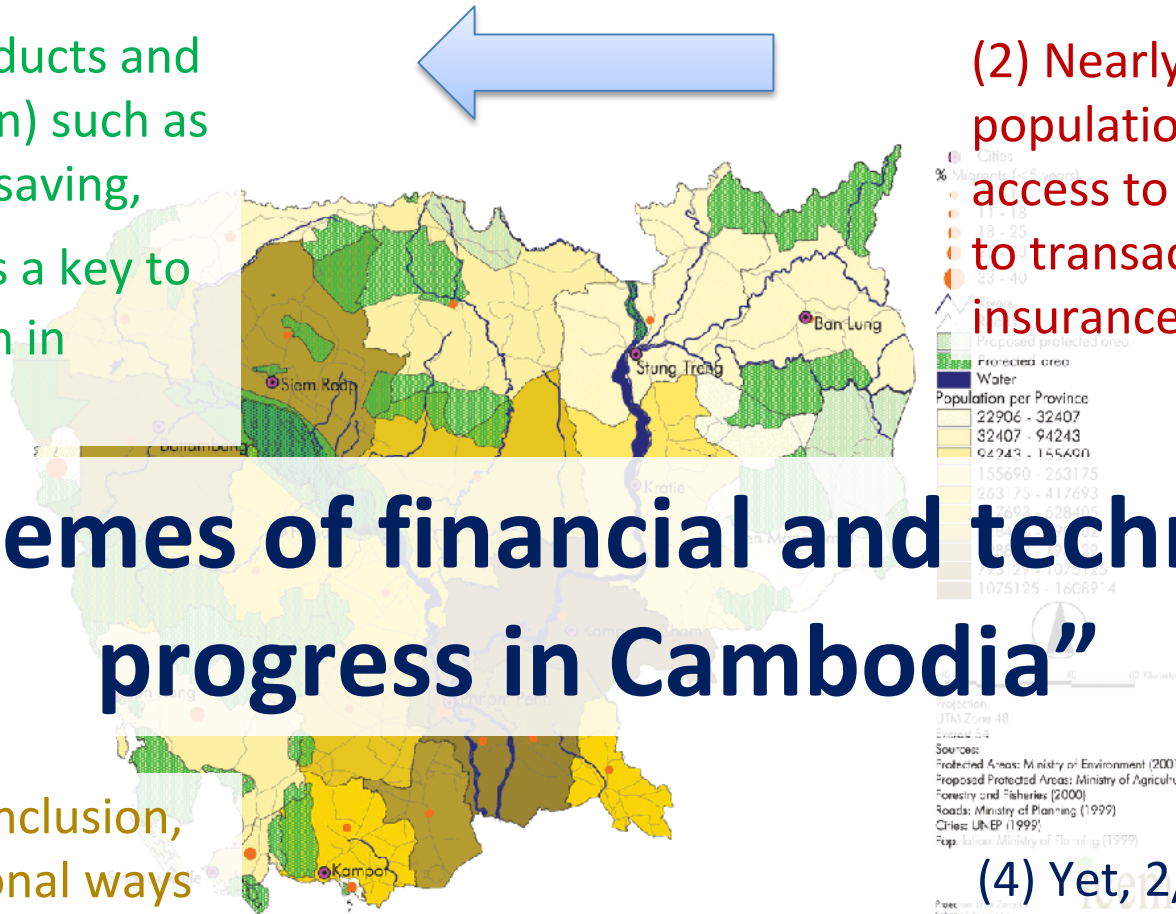
Brief review of financial sectors :

Financial inclusion: accessing by individuals and business to useful and affordable financial products and services – credits, savings, insurance, transactions, and payments – in a responsible and sustainable way. To target the poorest households by reducing poverty and boosting prosperity (World Bank, 2017):

Credits and saving: 2/3 Cambodia households (sources: MFI/Banks, private loan provider, relatives, other sources).
Loan and deposit accounts with commercial banks : 248 .73 adults (loan) and 48.11 (Deposit) among 1000 adults.

Account at financial institution and ATMs: Representing a small proportion of total population (13 among 100,000 adults, 15.29 adults for income richest 60% and 8.83 adults for income poorest 49%).

Accessing to insurance, online transactions and payments: is in rising trends but it represents a small share of population who located in urban in major provinces (Phnom Penh, Siem Reap, Sihanouk, Battambang, …).

Strong rising of micro-finance institutions comparing to commercial banks, specialized banks and financial leasing companies.

2
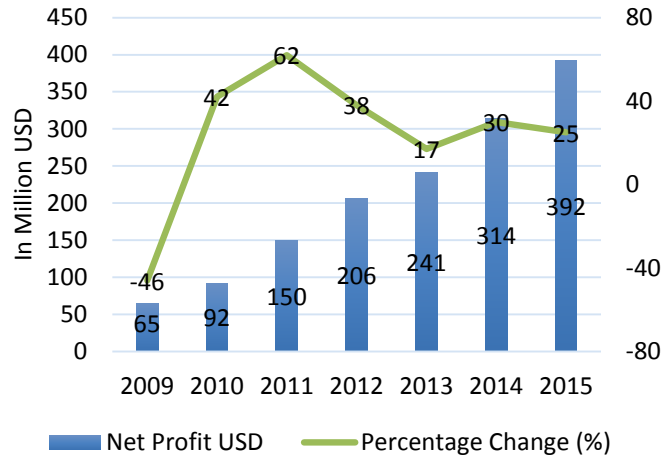
Bank – Net profit
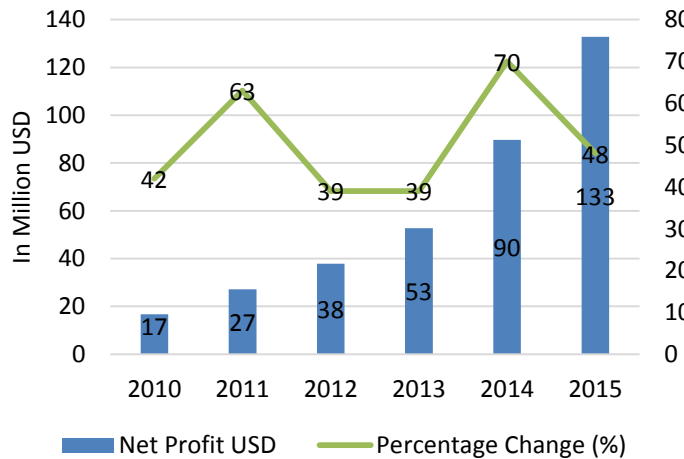
Number of Banks and MFIs

Bank – credit by business line

MFIs – Net profit

MFIs – Loan and Deposit (million USD)

MFIs – credit by business line

Source: *National Bank of Cambodia (NBC) 2015 Annual Supervision Reports*

3
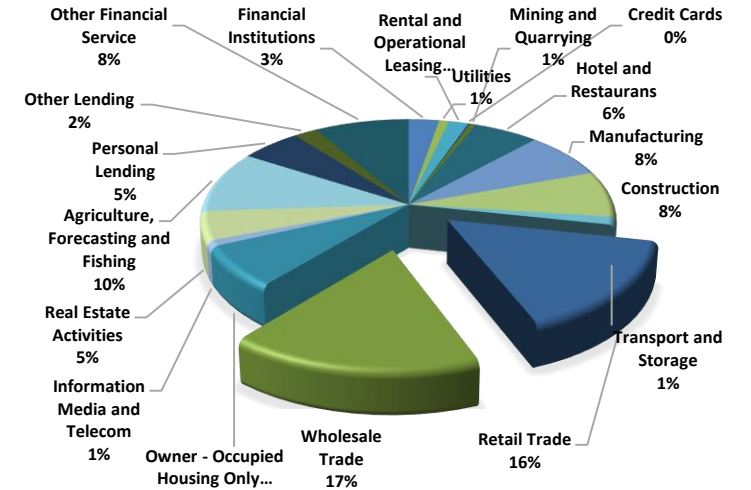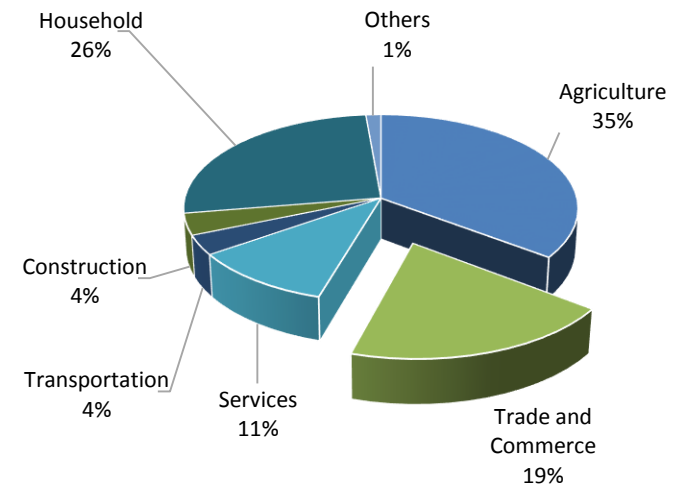
Brief review of financial sectors and technological progress :
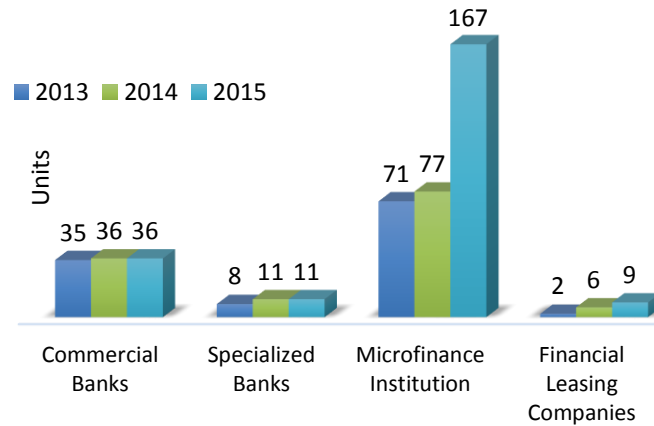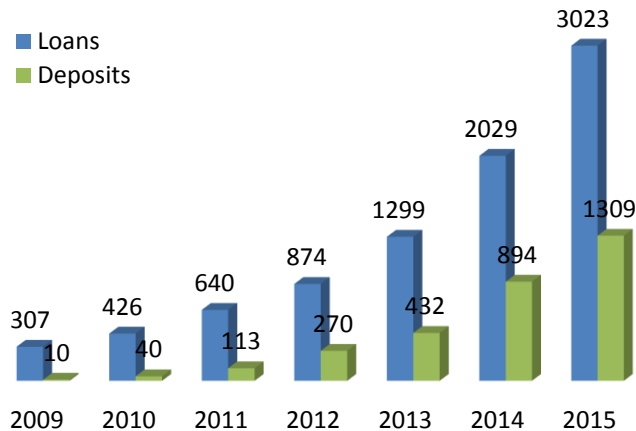
Accessing to financial services and products by new technological innovation: help to promote banking and financial sectors to more efficient risk management and helps to reduce operational cost. To benefit the poorest population:

Key questions: **how technological progress in macro level help to increase technological role of traditional financial way to promote financial inclusion?**

Modern ways at macro level

Traditional ways at micro / firm level

Top class

Banks and MIFs

Population access to internet

Offices & Staffs

Fixed – telephone subscription and Mobile telephone cellular subscribers

Middle class

ATMc / Bank account

Mobile network coverage and internet

POS, Debit / Credit cards

Lowest class

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Fixed - telephone subscription

Legend:
- Fixed-telephone subscriptions
- Fixed-telephone subscriptions per 100 inhabitants

Population access to Internet

Legend:
- Broadband internet subscribers
- Fixed broadband internet subscribers per 100 people

Account at financial institution

Legend:
- Automated teller machines (ATMs) (per 100,000 adults)
- Account at a financial institution, income, richest 60% (% ages 15+)
- Account at a financial institution, income, poorest 40% (% ages 15+)

Mobile telephone cellular subscribers

Legend:
- Mobile-cellular telephone subscriptions
- Mobile-cellular telephone subscriptions per 100 inhabitants

Mobile network coverage and internet

Legend:
- Mobile network coverage percent of the population
- Percentage of Individuals using the Internet, per 100 people

Comparison between loan and bank account

Legend:
- Loan Accounts with Commercial Banks Per 1,000 Adults
- Number of Bank Accounts per 1,000 adults
- Deposit Accounts with Commercial Banks Per 1000 Adults

Source: All graphics are compiled from The Telecommunication Development Sector (ITU-D), Retrieved URL: http://www.itu.int/en/Pages/default.aspx

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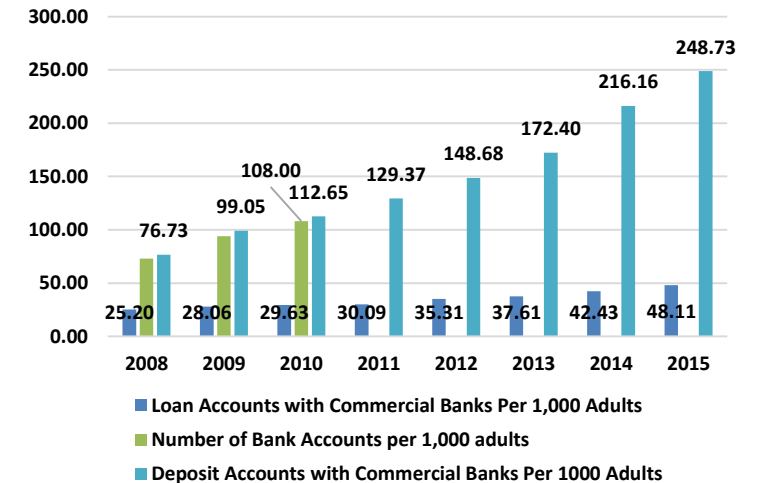
Objective of this research project:

i. What is the **dynamic impact** of technological progress on financial inclusion in Cambodia? And,

ii. Does its dynamic stage represent **convergence or divergence hypothesis** during the observed period and in the foreseeable future?

The existing literatures: Technological progress and its impacts on access to finance:

- **(+)** Technological in micro / firm level in financial and banking sectors (explained by accessing to ATMs, POS terminals, debit cards, credit cards, etc.) and macro level (explained by accessing to smart phone mobile, internet, internet banking, mobile banking, telephone banking)

- => **(+)** Higher financial inclusion => **(+)** Economic growth and better welfare of whole population (also the poorest households)

Is it holding a huge promise in 41 commercial and specialized banks and 87 MFI institutions in Cambodia in short and long run?

How I find it?

- **Raw dataset based on cross-sectional firms data:**
  - *During time interval of 2009 and 2016 (N = 7 years)*
  - *With 588 total observations*

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MFIs

- **Principal data sources :**
  - *National bank of Cambodia (NBC) and*
  - *World development indicator (WDI), the World Bank*
  - *International Telecommunication Union (ITU)*
  - *And other reliable sources*

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Commercial & Specialized banks

The selected variables:

Loan portfolio (Dependent variable)

Technological progress – at firm / micro level: **ATMs**, **operating and administrative expense excluded depreciation.**

Technological progress – at macro level: **fix-telephone subscriber**, **mobile cellular subscriber**, **broadband internet subscriber**, and **number of internet users (radio of total population).**

Control variables: **number of branches and staffs**, **net profit** and **non – performance loan radio.**

Others: **Time dummy effect, cross-sectional dummy effect, lag of loan portfolio at time (t -1)**

The econometric model:

$$Loan_{it} = \sum_{k=1}^{K} \vartheta_k loan_{it-k} + \varphi[TP]_{it} + \emptyset W'_{it} + \varepsilon_{it} \qquad (3.1)$$

$$for\ i = 1, 2, \dots, N\ and\ t = 2009\ to\ 2016$$

The baseline estimation equation :

With regard to time dummy, let's denote $\tau_j T_j$ as time trend effect or time dummy where τ_j is the parameters of time trend, T_j. It equals to 1 on year j and 0 otherwise. For any given year j, denotes the function by setting $T_j = 1$ for j equates to determined period and 0 otherwise. As the result, we get an expression as follows: time dummy $= \sum_{j=1}^{T-1} \tau_j T_j$

Therefore, we get the new baseline model of technological progress and financial productivity as follows:

$$Loan_{it} = \sum_{k=1}^{K} \vartheta_k loan_{it-k} + \varphi[TP]_{it} + \emptyset W'_{it} + \sum_{j=1}^{T-1} \tau_j T_j + \varepsilon_{it} \qquad (3.2)$$

$$for\ i = 1, 2, \dots, N\ and\ t = 2009\ to\ 2016$$

Why Static and Dynamic Panel Data Model?

- Important to control of the dynamics of the process
- Discover new or different relationship between the dependent and independent variables.

The choice of using Arellano-Bond system GMM estimator : xtabond2 command on STATA

- *Suitable for datasets with large panels ($N \to \infty$)and short periods (T finite)*
- *Permitted to use enough instruments to avoid the endogenous problem and at the same improve the efficiency of the estimation.*
- *With 2 equations : Level and Difference equation*
  - ⟹ *Difference as the instrument for level equation*
  - ⟹ *Level as the instrument for difference equation*

- *To avoid the problem of multicollinearity, we estimate correlation between explanatory variables.*
- *Hansen test : robustness test*
- *Sargan test (H0 = Instruments as a group are exogenous)*
- *Arellano-Bond test (H0 = no autocorrelation) see AR(2)*
- *Resolving too many number of Instrument by "collapse command".*

Justification	Obs	Mean	SD	Min	Max	Stationary Test	Normality Test
Explained variable							
Loan portfolio or credit	570	11.26	2.21	2.83	16.24	928.77***	3.3***
Bank_loan portfolio or credit	574	5.41	6.40	0.00	16.24	641.21***	9.39***
MFIs_loan portfolio or credit	584	5.68	5.24	0.00	15.24	287.56***	9.09***
Loan portfolio growth rate	410	-1.01	1.42	-6.86	4.34	737.79***	6.14***
Explanatory variables							
Technological progress factors							
Operating and investment expense (excluded depreciation)	530	8.72	1.68	4.57	13.29	549.69***	1.34*
Number of ATMs standing	161	2.77	1.36	0.00	5.70	120.95***	1.7**
Point of Sale (POS) terminals	81	5.61	1.27	2.20	8.41	85.8***	1.98**
Number of debit cards issued	138	9.33	1.81	4.87	13.64	245.02***	1.32*
Number of credit cards issued	69	7.43	1.26	3.61	9.32	60.85***	2.9***
Fixed-telephone subscriptions	588	5.48	0.25	4.73	5.77	969.39***	10.22***
Fixed-telephone subscriptions per 100 inhabitants	588	0.30	0.25	-0.42	0.59	794.12***	9.64***
Percentage of individuals using the internet, per 100 people	588	0.87	0.51	-0.28	1.41	425.1***	7.78***
Broadband internet subscribers	588	4.70	0.24	4.34	4.99	667.85***	8.6***
Fixed broadband internet subscribers per 100 people	588	-0.48	0.22	-0.82	-0.21	609.59***	8.35***
Mobile-cellular telephone subscriptions	588	7.22	0.17	6.80	7.32	1497.29***	11.79***
Mobile-cellular telephone subscriptions per 100 inhabitants	588	2.04	0.15	1.65	2.13	1258.51***	11.87***
Pre-determined and endogenous factor (controlled variables)							
Lag of loan portfolio at time (t -1)	452	11.31	2.17	2.83	16.12	739.23***	3.05***
Nonperformance loan radio (NLR)	432	-4.31	1.91	-13.13	-0.21	737.79	4.39***
Net Profit	422	8.26	2.07	1.73	13.10	608.47	0.79
Number of staffs	571	4.59	1.62	1.10	9.41	1126.48	5.84***
Number of branches	320	1.31	1.32	0.00	5.56	328.65	5.68***

No.	Justification	1	2	3	4	5	6	7	8	9	10	11
1	Loan portfolio	1										
2	Loan portfolio at time (t-1)	0.9725	1									
3	Non – performance radio	-0.1582	-0.1188	1								
4	Net profit	0.8969	0.905	-0.1341	1							
5	Number of staffs	0.7734	0.7405	-0.125	0.723	1						
6	Number of branches	0.7696	0.7313	-0.1422	0.7218	0.9309	1					
7	Operation and administrative expense	0.8817	0.8555	-0.1568	0.8201	0.9401	0.8954	1				
8	Automated teller machines (ATMs) (per 100,000 adults)	0.7142	0.6965	-0.1126	0.676	0.8185	0.8718	0.8256	1			
9	Fixed-telephone subscriptions	-0.2059	-0.2098	0.0871	-0.0932	-0.0776	-0.0671	-0.1374	-0.1403	1		
10	Percentage of Individuals using the Internet	0.2215	0.2231	-0.1242	0.0997	0.0561	0.0441	0.1361	0.1115	-0.9229	1	
11	Mobile-cellular telephone subscriptions	0.1961	0.1926	-0.1014	0.1463	0.0107	-0.0252	0.1116	-0.0153	-0.2544	0.4932	1

Source: *Author's estimates*

Note: *Data generated from 41 banks and 83 MFIs (2016) / using commend in STATA.13: generate lagLaon = Loan[_n - 1], for taking lag dependent variable or gen Var = L.(n).Var. Avplots allows the regression OLS in decomposing into graphic and it is easily to see the correlation among explained and explanatory variables. Moreover, as showed in appendix III, it is demonstrated that the results is mostly followed the hypothesis setting but it is indicated the autocorrelation and heteroskedasticity as the dataset does not flow beyond the regression line (95% confidence interval).*

Correlation of technology components to deposit accounts at commercial banks (right)
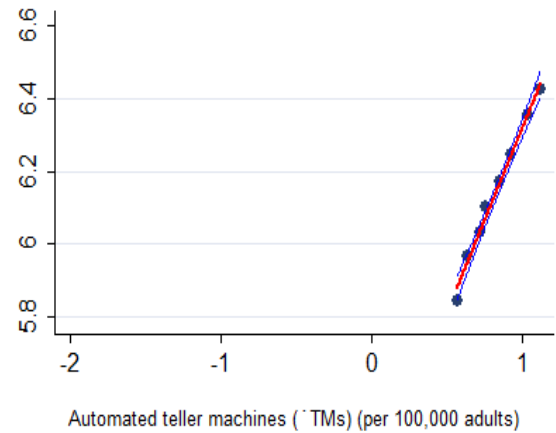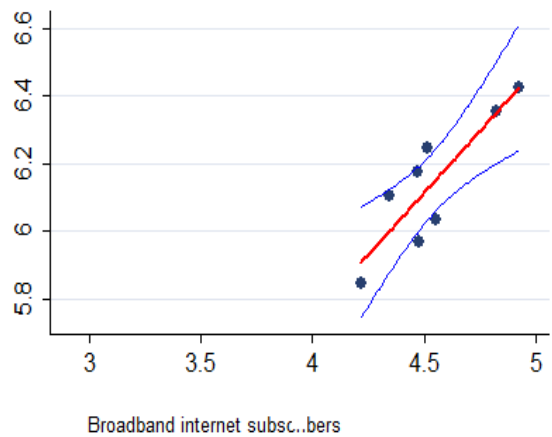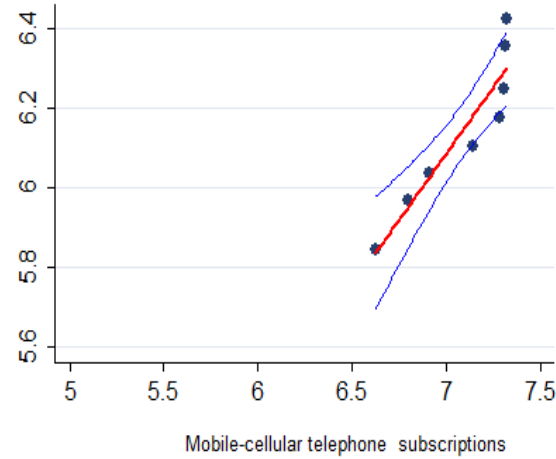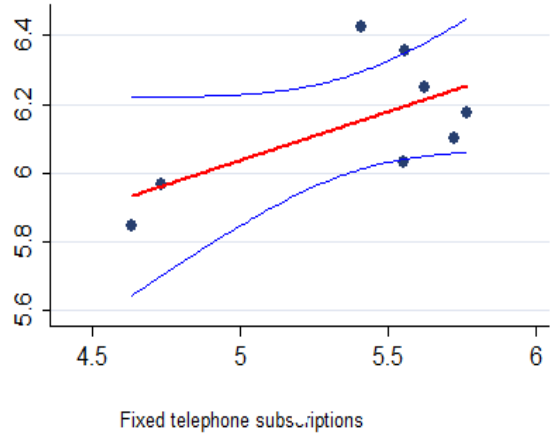
Correlation of technology components to number of bank accounts per 1,000 adults (right)
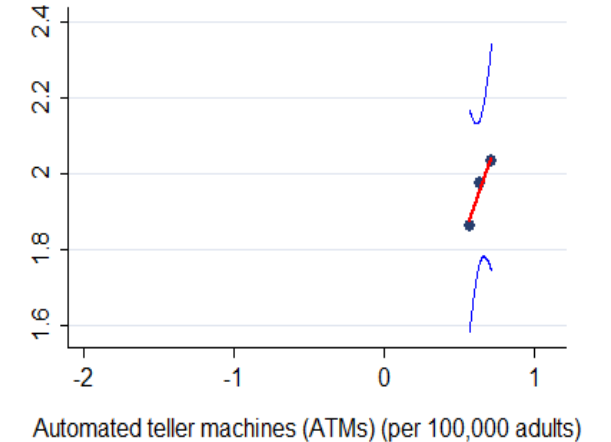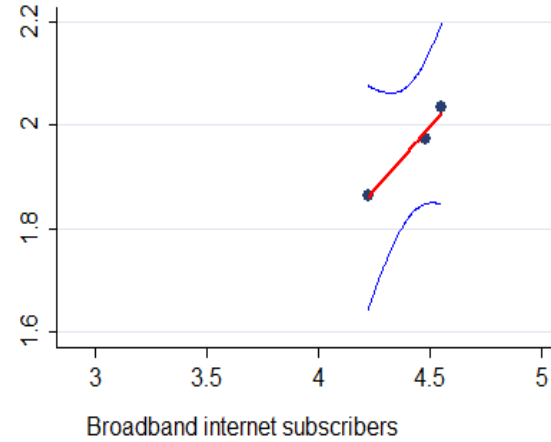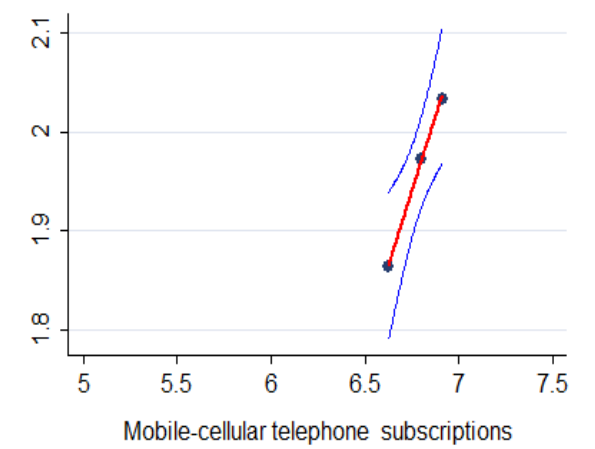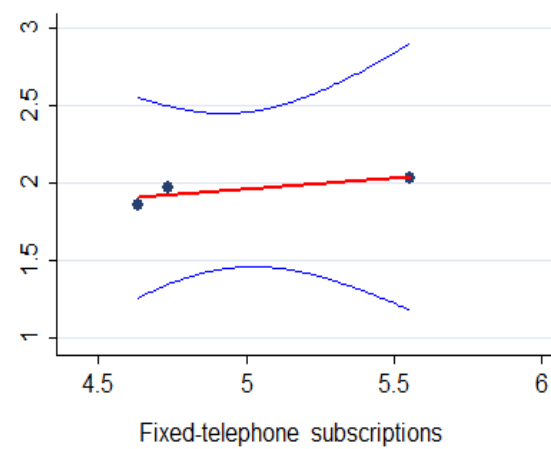
Source: Author's estimates

Correlation technology components to outstanding loans from (MFIs) (left)

Correlation technology components to number of loan accounts at other financial intermediaries (right)
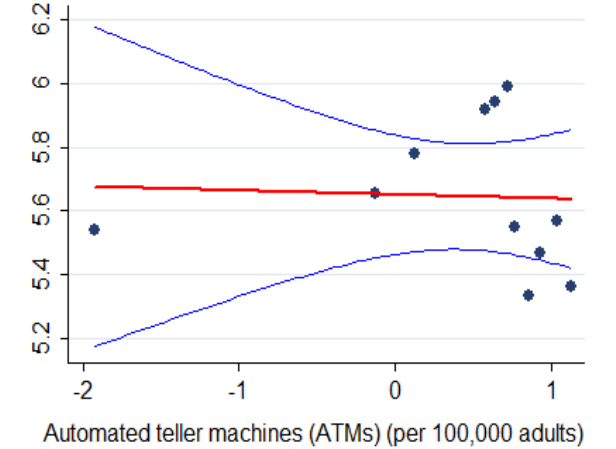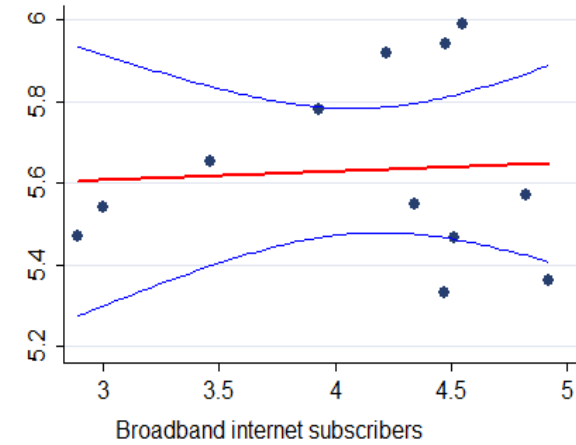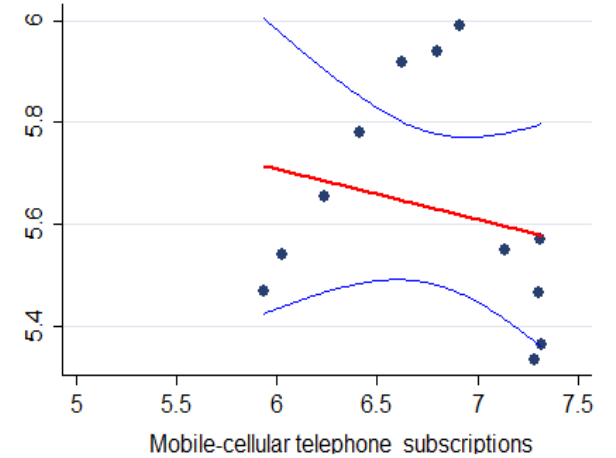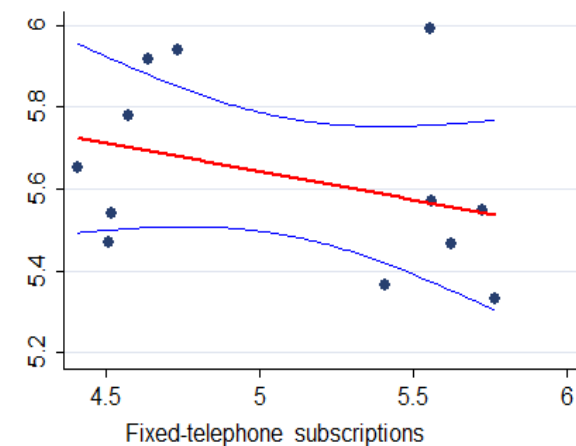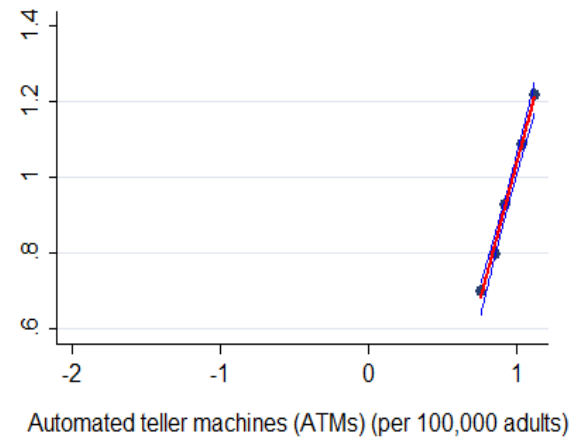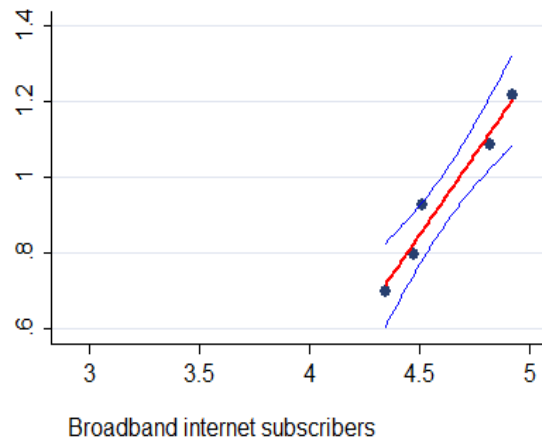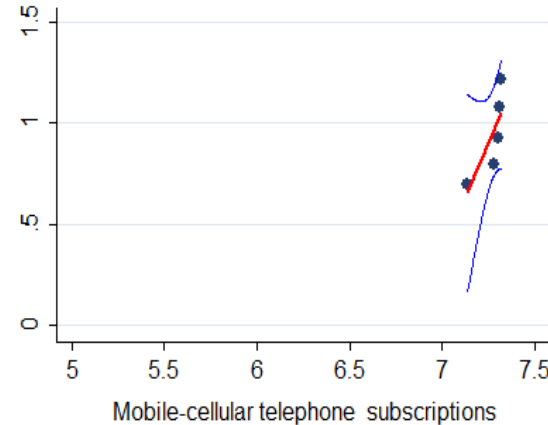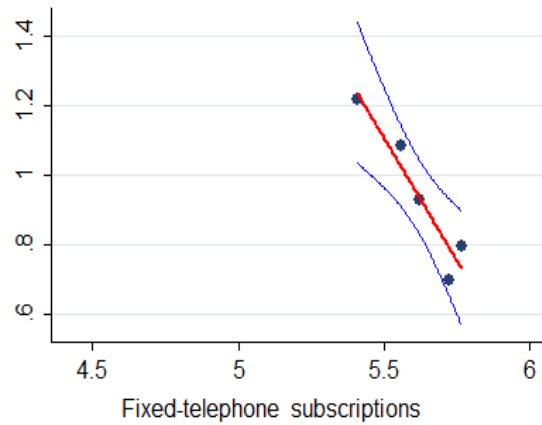
Source: Author's estimates

Correlation technology components to nonlife (left) and life (right) insurance premium volume to GDP
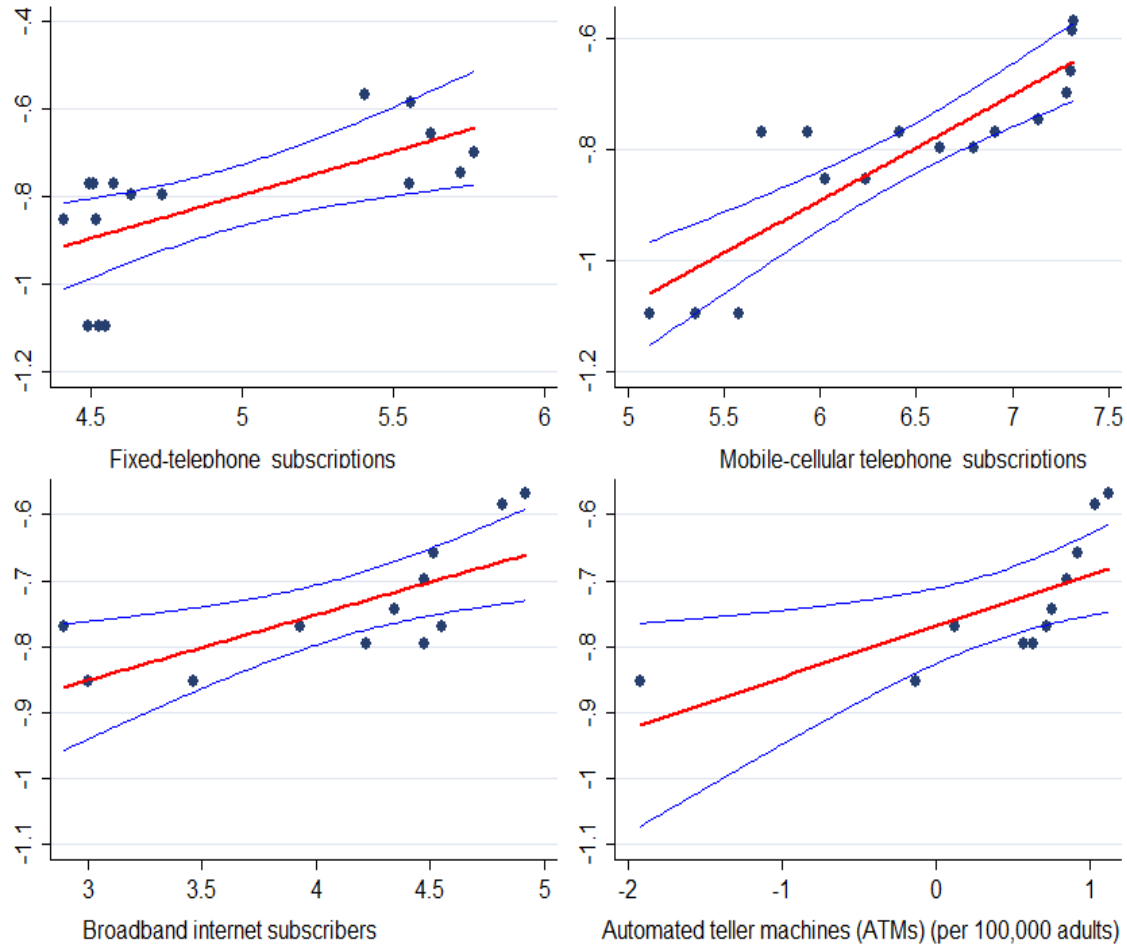
Correlation technology components to life (right) insurance premium volume to GDP
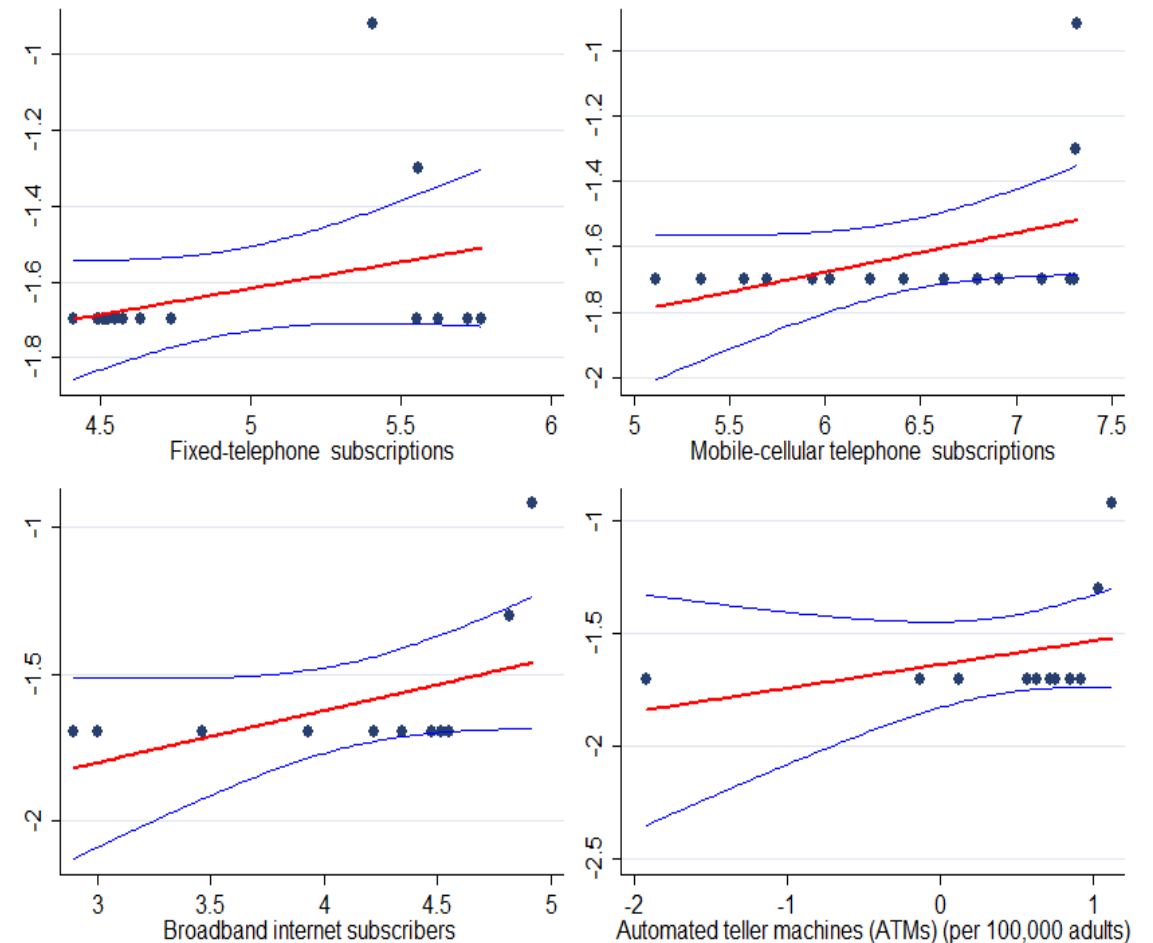
Source: Author's estimates

Regression diagnostic AV plots of simple OLS estimator in 95% level of confidential interval
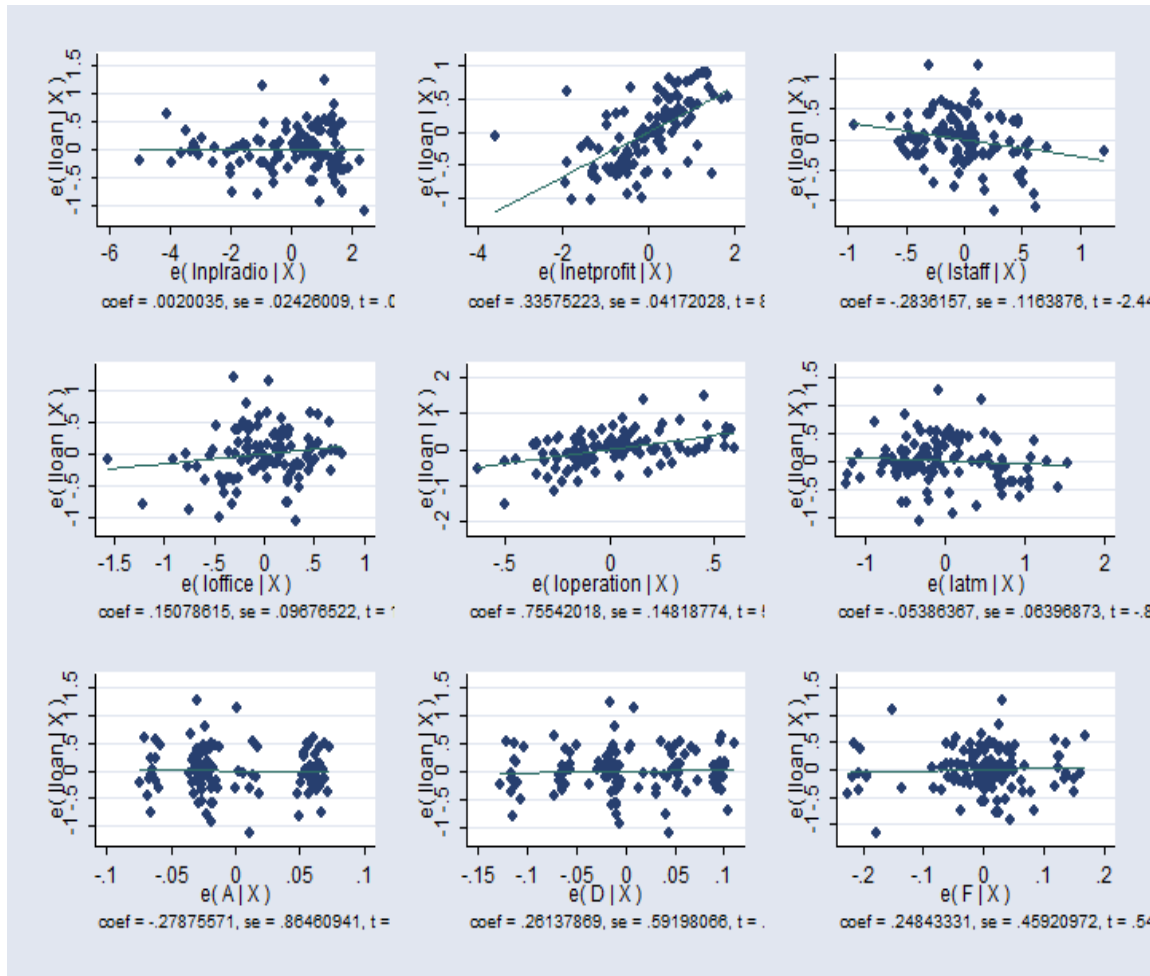
Technological progress and loan portfolio

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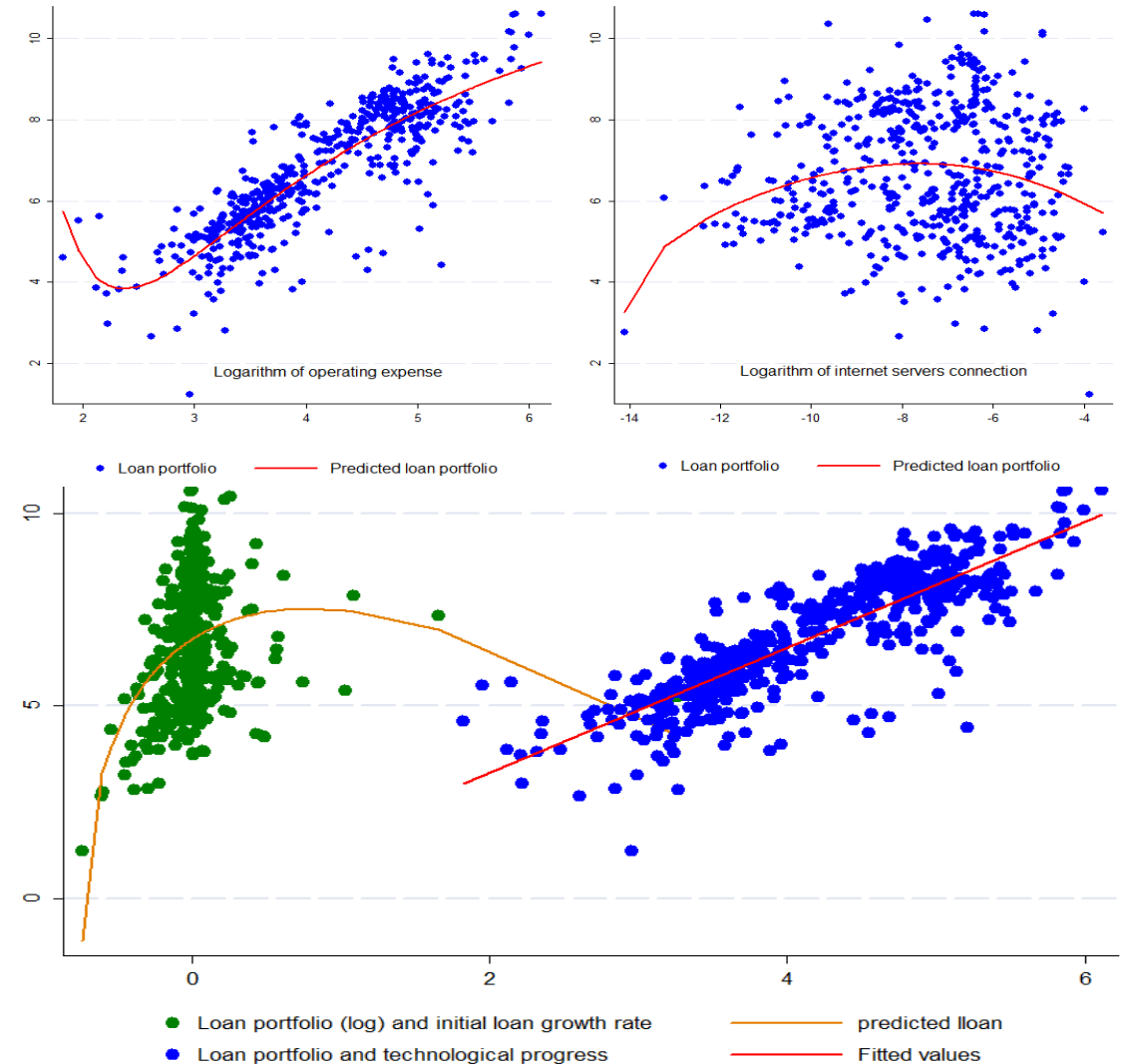
Our empirical econometric estimation approaches:

- First of all, the research study applies static panel data models without controlling time dummy and cross-sectional dummy effect => **Basic Static Model**

- Secondly, to controlling cross sectional heteroskedasticity and autocorrelation issue, the conventional approach such as dynamic panel data GMM base system and difference GMM should be replaced => **Basic Dynamic Panel Data Model**

- Thirdly, due to technological progress or change is treated as an endogenous factors, or meaning that technical progress is closely associated with the knowledge emerging from research and development activities, endogenous technical change is considered to be generated by formal R&D activities, (G. Zaman and Z. Goschin, 2010) => **Dynamic Panel Data, Pre-determined and Endogenous Factor Model**

- Finally, to eliminate the problem of over instruments occurred in dynamic panel data method of Arellano and bond (1991) and Blundell and Bond (1998), D Roodman (2006) proposed a new commend on dynamic panel data model, say xtabond2, the conventional approach taking into account the idea of system and difference GMM. => **IV - Dynamic Panel Data, D. Roodman (2006)**

=> **The most updated and advanced econometric models to estimate the problematic!**

Basic Static Model

Loan portfolio	(1)	(2)	(3)	(4)
Exogenous factors				
Non – performance radio		-0.0083 (-0.42)	-0.0083 (-0.42)	-0.0069 (-0.41)
Net profit		0.0859** (2.80)	0.0859** (2.80)	0.0544* (2.33)
Number of staffs		0.252* (2.67)	0.252* (2.67)	0.353** (3.50)
Number of branches		-0.149* (-2.15)	-0.149* (-2.15)	-0.0875 (-1.77)
Technological progress or innovation				
Operation and administrative expense	1.181*** (9.12)	1.343*** (13.81)	0.927*** (7.59)	0.607*** (6.14)
Automated teller machines (ATMs) (per 100,000 adults)	-0.150 (-1.83)	-0.119 (-1.46)	-0.0413 (-0.48)	-0.0771 (-1.02)
Fixed-telephone subscriptions			-0.265 (-0.77)	-0.216 (-0.85)
Percentage of Individuals using the Internet			0.0313 (0.15)	0.121 (0.86)
Mobile-cellular telephone subscriptions			0.697* (2.16)	0.721** (3.66)
Constant term	0.0847 (0.10)	2.207* (2.64)	2.207* (2.64)	0.620 (0.25)
Time dummy effect	No	No	No	No
Cross – sectional dummy effect	No	No	No	No
R^2	0.835	0.893	0.893	0.914
Number of observations	154	114	114	114
F – Statistic	204.41 [0.0000]	88.00 [0.0000]	123.72 [0.0000]	949.67 [0.0000]

Basic Dynamic Panel Data Model

Loan portfolio	(1)	(2)	(3)	(4)
Lag dependent regressor				
Loan portfolio at time (t-1)	0.433** (2.59)	0.300*** (0.99)	0.123 (0.79)	0.194*** (0.41)
Exogenous factors				
Non – performance radio		-0.0137 (-0.11)	-0.0147 (-0.80)	-0.0154 (-0.67)
Net profit		0.0387*** (0.53)	0.0256 (1.00)	0.0168 (0.42)
Number of staffs		0.347*** (1.13)	0.425*** (5.02)	0.653*** (0.34)
Number of branches		-0.0696 (-0.43)	-0.0397 (-0.86)	-0.138 (-0.18)
Technological progress or innovation				
Operation and administrative expense	0.923*** (4.87)	0.536*** (0.48)	0.379** (2.47)	0.205 (0.14)
Automated teller machines (ATMs) (per 100,000 adults)	-0.0912 (-0.61)	-0.0764 (-0.13)	-0.0987 (-1.61)	-0.0947 (-0.25)
Fixed-telephone subscriptions	0.499 (0.91)		-0.136 (-0.56)	-0.107 (-0.14)
Percentage of Individuals using the Internet	0.0830 (0.32)		0.202 (1.77)	0.176*** (0.35)
Mobile-cellular telephone subscriptions	-0.234 (-0.40)		0.727** (2.26)	0.623** (0.37)
Constant term	-2.847 (-1.06)	2.079 (8.52)	0.237 (0.13)	0.810 (0.62)
Time dummy effect	Yes	Yes	Yes	Yes
Cross – sectional dummy effect	No	No	No	No
Number of observations	119	85	85	85
AB autocorrelation test				
AR (1)	0.0069 [0.9945]	-0.4284 [0.6684]	0.0805 [0.9358]	-0.0454 [0.9638]
AR (2)	-1.5818 [0.1137]	-0.557 [0.5775]	-1.6792 [0.0931]	-1.1051 [0.2691]
Wald – Statistic	330.05 [0.0000]	3558.52 [0.0000]	7804.02 [0.0000]	703.43 [0.0000]

Left table — Others' Findings

Loan portfolio	Dynamic Panel Data, Pre-determined and Endogenous Factor Model			
	(1)	(2)	(3)	(4)
Lag dependent regressor				
Loan portfolio at time (t-1)	0.298*** (3.95)	0.236 (0.11)	0.282* (2.55)	0.210 (0.07)
Exogenous factors				
Non – performance radio	-0.0045 (-0.13)	-0.0228 (-0.11)	-0.0098 (-0.53)	-0.0034 (-0.01)
Net profit	0.0656 (1.22)	0.0353 (0.19)	0.0083 (0.30)	0.0270 (0.07)
Number of staffs	0.351*** (3.76)	0.228 (0.17)	0.395*** (4.00)	0.288 (0.28)
Number of branches	-0.0516 (-0.87)	0.0188 (0.02)	-0.0124 (-0.19)	-0.0743 (-0.04)
Technological progress or innovation				
Operation and administrative expense	0.385*** (3.40)	0.618 (0.17)	0.369** (3.03)	0.712 (0.13)
Automated teller machines (ATMs) (per 100,000 adults)		-0.0686 (-0.12)	-0.0907 (-1.83)	-0.0581 (-0.16)
Fixed-telephone subscriptions			0.0629 (0.30)	0.331 (0.16)
Percentage of Individuals using the Internet			0.151 (1.57)	0.146 (0.10)
Mobile-cellular telephone subscriptions			0.457* (2.23)	0.131 (0.07)
Constant term	3.091*** (4.82)	2.477 (0.24)	-0.416 (-0.25)	-1.611 (-0.07)
Time dummy effect	Yes	Yes	Yes	Yes
Cross – sectional dummy effect	No	No	No	No
Number of observations	118	85	85	85
AB autocorrelation test				
AR (1)	-0.3838 [0.7011]	-0.0962 [0.9233]	-0.8405 [0.4006]	-0.0254 [0.9797]
AR (2)	-0.8279 [0.4077]	-0.6284 [0.5297]	1.671 [0.0947]	-0.7685 [0.4422]
Sargan test (validity)	Accepted	Accepted	Accepted	Accepted
Wald – Statistic	2185.85 [0.0000]	63.31 [0.0000]	15070.87 [0.0000]	649.86 [0.0000]

Right table — My Findings

Loan portfolio	IV - Dynamic Panel Data, D. Roodman (2006)			
	(1)	(2)	(3)	(4)
Lag dependent regressor				
Loan portfolio at time (t-1)	0.262*** (5.70)	0.189** (2.76)	0.210** (3.08)	0.684*** (17.58)
Exogenous factors				
Non – performance radio			-0.0134 (-1.00)	-0.0186* (-2.08)
Net profit			0.0181 (0.83)	0.0456* (2.18)
Number of staffs			0.393*** (4.09)	0.128* (-2.11)
Number of branches			-0.0294 (-0.47)	0.199*** (4.64)
Technological progress or innovation				
Operation and administrative expense	0.874*** (9.87)	0.870*** (9.85)	0.438*** (3.75)	0.272** (3.30)
Automated teller machines (ATMs) (per 100,000 adults)	-0.0133 (-0.24)	-0.0191 (-0.33)	-0.100* (-2.02)	-0.0785** (-2.67)
Fixed-telephone subscriptions		0.0226 (0.08)	0.0109 (0.04)	-0.105 (-0.33)
Percentage of Individuals using the Internet		0.0652 (0.36)	0.159 (0.94)	0.0365 (0.17)
Mobile-cellular telephone subscriptions		0.319 (1.56)	0.508** (2.77)	0.178 (1.03)
Constant term				0.765 (0.35)
Time dummy effect	Yes	Yes	Yes	Yes
Cross – sectional dummy effect	No	No	No	No
Number of observations	85	85	85	113
AB autocorrelation test				
AR (1)	-0.52 [0.600]	-0.24 [0.814]	-0.43 [0.665]	0.08 [0.933]
AR (2)	-2.26 [0.024]	-2.25 [0.024]	-2.51 [0.012]	-2.53 [0.011]
Sargan test	Rejected	Rejected	Rejected	Rejected
F– Statistic	340.40 [0.0000]	172.07 [0.0000]	135.94 [0.0000]	648.85 [0.0000]

Economic significance of a one-SD increase of explanatory factors on line of financial loan portfolio (% Probability)

Legend: ■ Model (4) ■ Model (3) ■ Model (2) ■ Model (1)

Values shown in chart:
- Percentage of Individuals using the Internet: 0.034
- Operation and administrative expense: 1.193, 0.645
- Number of staffs: 0.466, 0.568
- Net profit: 0.135
- Loan portfolio at time (t-1): 0.453, 0.643

Economic significance of a one-SD increase of explanatory factors on line of financial loan portfolio (% Probability)

Horizontal bar chart with the following categories and labeled values:

- Mobile-cellular telephone subscriptions: **0.120**
- Percentage of Individuals using the Internet
- Automated teller machines (ATMs) (per 100,000 adults)
- Operation and administrative expense: **0.635**, **1.546**
- Number of staffs: **0.687**
- Net profit: **0.080**
- Loan portfolio at time (t-1): **0.265**, **0.934**

X-axis: -0.500, 0.000, 0.500, 1.000, 1.500, 2.000

Legend: ■ Model (4) ■ Model (3) ■ Model (2) ■ Model (1)

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Economic significance of a one-SD increase of explanatory factors on line of financial loan portfolio (% Probability)

Mobile-cellular telephone subscriptions

Automated teller machines (ATMs) (per 100,000 adults) — **-0.106**

Operation and administrative expense — **0.456**, **1.464**

Number of branches — **0.262**

Number of staffs — **0.207**

Net profit — **0.094**

Non – performance radio — **-0.035**

Loan portfolio at time (t-1) — **1.475**, **0.565**

■ Model (4) ■ Model (3) ■ Model (2) ■ Model (1)

Traditional technology help so little while modern technology sees itself in transforming !

How Technology affects Banking Sector?

Loan

Branches/ Staffs

Profit

Loan creates loan !

Over-indebtness

Non – performance loan
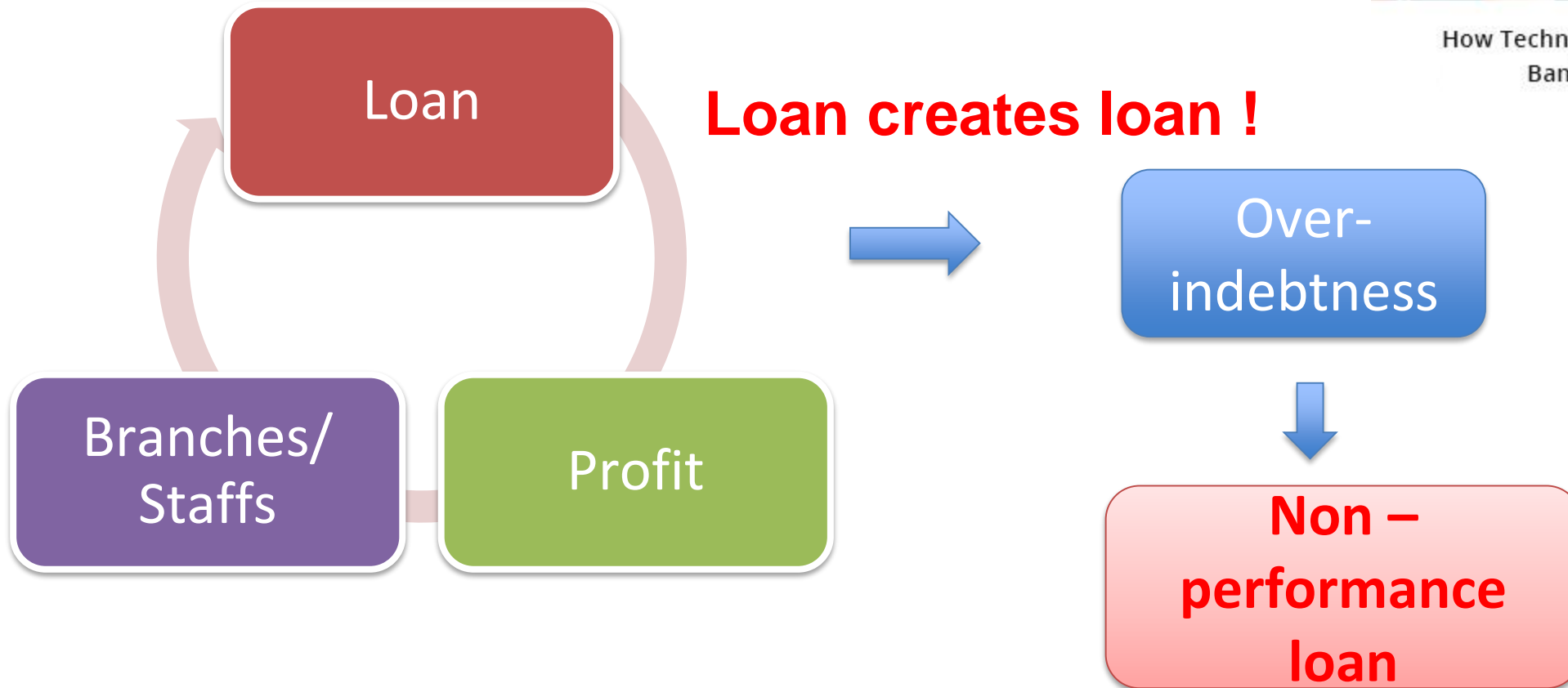
Description	Simultaneous Equation Model, Dynamic Base			
	OLS (1)	OLS (2)	GMM (1)	GMM (2)
Observation period (2009-2016) **Convergence** 0<|parameter|<1	**0.79*** (14.50)**	**0.51*** (8.39)**	**0.85*** (10.30)**	**0.83*** (11.17)**
Divergence |parameter|>1	Rejected	Rejected	Rejected	Rejected
Prediction at next year periods	**1.66*** (25.06)**	**1.06*** (3.83)**	2.41 (0.39)	1.05* (2.74)
Concluding remarks — **Convergence** 0<|parameter|<1	Rejected	Rejected	Rejected	Rejected
Divergence |parameter|>1	Yes	Yes	Inconclusive	Inconclusive
Wald Chi(2)	196.24*** [0.0000]	153.02*** [0.0000]	232.77*** [0.0000]	126.53*** [0.0000]
Number of observations	152	152	119	119

OLS (1) = 0.79***
OLS (2) = 0.51***
GMM (1) = 0.85***
GMM (2) = 0.83***

Technological progress

$|\beta^*| > 1$ *Divergence*

Financial loan portfolio

OLS (1) = 1.66***
OLS (2) = 1.06***
GMM (2) = 1.05*

Convergence

$0 < |\beta^*| < 1$

2009   2016   Next 5   year
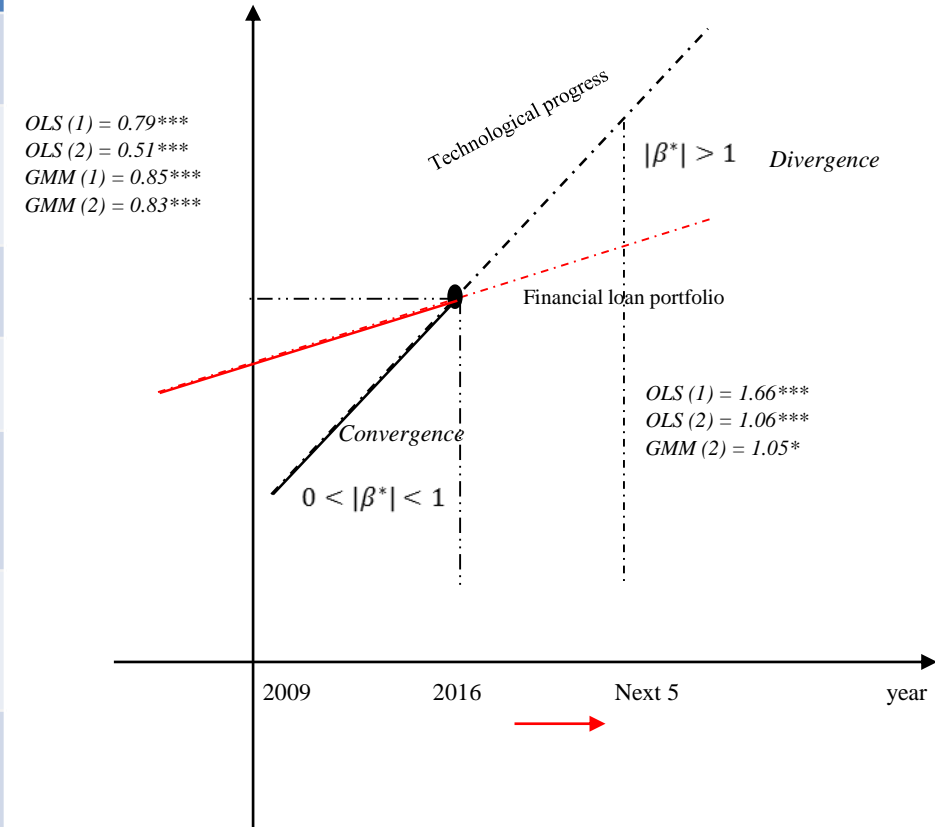
Source: Author's estimates

*Note: The statistical value in the parenthesis indicates either $t - statistic$ or $z - statistic$ and inside the bracket is p -value. The sign notification of * $p<0.05$, ** $p<0.01$, *** $p<0.00$ denotes the significant level of variables. All variables are already - difference exogenous variables, GMM based and loan is generated by loan divided by net profit. The null hypothesis of Sargan test is instrument is valid.*

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Breaking points of divergence between financial inclusion and technology:

- Based on the findings above, financial inclusion index measured by **financial loan portfolio** has evolved to **steady state** as long as **technological progress** has raised in **rising linear trend**. The divergence process will increase more important unless there are breaking points of technological innovation allowing to boost other components of financial inclusion such as saving, insurance, transaction and payments.

- => An **emerging of e-money or money transfer** using phone as the main mean of money transfer in the nationwide since 2009 and e-Banking or e-money take place after the country was hit by the global financial crisis in 2008 and 2009.

- => **Cashless system** is less costly and more transparent for the whole economy and the new technology to provide smooth, efficient, safe and affordable interbank transactions which will ultimately benefit end users.

- => **Fintech** will transform the banking industry with the new coming regulation as well as plans to push (motivate?) banks towards innovations and cooperation with non-bank players.

- => **Innovations in loan technology** may lead even reputable, good banks to expand lending excessively in order to demonstrate their confidence in their loan technology, and weaker banks may be tempted to imitate then in order not to reveal their weaknesses.

Concluding Remarks and Suggestions

- This research study examines the **dynamic stage of technological progress toward cross-sectional firm in financial sector** in Cambodia of 41 banks and 87 MFIs from 2009 to 2016.

- Due to the sample observations are consisted of large cross-sections and short periods (N > T), dynamic panel data method, GMM base Arellano and Bond (1991) and D. Roodman (2006) for removing instrumental issue, together with endogenous and predetermined factors method, are employed to examine. Yet, AB autocorrelation test and Hansen or Sargan diagnostic test are adopted to detect the autocorrelation (AR) and over restriction of instrument.

Concluding Remarks and Suggestions

The empirical outcomes reveal that :

- ✓ *The role of technology – based in promoting loan portfolio within the period of observations but a huge promise is come from an internal factor such net profit, number of staffs and branches.*

- ✓ *The contribution of technology progress is promisingly shared in increasing loan portfolio during the observed period but conversely the trend in divergence when time path is augmented.*

Contribution to the policy makers

- **Over-indebtness:** the study figures out that loan creates loan. Reducing interest rates no higher than 18 percent per year of lending of all microfinance institution is for short term; however, promoting financial literacy and assessment is a key challenging policies of the NBC in the long run.

- **Financial literacy and assessment:** still have 10% of 90% who connected to internet subscription but not using mobile banking mobile, thus attracting them by adopting new technology based.

- **Promoting other potential components of financial inclusion such as "simply saving":** since there are large majority of Cambodian population living in rural area, especially the poorest, cannot access to saving, payment and transaction. It is better to take advantage from technological progress to improve them. For instance, the saving for old time since we were young in public real estate (model of public housing in Singapore) to benefit saving and interest. Let's imagine the world where we just need only $ and phone number and we can save (like Wing etc.).

Contribution to the policy makers

- **Product designation and development:** loan condition, interest rate, closely landscape, launch other services such as online platforms for loan seekers or online software to deliver accounting services for small business owners.

- **Develop and adopt digital platforms:** it would provide access to more financial products and services for unbanked people or people living in rural locations.

- **Accelerating technological advancement and adoption:** since a lot need to be done to create confidence in the minds of customers about the benefits and security of the automated delivery channels. Lack of use of ATM channels is expressed in lack of confidence characterized by ineptitude, lack of knowledgeable programmers and security experts that could guide and implement a secure transaction channel regardless of the level of education of the ATM card users.

- **Regulation and formulation on cybernation:** cyber - security is somehow regulating to respond to the transformation of financial technology throughout the new regulations and frameworks.

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Focus on:

"Financial Inclusion: Assessing IT's impact on Financial Inclusion and Profitability in Cambodia"

Table of Contents

1. Introduction : Background, Objective and Scope of study
2. Literature Review : Overview of prior study, Data Envelopment Analysis, and Conceptual Model
3. Research Methodology : Research procedure
4. Empirical Results and Discussion
5. Conclusion and implication

Introduction

▸ Cambodia's economy maintains an economic growth rate of 7% in 2016

▸ Financial system is dominated by banks

▸ Bank's assets 27.8 billion US dollars (Credit = 17.6 Billion USD, Deposit = 15.4 billion USD, Liquidity ratio = 128%, Solvency ratio = 22.4% and NPL = 3.5%)

▸ MFIs (Liquidity ratio = 152%, Solvency ratio = 21% and NPL = 1%)

➔ Banking system remains healthy that contributed to support sustainable and inclusive economic growth

▸ NBC has introduced LPCO to bank and MFI that needs source of fund at low a cost

▸ In 2016, NBC has introduced FAST payment to promote financial inclusion increase in efficiency and lower cost (FSDS: 2011-2020)

Introduction—Con't

▸ To accommodate the increasing demand from the public, we have 812 bank offices, ATMs = 1,260 and POS = 11,761, and 4,154 MFIs offices and 2,083 registered MFIs offices that provide financial services.

▸ → Banking system in Cambodia plays a crucial role in promoting the access to and usage of financial services to all people—both the rich and the poor in urban and rural areas

▸ → These indicate that the presence of IT in banking system has profound implications for financial inclusion and financial productivity and the provision of financial services to undeserved citizens

▸ There are substantial studies mostly applied DEA in assessing bank performance efficiency and other financial institution

Introduction—Con't

- There exist a number of attempts used various statistic approaches to measure financial inclusion across the countries
- While there are limited empirical research to assess financial inclusion linking to assess profitability among bank and financial institution and
- Most studies focus on access to and usage of financial service; however, there significant gaps exist; particularly,
  - Much information is missing on the usage and quality of financial services and financial infrastructure and inadequate on access to finance likes the number of bank account or mobile bank account
- The objectives :
  - Employ a two-stage value chain DEA application to measure the financial inclusion and profitability efficiency score
  - To determine how IT can impact on financial inclusion and strengthen profit among commercial banks and MDIs in Cambodia

Introduction—Con't

▸ Scope of study

- Approach—Data envelopment analysis and service quality questionnaire by using principle component/factor analysis

- The proposed approach treats financial inclusion and profitability as the capacity of financial system to offer financial products and services to all people.

- Focus on financial inclusion and profitability stage

Literature Review

Financial Inclusion:

Definition

▸ Simply defined, financial inclusion is the access to and use of formal financial services by everyone particularly, households and firms. It is seen by policymakers as a way to improve people's livelihoods, reduce poverty, and advance economic development, (IMF 2015)

▸ Financial inclusion may also be interpreted as having access to and using the type of financial services that meet the user's needs, (BIS, 2015)

Profitability

▸ Is the ability that how well a bank runs their business by using their inputs (expenses) to generate income/revenue.

Literature Review—Con't

▶ **Overview of Prior study:**

  ▶ Financial Inclusion and Technology   : 17 articles (2011-2016)

  ▶ Data Envelopment Analysis   : 12 articles (1978-2016)

  ▶ SERQUAL   : 7 articles (1985-2013)

  ▶ Others   : 5 articles (2007-2016)

▶ **Data Envelopment Analysis**

  • … is nonparametric and mathematical technique for assessing the relative efficiency of performances and benchmarking of decision-making units (DMUs) by converting complex multiple inputs to multiple outputs (Cook, Tone, & Zhu, 2014; Ebrahimnejad et al. 2014; Halkos, Tzeremes & Kourtzidis, 2014; Chen at al. 2009; Chen & Zhu, 2004; & Ho & Zhu, 2004)

Data Envelopment Analysis

▶ …is oriented approach—input-oriented and output-oriented Input-oriented approach refers to decreasing the level of input utilizations (minimize cost) for remaining the current level of outputs

▶ Output-oriented approach is to increasingly produce the level of outputs (profit maximization) while remaining the current level of input utilizations (Titko & Jureviciene, 2014; Chen & Zhu, 2004; Manandhar & Tang, 2002; Charnes et al. 1978; Banker et al. 1984)

Two-stage Value Chain DEA

▸ **DEA offers (Chen &Zhu, 2004)**

  ▸ Efficiency rating, or score, for each DMU

  ▸ Efficiency reference set as best-practice : peer units

  ▸ Target value for the inefficient DMU

  ▸ Information on how much inputs can be decreased or outputs increased to make the unit efficient – improving overall performance

Two-stage Value Chain DEA

$$\min \quad w_1\theta^1 - w_2\theta^2$$

Subject to

(1st stage: Financial Inclusion efficiency)

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta^1 x_{i0}, \qquad \forall i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j z_{dj} \geq \tilde{z}_{d0}, \qquad \forall d = 1, \dots, D$$

$$\sum_{j}^{n} \lambda_j = 1, \qquad \forall j = 1, \dots, n$$

$$\lambda_j \geq 0, \qquad \forall j = 1, \dots, n$$

(2nd stage: Profitability efficiency)

$$\sum_{j=1}^{n} \mu_j z_{dj} \leq \tilde{z}_{d0}, \qquad \forall d = 1, \dots, D$$

$$\sum_{j=1}^{n} \mu_j y_{rj} \geq \theta^2 y_{r0}, \qquad \forall r = 1, \dots, s$$

$$\sum_{j}^{n} \mu_j = 1, \qquad \forall j = 1, \dots, n$$

$$\mu_j \geq 0, \qquad \forall j = 1, \dots, n$$

Two-stage value chain DEA—Con't

- The symbol " $\sim$ " represents unknown decision variables
- The values of $\tilde{z}_{d0}$ are unknown variable, which are optimal intermediate computed by the model
- w_1 and w_2 are the weights reflecting the total preference over the two stages
- The value of w_1 and w_2 will be equal or add up to 1 when first stage and second stage are equally essential.
- **Theorem** : If $\theta^{*1} = \theta^{*2} = 1, \lambda_{j0}^* = \mu_{j0}^* = 1,$ and $\tilde{z}_{d0}^* = z_{dj}$ are in feasible solution, it indicates that in first stage and second stage are efficient, so the decision-making units also gain relative efficiency scores.

Figure 1: Conceptual Model

Commercial banks and MDIs
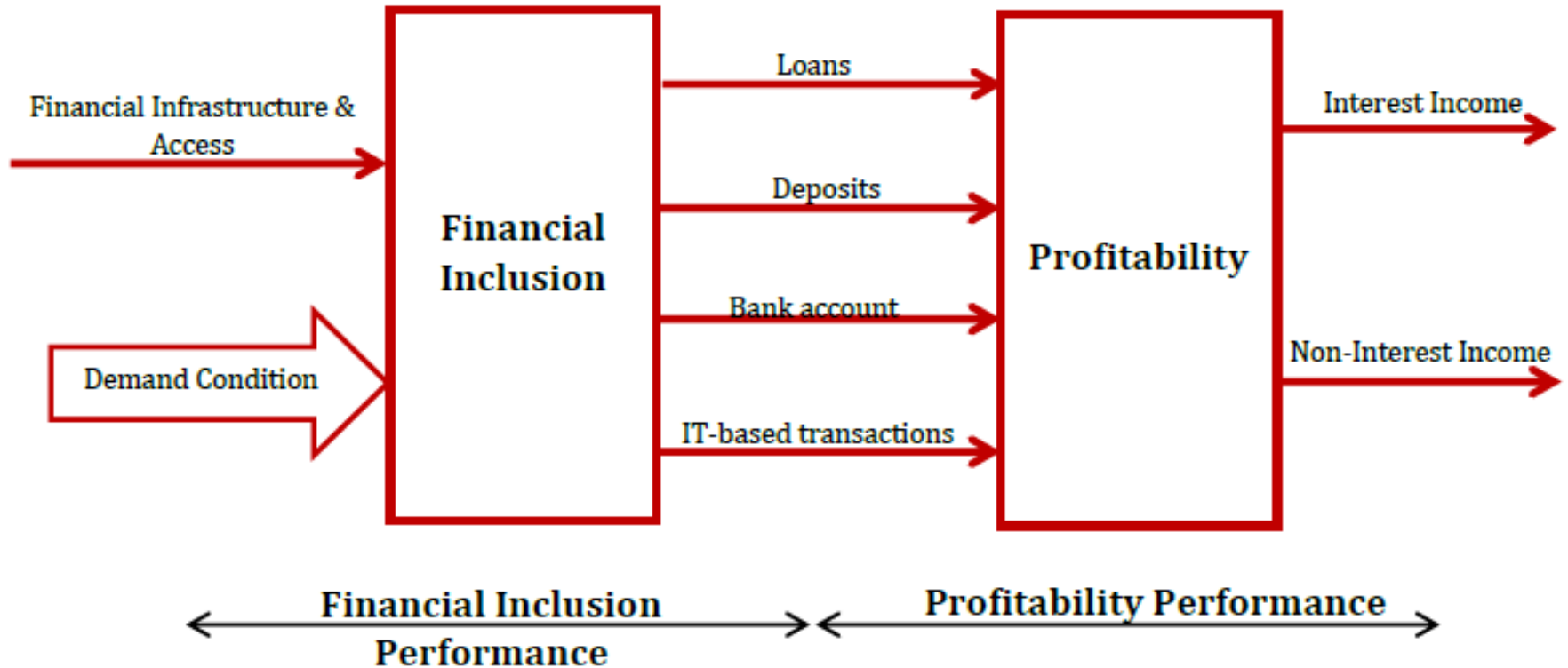
Figure 2.1: Two-stage value chain model

Table 1: Variables using in DEA model

Variables	Descriptions	Unit
Financial Inclusion Inputs (x_{dj})		
- Financial Infrastructure and Access		
x_1: # of branches	Total number of branch offices	Number
x_2: # of ATMs	Total number of ATMs	Number
x_3: # of employees	Labor or Full-Time Equivalents (FTEs)	Persons
x_4: Interest expenses	Total interest expenses	Riel
x_5: Operating expenses	Total non-interest expenses	Riel
- Demand Side		
x_6: Demand conditions	Customer's perception on quality of financial service	scale
- Usage of financial services		
z_1: Total loans	Loans and advance to customer	Riel
z_2: Total Deposits	Current, saving, checking, time	Riel
z_3: Total Bank accounts	Total bank accounts	number
z_4: Total IT-based transaction	Cash-in-Cash-out transaction from ATMs &payments	number
Profitability Outputs (y_{dj})		
y_1: Interest income	Total interest income	Riel
y_2: Non-interest income	Total non-interest income	Riel

Research Methodology

- Primary studies:
  - Data and sample size: 2016, 7 MDIs and 36 CBs
  - Two-stage value chain DEA: Financial inclusion and profitability
- Data Collection:
  - Quantitative: NBC's website
  - Qualitative: 266 Survey through Google form, Hybrid service quality

Empirical Results and Discussion (Table 2 : Score)

DMUs	Financial Inclusion	Profitability	Overall
1	1	1	1
2	1	1	1
6	1	1	1
8	1	1	1
10	1	1	1
11	1	1	1
12	1	1	1
14	1	1	1
15	1	1	1
16	1	1	1
19	1	1	1
21	1	1	1
22	1	1	1
25	1	1	1
28	1	1	1
30	1	1	1
34	1	1	1
39	1	1	1
5	1	0.999	0.999
4	1	0.874	0.937
26	0.921	0.942	0.932
17	1	0.850	0.925
41	1	0.833	0.916
37	1	0.812	0.906
9	0.963	0.836	0.899
32	0.911	0.810	0.860
31	1	0.679	0.839
7	1	0.647	0.824
20	1	0.627	0.814
42	0.992	0.621	0.807
3	1	0.604	0.802
13	0.960	0.594	0.777
33	1	0.549	0.774
36	0.997	0.490	0.743
29	1	0.477	0.738
23	1	0.409	0.704
18	1	0.378	0.689
43	1	0.375	0.688
24	0.853	0.466	0.660
40	1	0.301	0.651
38	1	0.256	0.628
27	1	0.255	0.627
35	1	0.210	0.605
Mean	**0.991**	**0.765**	**0.878**

Financial Inclusion, Profitability and Overall Efficiency Score

- 43DMUs consist of overall efficiency score in average accounted for 87.8% (each DMUs efficiently perform in financial inclusion activity accounted for 99.1% and fairly good performs in profitability at 76.5%.

- Financial institutions have strengthened financial infrastructure and the services quality to the value customer very well while the use of financial products and services are limited → need to put much effort to promote the use of financial services through introducing new products and services in order to gain high profitability.

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Empirical Results and Discussion

Table 3: Average of Inputs, Intermediations and Outputs

KPIs	Actual	Optimum	Percentage Gap
Inputs			
Number of branches	48.05	41.19	-14.28%
Number of ATMs	36.44	28.28	-22.41%
Number of employees	1,105.95	1,041.69	-5.81%
Interest expenses	64.32	60.26	-6.31%
Operating expenses	62.40	59.65	-4.40%
Service quality	3.66	3.61	-1.41%
Mean			**-9.10%**
Intermediations			
Total loans	1,526.72	1,746.17	14.37%
Total deposits	1,658.67	2,135.86	28.77%
Number of bank accounts	154.69	163.44	5.65%
Number of IT-based Transactions	594.33	786.35	32.31%
Mean			**20.28%**
Outputs			
Interest income	1,825.20	2,236.40	22.53%
Non-interest income	195.75	261.82	33.75%
Mean			**28.14%**

Empirical Results and Discussion

Identify how IT impact on financial inclusion and profitability

‣ Assumption: type of IT adopt at branch, ATMs, and how much of operational expenses spent on IT-related valued added activities to produce loan, deposit, bank account and IT-based transaction and many more

‣ According to Table 2 & 3, 83.7% and 16.3% represent the financial institutions efficiently and very good perform in financial inclusion indicating that most DMUs use their financial infrastructure very well; particularly, using the number of branches and ATMs about 85% and 78%, respectively to leverage the use of financial services accounted for 20% in average, which increases 32% in IT-based transactions, 29% in total deposit and 14% in total loan in entire financial system.

‣ The model also shows the cost reduction within the financial inclusion stage in average accounted for 9% (14% for branches, 22% for ATMs, …)

Empirical Results and Discussion

Table 4: Pearson Correlations

KPIs	Branche	ATMs	Employe	Int Exp	Oper Exp	SQ	T. Loans	T. Depo	B. ACC	IT-TRN	Int Inc	Non-Int Inc
Branche	1	.518**	.813**	.668**	.777**	.164	.482**	.325*	.780**	.513**	.690**	.339*
ATMs		1	.783**	.823**	.828**	.625**	.826**	.799**	.783**	.692**	.846**	.842**
Employe			1	.899**	.983**	.494**	.803**	.674**	.975**	.669**	.946**	.716**
Int Exp				1	.904**	.585**	.944**	.860**	.851**	.589**	.977**	.788**
Oper Exp					1	.552**	.849**	.743**	.979**	.717**	.961**	.798**
SQ						1	.664**	.698**	.467**	.352*	.610**	.730**
T. Loans							1	.964**	.786**	.625**	.947**	.906**
T. Depo								1	.671**	.610**	.857**	.937**
B. ACC									1	.773**	.923**	.739**
IT-TRN										1	.665**	.697**
Int Inc											1	.845**
Non-Int Inc												1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

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Empirical Results and Discussion

- Table 4 illustrates the number of ATMs has strong correlation with the use of financial products and services and profitability, and IT-based transactions also has strong correlation with profitability, so the DMUs could improve profit efficiency through increased the use of IT.

- The model also provides the increased profit 28% in average (23% and 34% for interest and non-interest income, respectively) through financial services utilization such as loans, deposit, bank account and IT-based transactions (32%) represented in Table 3.

- This study also find that customers visit bank branches, employees and ATMs rather than using e-banking or mobile banking services

Empirical Results and Discussion

- ▸ Customer's perception on service quality
  - ▸ Most customer feels that technology adopting by financial institutions give them feel convenience about 77%, while its user-friendly and security are still limited which are about 61%, so the financial institution need to improve technology convenience to customer through user-friendly and security.
  - ▸ Most customer gets truth in bank employees about 80% and mostly get access to the branch to use financial services accounted for 70%, which is compatible to DEA model.
  - ▸ The value customer provides low rate the ease of subscription to the financial service at 50%; particularly, opening new bank account, which is more complicated process and requirements.

Empirical Results and Discussion

▸ All in all, the results show that IT adoption has significant impacts on financial inclusion and profitability, which can increase financial services and profit through cost effectiveness (cost reduction in financial infrastructure); in particular, financial institution could also enhance fees for personal services. The result is consistent with prior studies.

Conclusion and Policy Implications

‣ Conclusion

 ‣ This study focuses on firm's level efficiency performance on the supply side, which financial inclusion can be treated as operational performance efficiency in transforming the access to financial service (financial infrastructure and demand condition) into actual use of financial services that it is used to convert into actual profit.

 ‣ The comparable measure of financial inclusion and profitability can be derived from a two-stage value chain DEA which calculates the relative efficiency rating scores based on homogenous outputs to inputs. It determines a process improvement of financial system through determining a target value of inputs and outputs should be benchmarked; especially determined how IT impacts on financial inclusion and profitability.

Conclusion and Policy Implications

▸ Recommendation and Policy Implication

▸ According to the finding, the value customer still gets access to and use of financial services at the bank branches with employees, where the bank branches adopt basics technology such as software use and ATMs to leverage their conventional products and services, cost efficiency and profit, indicating that the value customer has limited knowledge in financial technologies—e-banking, mobile banking, selfies-banking, mobile payment and other disruptive financial technologies.

Conclusion and Policy Implications

▸ Therefore, in order to promote access and used of financial services and profit within micro-level links to macro-level, financial institutions' management as well as policy-maker should consider to introduce new financial technology products and services and to promote financial literacy to all people at the same time, while presently the active government policies such as national payment system and other form of payments, interest rate policies, consumer protection, and credit bureau.