FONDATION POUR LES ÉTUDES ET RECHERCHES SUR LE DÉVELOPPEMENT INTERNATIONAL

Email use and firm performance: evidence from submarine cable exposure to seismic shocks

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For the last decades, international connectivity of developing countries underwent a dramatic improvement, by the laying of hundreds of **fiber-optic telecommunications submarine cables (SMCs):**

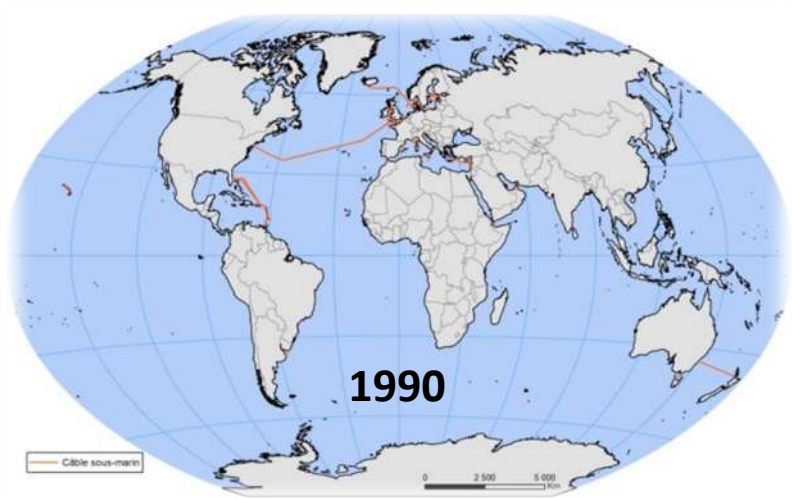
- Bringing fast and affordable Internet to developing countries (Aker & Mbiti, 2010)
- Irrigating a USD 20.4 trillion industry, and
- Connecting 3 billion Internet users worldwide (Internet Society 2015).

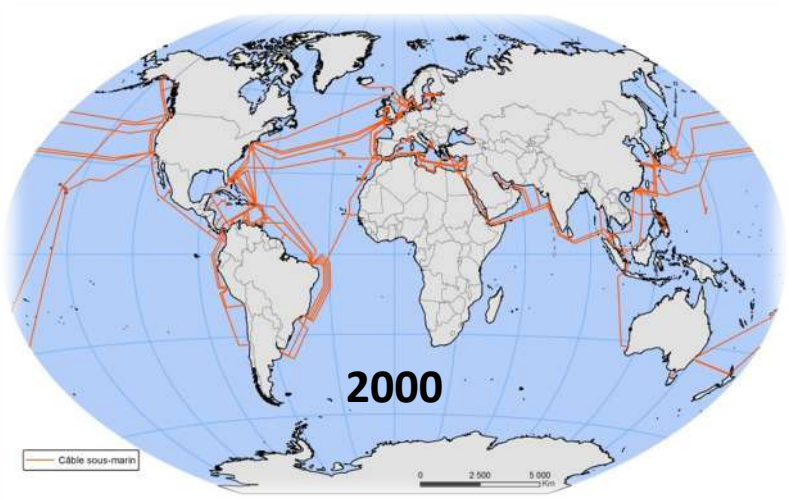
Today, more than 99% of the world telecommunications passes through SMCs.

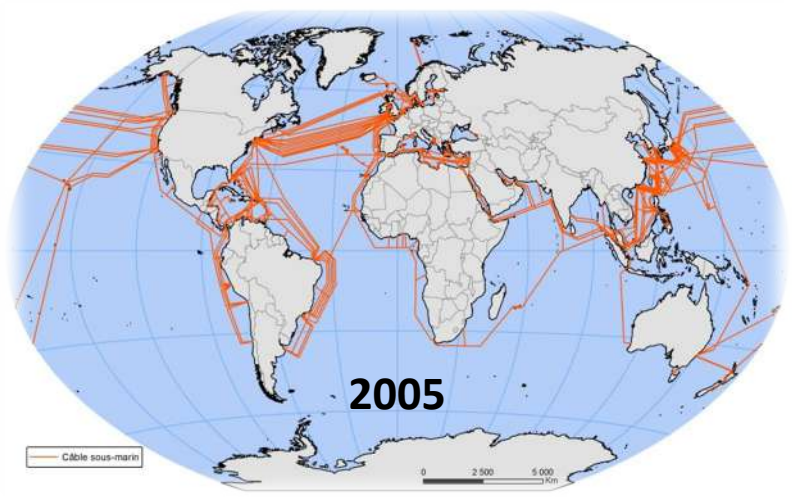
In 2013, “20 households with average broadband usage generate as much traffic as the entire Internet carried in 1995” (OECD, 2013)

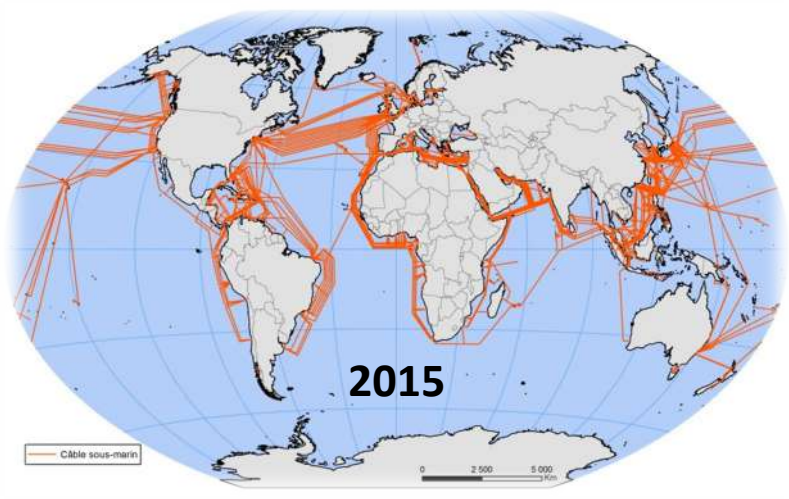
The submarine telecom infrastructures are now one of the mainstays of the global economy

The worldwide fiber-optic SMC network densification







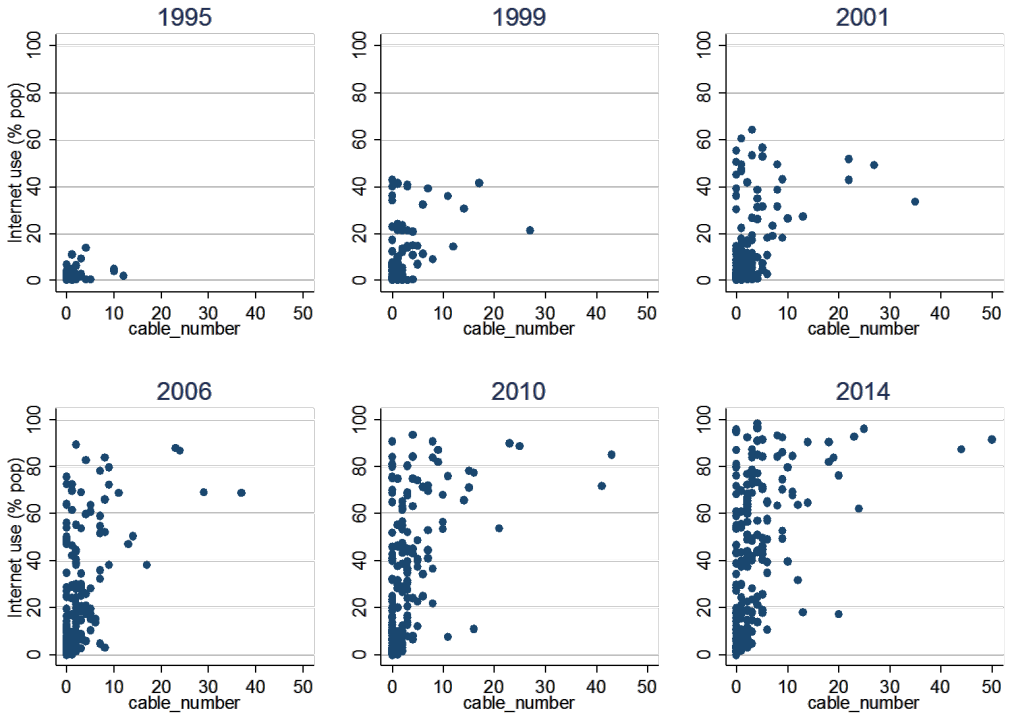


SMC deployment and Internet penetration

The number of SMCs plugging countries to the global Internet is expected to **boost Internet ecosystems** by:

- Widening the international traffic **bandwidth**
- Fastening the **internet speed**
- Increasing the **competition** between cable operators and ISPs
- Lowering the **cost** of telecommunications
- Increasing the **redundancy**, i.e. the resilience of telecommunications networks to cable faults and internet disruptions

SMC deployment and Internet use (% pop) worldwide



Sources: world evidence. 201 countries in 2014. Raw data from ITU (2016) and Telegeography (2016).

Digital vulnerability & SMC exposure to shocks

- Once a country is plugged to the rest of the world through SMC, countries are however **exposed to SMC faults** (Palmer-Felgate et al, 2013; Carter, 2009, 2014; Clark, 2016).
- SMC faults results from **human activities**: fishing nets, anchoring, piracy, sabotage
- or **natural hazards**: seismic events, typhoons, floods, etc.

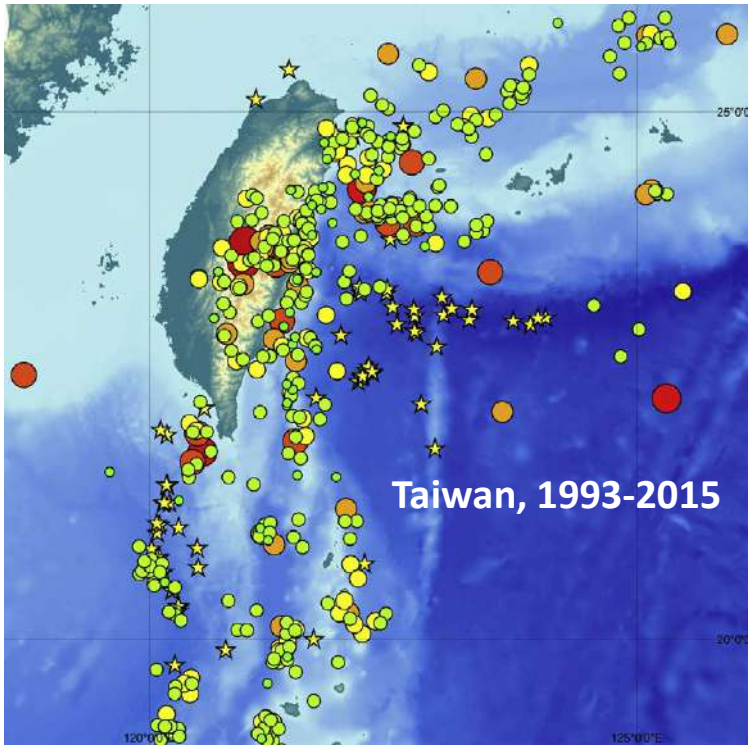
Source: The Maritime Executive

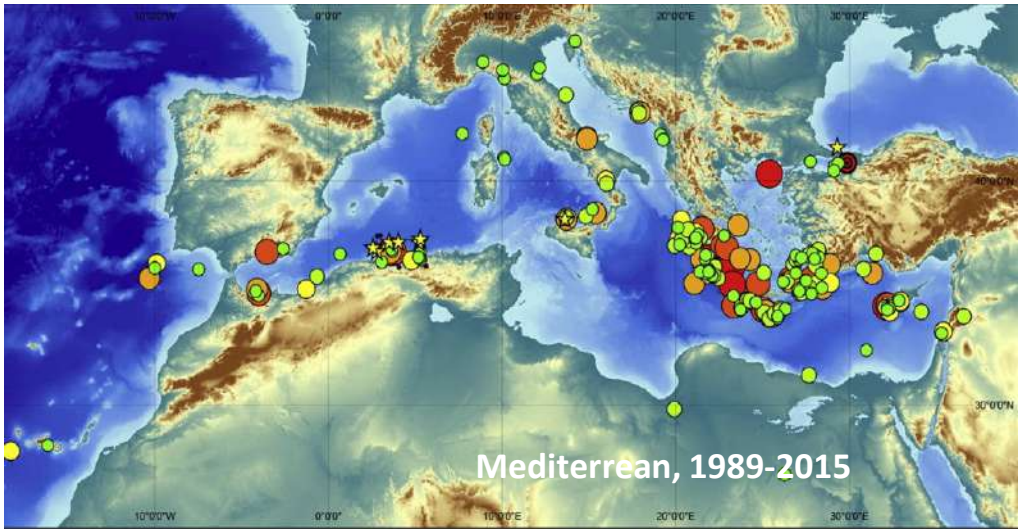
Digital vulnerability & SMC exposure to shocks

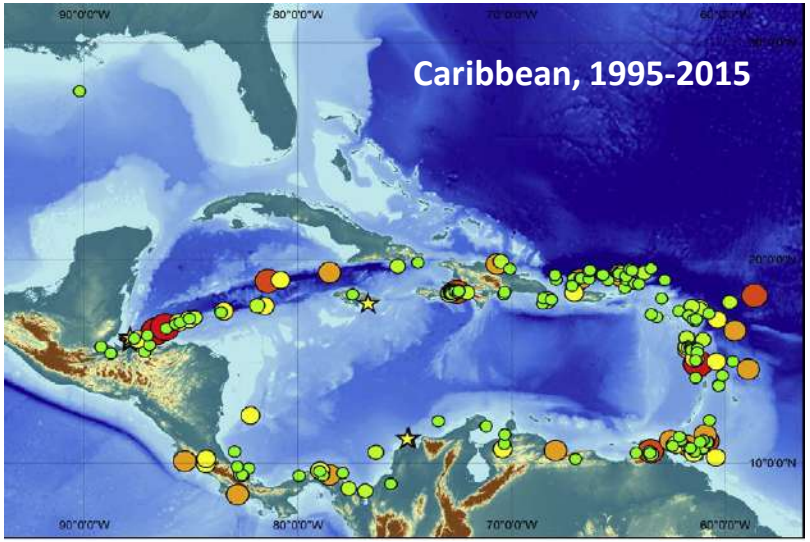
The simultaneous cut underwent by SEA-ME-WE 3, SEA-ME-WE 4 et FLAG cables on 19 Dec. 2008 induced a 24-hours outage and a 10-days slowdown of internet access **affecting million people and directly costed around 64 million dollars** (The Huff, May 25 2011)

On 30 Jan. 2008, SMC were again damaged in the Mediterranean, severely disrupting communications in the Middle East, Africa, and the Indian subcontinent.

Digital vulnerability & SMC exposure to shocks







☆ Cable breaks associated with seismic events

Mw
- 5.0 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6.0
- 6.0 - 6.5
- 6.5 - 7.0
- 7.0 +

Source: Pope, E. L., Talling, P. J., & Carter, L. (2017). Which earthquakes trigger damaging submarine mass movements: Insights from a global record of submarine cable breaks?. *Marine Geology*, *384*, 131-146.

Digital vulnerability & SMC exposure to shocks

There are **direct costs** for cable operators of repairing damaged cables, amounting to millions of dollars depending on cable repair frequency and length

…and **indirect costs** for the whole economy are related to :

- ❑ The telecommunication network instability
- ❑ The reporting of repair and insurance costs on internet tariffs
- ❑ The rerouting of internet traffic towards more expensive cable paths

Does the SMC network exposure to shocks affect firms performance?

Literature review

ICTs reduce production, transaction and information costs incurred by private agents (Aker, 2017; Goldfarb & Tucker, 2019), yielding a positive effect on:

- **Productivity and economic growth:**
  - ❑ Macro-level evidence of a positive impact of Internet penetration on **economic growth** in developed economies (Czernich et al, 2011) and developing countries (Niebel, 2018).
  - ❑ Micro-level evidence of a positive effect of ICT adoption on firm performance, especially on **firm's productivity** and **innovation**, including for non-exporting, single-plant, and smaller firms (Paunov & Rollo, 2015, 2016, Clarke et al, 2015)

- **Foreign exchanges:** Internet stimulates exports (Freund & Weinhold, 2004), but some find that **this effect is heterogeneous** among countries (Clarke & Wallsten, 2006) and firms (Bustos, 2011), and differs according to exports' characteristics (Fink et al, 2005; Blum and Goldfarb, 2007).

- **Employment:** ICTs diffusion **polarizes the labor market in favor of the skilled/educated workforce** in industrialized countries (Michaels et al, 2014; Akerman et al, 2015; Acemoglu and Restrepo, 2016) and developing countries (Hjort and Poulsen, 2019)

Paper's contribution

- It provides evidence on the effect of a specific and common usage of Internet by firms **– email use –** on their **revenue**, labour **productivity**, **exports**, and **employment**, in a sample of around **40 developing/transition economies**.
- It exploits **novel databases on the worldwide deployment of SMCs and seismic risk location.**
- It adopts an **IV strategy** that highlights the **firm vulnerability to seismic shocks upon the SMC network.**

Empirical framework

The model

We build a **pseudo-panel** by aggregating repeated cross-section dataset at the **location-level**, and conduct within fixed-effects estimation of this model :

$$Y_{j,l,t} = \alpha_0 + \alpha_1 Email_{j,l,t} + \alpha_2 X_{j,l,t} + \delta_t + (\gamma_j \times \delta_t) + \theta_l + \varepsilon_{j,l,t} \quad (1)$$

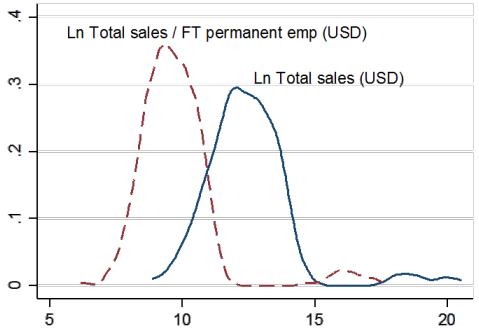
- Where the subscripts *j, l, t* respectively refer to the country, the location, and the survey year.
- Locations are observation units.
- $\boldsymbol{Y_{jlt}}$ is the firm outcome variable, $\boldsymbol{email_{jlt}}$ the email use variable, and $\boldsymbol{X_{jlt}}$ a set of control variables.
- We also include year (δ_t), country-year ($\gamma_j \times \delta_t$), and location (θ_l) fixed effects. $\varepsilon_{l,t}$ is a random error term.
- We apply sampling weights and correct std err. by cohort size.
- Huber-white robust standard errors, clustered at the country-year level.

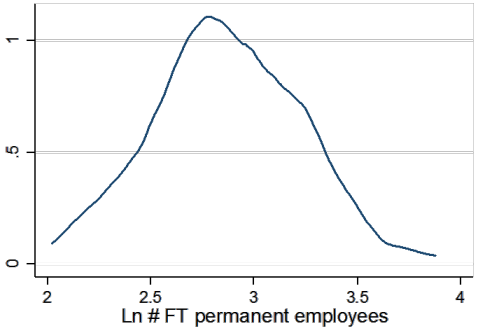
The data

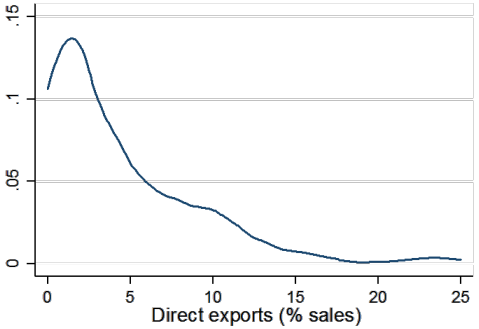
- Firm data drawn from the **World Bank Enterprise Surveys**, representative of developing and transition economies' formal manufacturing and service sectors.
- Sample of more than 30,000 firms, surveyed between 2006-2014, from 130-140 locations in some 40 developing and transition countries.
- **ECA** (47% of locations representing 34% of firms), **SSA** (23% of locations and 23.5% of firms), **LAC** (19% of locations representing 35% of firms), **MENA** (3% of locations and 1.4% of firms), and **EAP** (2% of locations and 1.1% of firms).
- Service firms (49.7%) and manufactures (50,3%), mostly operating in retail and wholesale trade (28%), in the food industry (12.3%), in other manufacturing (9.99%) and other services industries (8.6%).

4 main outcome variables (Y_{jlt}):

- ❑Ln total annual sales (in USD).
- ❑Ln (tot sales / FT permanent employees)
- ❑% of direct exports
- ❑Ln # of FT permanent employees







To further the email-employment nexus…

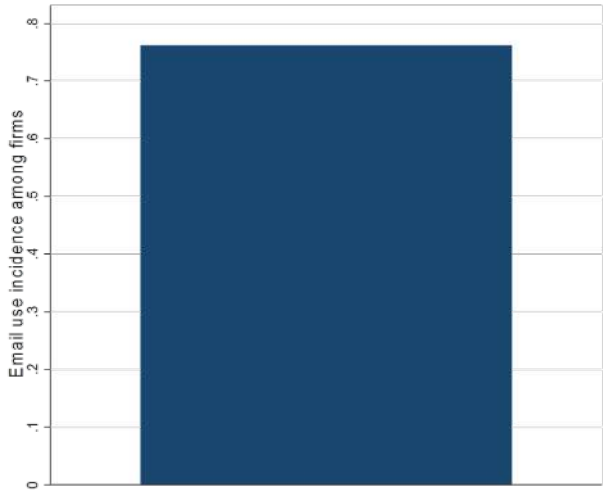
+ 4 additional **employment variables** focused on **manufactures**:

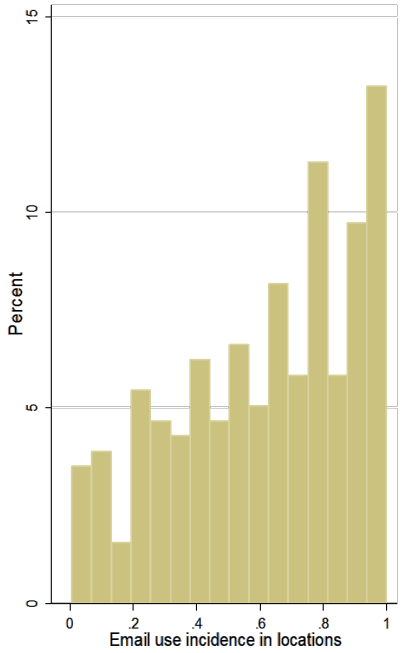
- ❑Ln # of production workers
- ❑Ln # of non-production workers
- ❑Ln # of skilled production workers
- ❑Ln # of unskilled production workers

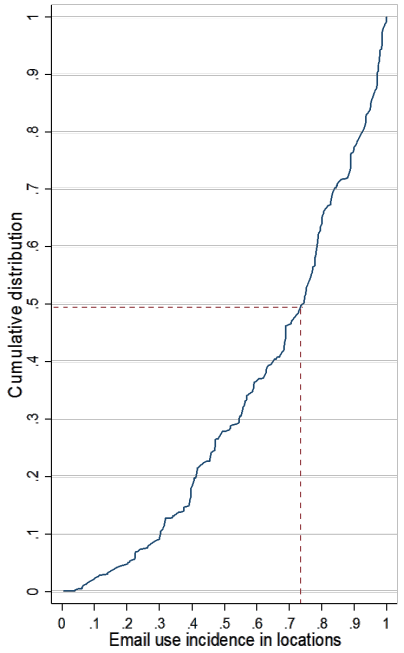
Data: World Bank Enterprise Survey. Baseline sample: 257 observations: 128 locations, 39 countries, based on data from 32,328 surveyed firms.

Interest variable ($Email_{j,l,t}$)

- % of firms which declare having used emails to communicate with its clients and suppliers during the past year
- most basic way to use Internet, reflecting both simple and more complex usages of the Internet







Data: World Bank Enterprise Surveys. Baseline sample: 32,328 firms from 128 locations, 39 countries. Firm-level observations in the left-hand side graph. Data aggregated at the location-level in the middle and right-hand side graphs (257 observations). Data has been aggregated using sample weights.

Control variables ($X_{j,l,t}$)

- Ln number of FT permanent employees when the firm has started operations
- Firm's age (in years),
- Top manager experience (in years),
- Ownership structure (state and foreign ownership, in %),
- Firm's experience of corruption obstacle to operations (no obstacle, …, severe obstacle)
- % of direct and indirect exports (indirect exports when the dep var is the % of direct exports),
- Ln annual number of power outages,
- Location distance to international connectivity infrastructure (in km, ln),
- Industry of activity.

IV framework

- Addressing simultaneity bias between email use and firm performance.
- Within FE 2-stage least square estimator (FE-2SLS), adding the 1st-stage equation to eq. (1):

$$Email_{j,l,t} = \beta_0 + \boldsymbol{\beta_1 Instruments_{j,l,t}} + \beta_2 X_{j,l,t} + \delta_t + (\gamma_j \times \delta_t) + \theta_l + \varepsilon_{j,l,t} \quad (2)$$

- Our IV combine two structural interrelated sources of digital vulnerability :
  - ❑ **(A) the SMC network exposure to seismic shocks**
  - ❑ **(B) digital isolation**, i.e. the location distance from key infrastructures, increasing the exposure to telecommunication disruptions.

Instrument$_{j,l,t}$ *= SMC network exposure to shocks*$_{j,t}$ *(A) x Location* distance from key infrastructures$_{j,l,t}$ *(B)*

(A) SMC exposure to seismic risk

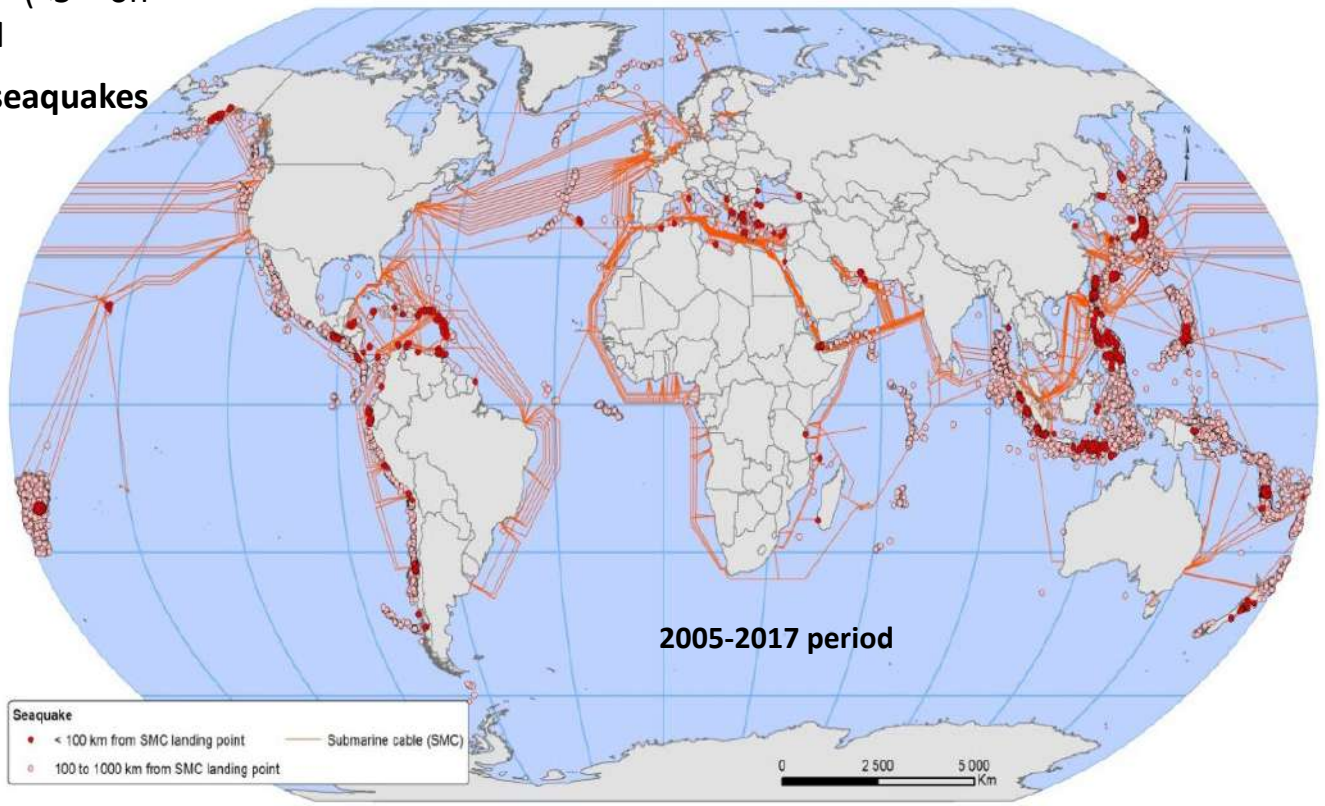
According to Pope et al (2017) and Carter et al (2009, 2014):

- Seaquakes erode, damage, or break entire sections of the cable network (multiple cables, multiple cuts),
- By shaking cables, destabilizing the seabed into which cables are buried, provoking submarine landslides, debris flows and turbidity currents.
- Seaquake weaken the network and increase the likelihood of faults caused by future shocks

(A) SMC exposure to seismic risk

Seismic shock variable = the **annual frequency of medium size seaquakes** :

- i.e. located within a **100-1000km radius from SMC landing stations**
- **Low-magnitude seaquakes** (<5 on Richter scale) **are not counted**
- Obs. with **large-magnitude seaquakes** (>6.5 on RS) **are dropped***



*Pope et al (2017) show that cable breaks are not necessarily associated with large magnitude seismic events.

(B) Digital isolation

Locations distant from key int. connectivity infrastructures (Gorman and Malecki, 2000; Grubesic and Murray, 2006; Grubesic et al, 2003; Gorman et al., 2004) :

- ❑ Have slower traffic
- ❑ Are more exposed to telecommunication disruptions
- ❑ and are slower to recover after telecommunication shutdowns.

Digital isolation variable parametrisation:

- ❑ We compute the (ln) distance in km between locations' centroid and the closest international connectivity infrastructure GPS coordinates.
- ❑ international connectivity infrastructure are **SMC landing stations** or **Internet Exchange Points**, which are the most important infrastructures for national and international telecommunications.

Instrument set (A)x(B)

The instrument set is decomposed into 2 sub-instruments, consisting of:

- **Instrument$_{j,l,t}$ 1:** Seaquake annual freq, 100-500km radius x Ln location distance to infrastructures
- **Instrument$_{j,l,t}$ 2**: Seaquake annual freq, 500-1000km radius x Ln location distance to infrastructures

Take into account non linear effect depending on seaquake distance to SMC, and to compute identification stat.

RESULTS

Baseline estimations

Var dep: (ln) Total sales	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Firm-level		Location-level[a]				
	Pooled OLS		Within-FE		Within FE-2SLS		
2nd stage estimates		Baseline sample		Baseline sample		Baseline sample	
Email use	**0.994*** (0.087)**	**1.284*** (0.096)**	**0.782* (0.459)**	**0.664 (0.625)**	**9.763** (4.665)**	**3.795** (1.310)**	**3.683*** (1.294)**
State-owned	-0.031 (0.623)	0.422 (0.714)	-0.458 (1.944)	-0.263 (2.041)		1.974 (1.389)	1.942 (1.370)
Foreign	0.464*** (0.135)	0.844*** (0.109)	1.441 (1.252)	0.783 (1.563)		-0.585 (1.633)	-0.206 (1.630)
Age	0.368*** (0.067)	0.415*** (0.072)	-0.213 (0.329)	-0.371 (0.449)		-0.869* (0.456)	-0.856* (0.454)
# power outages	-0.038 (0.067)	-0.026 (0.040)	0.032 (0.149)	0.101 (0.184)		0.196 (0.186)	0.191 (0.186)
% of exports	0.008*** (0.001)	0.008*** (0.002)	0.001 (0.011)	0.009 (0.014)		-0.009 (0.011)	-0.009 (0.011)
Initial # of FT employee	0.649*** (0.047)	0.477*** (0.055)	0.831*** (0.241)	0.830** (0.326)		0.724** (0.331)	0.731** (0.327)
Experience	0.006 (0.004)	-0.006 (0.005)	0.043** (0.017)	0.041* (0.023)		0.016 (0.023)	0.016 (0.022)
Obstacle: corruption	-0.027 (0.042)	-0.022 (0.034)	0.100 (0.108)	0.049 (0.117)		0.024 (0.094)	0.024 (0.093)
Distance to telecom infra	-0.033 (0.027)	0.209* (0.126)	-0.132* (0.073)	-0.130 (0.081)		-0.198** (0.081)	-0.194** (0.079)
1st stage est. (eq. (2))							
Seaquake freq 100-500km x Ln dist infra					0.000 (0.0007)	0.0007 (0.001)	
Seaquake freq 500-1000km x Ln dist infra					-0.004*** (0.001)	-0.006*** (0.001)	-0.006*** (0.001)
Controls	Yes	Yes	Yes	Yes	No	Yes	Yes
Fixed effects	Location, Year, Sector, Country×Year; Location×Year		Year; Country×Year; Location				
Observation units:	Firms				Locations		
# countries/locations/obs. treated	-		-		12/30/43	10/27/37	
Hansen test (p. value)					0.47	0.46	-
Weak-ident. SW F-test					4.80**	17.81***	29.43***
Under-ident. SW Chi2.					12.71***	55.14***	45.31***
R^2	0.59	0.63	0.86	0.87			
N	39,398	13,331	670	257	313	257	257
# locations	517	128	517	128	156	128	128
# countries	112	39	112	39	45	39	39
Original sample size (# firms)	-	-	90,515	32,328	43,539	32,328	32,328

- a 10% increase in email use incidence raises by 37-38% average total sales
- **Large effects,** not attributable to attrition bias (col (1) vs col (2); col (3) vs col (4)), …
- … data aggregation or spatial spillovers (col (1) vs col (3); col (2) vs col (4))

Baseline estimations (2/2)

	(1)	(2)	(3)	(4)	(5)	(6)
Var dep:	**(ln) Sales per worker**		**(ln) # FT employees**		**% direct exports**	
Email use	2.197**	2.303**	1.399**	1.247*	-1.338	0.028
	(0.961)	(0.980)	(0.682)	(0.653)	(6.571)	(5.370)
Controls	Yes		Yes		Yes[a]	
First stage estimates						
Seaquake freq 100-500km x Ln dist infra	0.0007		0.0007		0.0005	
	(0.001)		(0.001)		(0.001)	
Seaquake freq 500-1000km x Ln dist infra	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Fixed effects	Year; Country×Year; Sector; Location					
Observation unit	Location					
Hansen test (p. value)	0.47	-	0.17	-	0.29	-
Weak-identification SW F-test	17.81***	29.43***	14.14***	28.19***	14.31***	26.83***
Under-identification SW Chi-sq.	55.14***	45.31***	43.21***	42.86***	43.72***	40.79***
N	257	257	283	283	283	283
# locations	128	128	141	141	141	141
# countries	39	39	43	43	43	43

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors are presented in parentheses, are robust to heteroscedasticity and clustered by country and survey year. **a:** controls include the share of indirect exports, instead of the share of direct + indirect exports used in other regressions.

Manufacture vs service firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Var dep:	**(ln) Sales**		**(ln) Sales/worker**		**(ln) # of FT employees**		**% Direct exports[a]**	
	Manuf	Services	Manuf	Services	Manuf	Services	Manuf	Services
Email use	21.20	5.351***	10.23	4.011***	4.496	1.158**	-5.926	-9.903*
	(32.73)	(1.274)	(17.69)	(0.924)	(4.565)	(0.512)	(50.30)	(5.571)
First stage estimates:								
Seaquake freq 100-500km x Ln dist infra	0.0001	0.0016	0.0001	0.0016	-0.0007	0.0014	-0.0005	0.0013
	(0.001)	(0.0013)	(0.001)	(0.0013)	(0.001)	(0.0011)	(0.001)	(0.0011)
Seaquake freq 500-1000km x Ln dist infra	-0.0007	-0.008***	-0.0007	-0.008***	-0.0008	-0.009***	-0.0009	-0.009***
	(0.001)	(0.0016)	(0.001)	(0.0016)	(0.001)	(0.0015)	(0.002)	(0.0016)
Controls	Yes							
Fixed effects	Year; Country×year; Location							
Observation unit	Location							
Hansen test (p. value)	0.33	0.28	0.21	0.32	0.56	0.26	0.26	0.28
Under-ident.. SW F-test	0.15	15.45***	0.15	9.84***	0.74	15.95***	0.74	14.80***
Weak indent. SW Chi-sq	0.47	47.33***	0.47	26.73***	0.98	48.26***	0.98	44.78***
N	249	257	249	257	275	283	275	283
# Locations	124	128	124	128	137	141	137	141
# Countries	39	39	39	39	43	43	43	43

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors are presented in parentheses, are robust to heteroscedasticity and clustered by country and survey year. **a:** controls include the share of indirect exports, instead of the share of direct and indirect exports used in other regressions.

- The effect of email use on total sales, labour productivity, and employment is **driven by the service sector.**
- First-stage estimates stress that **manufactures are not digitally vulnerable**.

Manufactures' workforce composition

	(1)	(2)	(3)	(4)
Var dep:	**(ln) # workers**		**(ln) # prod. workers**	
	Non prod.	Prod.	skilled	unskilled
Email use	1.274***	0.506	-0.780	1.822**
	(0.585)	(0.458)	(0.586)	(0.823)
1st stage est.				
Seaquake freq 100-500km x Ln dist infra	0.0002	0.0002	0.0002	0.0002
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Seaquake freq 500-1000km x Ln dist infra	-0.005***	-0.005***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Fixed effects	Year; Country-year; Sector; Location			
Controls	Yes			
Hansen test p-value	0.86	0.33	0.12	0.95
Under-ident.. SW F-test	14.95***	14.95***	14.95***	14.95***
Weak indent. SW Chi-sq	46.51***	46.51***	46.51***	46.51***
N	277	277	277	277
# locations	138	138	138	138
# Countries	41	41	41	41

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors in parentheses are robust to heteroscedasticity and clustered by country and survey year.

- A greater local incidence of email use is found to **increase the number of non-production workers** and **unskilled production workers in manufactures**.
- **Employment spillovers** from the digitization of local ecosystems

Robustness

Robustness 1: are 1st-stage estimates meaningful ? (omitted variable bias?)

➔ Alternative interest variable: "*to what extent are telecommunications an obstacle for firms operation?*"

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Var dep:	**(ln) Sales**		**(ln) Sales/worker**		**(ln) # of FT employees**		**% Direct exports[a]**	
Telecom obstacle	-1.030***	-1.226**	-0.743***	-0.766***	-0.237*	-0.425**	5.313*	5.773*
	(0.354)	(0.483)	(0.306)	(0.360)	(0.126)	(0.483)	(3.035)	(3.290)
First stage estimates:								
Seaquake freq 100-500km x Ln dist infra	0.004		0.004		0.004		0.002	
	(0.006)		(0.006)		(0.006)		(0.005)	
Seaquake freq 500-1000km x Ln dist infra	0.019***	0.018***	0.019***	0.018***	0.017***	0.017***	0.031**	0.033**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.0.13)	(0.013)
Controls	Yes							
Fixed effects	Year; Country×year; Location							
Hansen test (p. value)	0.22	-	0.81	-	0.15		0.26	
Under-ident.. SW F-test	7.64**	11.62**	7.64**	11.62**	6.55**	7.65**	3.55*	6.79**
Weak indent. SW Chi-sq	23.60***	17.85***	23.60***	17.85***	19.96***	11.60***	10.83***	10.30***
N	255	255	255	255	281	281	281	281
# Locations	127	127	127	127	140	140	140	140
# Countries	38	38	38	38	42	42	42	42

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors are presented in parentheses, are robust to heteroscedasticity and clustered by country and survey year. **a:** controls include the share of indirect exports, instead of the share of direct and indirect exports used in other regressions.

Robustness 2: are results robust to landlocked countries exclusion?

Var dep:	(1) (ln) Total sales	(2) (ln) Sales / worker	(3) (ln) # of FT employees	(4) % Direct exports[a]
Email use	**3.976*****	**3.195*****	**1.628*****	**-7.959**
	(0.816)	**(0.956)**	**(0.425)**	**(0.255)**
1st stage est.				
Seaquake freq 100-500km x Ln dist infra	-0.002	-0.002	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Seaquake freq 500-1000km x Ln dist infra	-0.007***	-0.007***	-0.006***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Fixed effects	Year; Country×year; Location			
Controls	Yes			
Hansen test p-value	0.29	0.26	0.20	0.32
Under-ident.. SW F-test	15.18***	15.18***	53.76***	40.37***
Weak indent. SW Chi-sq	60.90***	60.90***	203.47***	152.78***
N	108	108	124	124
# locations	54	54	62	62
# Countries	18	18	20	20

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors in parentheses are robust to heteroscedasticity and clustered by country. a: controls include the share of indirect exports, instead of the share of direct and indirect exports used in other regressions.

Robustness 3a: addressing location selection bias by excluding mobile firms, i.e. large & foreign firms.

Var dep:	(1) (ln) Total sales	(2) (ln) Sales / worker	(3) (ln) # of FT employees	(4) (%) Direct exports[a]
Email use	3.230***	1.967***	0.679*	11.29***
	(0.582)	(0.532)	(0.375)	(4.165)
1st stage est.				
Seaquake freq 100-500km x Ln dist infra	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Seaquake freq 500-1000km x Ln dist infra	-0.008***	-0.008***	-0.008***	-0.008***
	(0.0013)	(0.0016)	(0.0014)	(0.0015)
Fixed effects	Year; Country×year; Location			
Controls	Yes			
Hansen test p-value	0.65	0.33	0.10	0.14
Under-ident.. SW F-test	20.31***	20.31***	17.37**	17.89**
Weak indent. SW Chi-sq	62.22***	62.22***	52.57***	54.13***
N	257	257	283	283
# locations	128	128	141	141
# Countries	39	39	43	43

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors are presented in parentheses, are robust to heteroscedasticity and clustered by country and survey year. **a:** controls include the share of indirect exports, instead of the share of direct and indirect exports used in other regressions.

Robustness 3b: addressing location selection bias by excluding capital cities and provinces.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Var dep:	**(ln) Total sales**		**(ln) Sales / worker**		**(ln) # of FT employees**		**(%) Direct exports[a]**	
Email use	4.062***	4.166***	4.911***	4.438**	0.874**	1.055**	9.901*	9.349
	(1.444)	(1.578)	(1.728)	(1.929)	(0.405)	(0.521)	(5.892)	(7.449)
First stage estimates:								
Seaquake freq 100-500km x Ln dist infra	-0.0016		-0.0016		-0.002		-0.002	
	(0.0006)		(0.0006)		(0.001)		(0.001)	
Seaquake freq 500-1000km x Ln dist infra	-0.013**	-0.011**	-0.013**	-0.011**	-0.016***	-0.014***	-0.017***	-0.015***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
Controls	Yes							
Fixed effects	Year; Country×year; Location							
Hansen test (p. value)	0.85	-	0.66		0.50		0.86	
Under-ident.. SW F-test	4.14*	4.82*	4.14*	4.82*	7.99**	8.90**	6.53***	8.38**
Weak indent. SW Chi-sq	15.77***	9.07***	15.77***	9.07***	30.37***	16.74***	22.38***	14.20***
N	141	141	141	141	149	149	149	149
# Locations	70	70	70	70	74	74	74	74
# Countries	31	31	31	31	34	34	34	34

Note: * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors are presented in parentheses, are robust to heteroscedasticity and clustered by country and survey year. **a:** controls include the share of indirect exports, instead of the share of direct and indirect exports used in other regressions.

Robustness 3c: addressing location selection bias by excluding locations < 100km from connectivity infrastructure.

	(1)	(2)	(3)	(6)
Var dep:	**(ln) Total sales[a]**	**(ln) Sales / worker [a]**	**(ln) # FT employees[a]**	**(%) Direct exports[ab]**
Email use	5.951**	4.364**	1.582***	-67.55***
	(2.488)	(1.873)	(0.497)	(34.82)
1st stage est.				
Seaquake freq 100-1000km x Ln dist infra	-0.050*	-0.050*	-0.046*	-0.032
	(0.026)	(0.026)	(0.024)	(0.025)
Fixed effects	Year; Country×year; Location			
Controls	Yes			
Under-ident.. SW F-test	3.81*	3.81*	3.64†	1.72
Weak indent. SW Chi-2	7.11***	7.11***	6.74***	3.31*
N	169	169	179	179
# locations	84	84	89	89
# Countries	36	36	39	39

Note: † significant at 15%, * significant at 10%, ** significant at 5%, *** significant at 1%. Control estimates not reported. Standard errors are presented in parentheses, are robust to heteroscedasticity and clustered by country and survey year. a: "continuously-updated" GMM estimator. b: controls include the share of indirect exports, instead of the share of direct and indirect exports used in other regressions.

Conclusion

Main results:

According to baseline FE-IV estimations, a 10% increase in email-use incidence raises by 37-38% the firms' average annual sales, by 22-23% their average sales per worker, by 12-14% the average number of full-time permanent workers.

- ❑ These positive effects appear to be **driven by** the **service sector**…
- ❑ … but positive spillovers of email use on **manufactures' non-production workers** and **unskilled production workers** are found.
- ❑ A large positive effect of email use on firms' direct exports is found **for domestic SMEs**, and in **intermediary-size cities**.

Main lessons:

- through the IV approach followed in this paper, we also pointed out the rise of new **(digital) vulnerabilities** countries may be subject to.
- within-country **spatial heterogeneities in ICT access and use** are found to be a central element of the ICT-growth nexus.

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Thank you!