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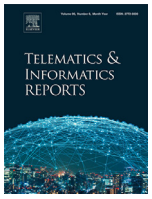

Mobile phones, the internet, and emigration to OECD countries

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ABSTRACT

We examine to what extent mobile phones and the internet drive emigration to OECD countries. Using a panel of countries from 1990 to 2010 (when these technologies became more prevalent), we regress the stock of immigrants in OECD countries from source country i on the percentage of *i*'s population having access to the internet as well as the percentage of the population having mobile phones. We find that the internet dissuades migration from *i* to the OECD whereas mobile phones encourage it. We then consider to what extent these technologies substitute or complement other informational linkages by interacting each technology in source country *i* with the stock of prior immigrants in destination country *j*. We find substitution effects between these technologies and past migration.

1. Introduction

Numerous studies have considered push and pull factors affecting migration. Mayda [23], Hatton and Williamson [20], Berthélemy et al. [8], and Beine et al. [7] provide surveys of this literature. This paper considers technological factors that could drive (push) emigration to OECD countries, namely the degree of access to the internet and the prevalence of mobile phones in migrant-source countries. However, we allow effects of these two technologies to differ, especially since our sample runs from 1990 to 2010 and so before mobile phones became "smart phones".

The internet could allow for greater information flows thereby facilitating migration. Completing online forms could also make migration easier. In some cases, however, the internet could lower immigration as people can sell labor services without physically moving as in Agrawal et al. [1]. Mobile phones provide another way for people to communicate but, at least before 2010, were less useful at transmitting documents or other large sources of information. They would allow people to remain connected to family and friends staying in the source country but likely prove less beneficial for conducting business tasks offsite.

We find examining the impact of these technologies on emigration particularly interesting given their recent emergence. We consider these new technologies as changes in structural characteristics, ones that transcend fluctuating business cycle conditions or sudden but temporary political upheavals. But unlike other persistent factors such as geography, culture, and language, the recent emergence of these technologies allows one to exploit their increasing prevalence to examine how these changes have impacted emigration to OECD countries. Adoption of these technologies is not immediate and differences in the speed of adoption provide variation that can be exploited in empirical analyses. Therefore, our period of study, 1990 to 2010, provides an insightful window to examine the effects of these technologies. When these technologies become (nearly) ubiquitous in future periods, the lack of variation will preclude examining their effects.

In a similar paper, Winkler [33] finds that internet adoption is associated with less emigration to OECD countries. However, we extend this analysis in two important ways. First, to what extent might other types of technologies in communication such as mobile phones mirror these results? Our initial specification considers how internet accessibility and mobile phone prevalence are associated with greater emigration to an OECD country regardless of the specific destination country. We regress a measure of the total emigrants from country *i* in any OECD country upon a measure of internet accessibility and a measure of mobile phone prevalence in country *i*. This approach presumes that each of these technologies impacts migratory destination decisions uniformly across countries and so specifying a particular destination is not relevant.

A second specification allows us to examine another issue that Winkler [33] did not explore nor has anyone (to the best of our knowledge). We consider to what extent these technologies could each substitute for or complement other informational channels that make migration easier. For example, suppose a large stock of immigrants from *i* live in country *j* and so can provide a source of information about country *j* regardless of whether inhabitants of *i* have internet access. If obtaining information about *j* is the main benefit of the internet (with regard to migration) then the effect of the internet on emigration from *i* to

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j should decline. On the other hand, perhaps the internet could complement other sources of information. A larger existing stock of immigrants providing some information about a particular destination country could then make it easier to focus subsequent queries. To explore whether technologies like the internet and mobile phones substitute or complement other information flows, the dependent variable is no longer the total number of immigrants from i in OECD countries but the number of immigrants from *i* in country *j*. The dependent variable is now location specific. The key right-hand side variables are the interactive terms, $TOTAL_{ij1990}{}^{*}INTERNET_{it}$ and $TOTAL_{ij1990}{}^{*}MOBILE_{it}$. $INTERNET_{it}$ ($MOBILE_{it}$) denotes a measure of internet accessibility (mobile phone prevalence) in country *i* at time *t* and $TOTAL_{ij1990}$ denotes the total number of immigrants in 1990 from source country *i* living in country *j* and captures, albeit imperfectly, the potential for one to gain and experience familiarity with destination country *j*. A positive coefficient on this interactive term would suggest that the technology complements these other sources of information whereas a negative coefficient would suggest a substitution effect.

The specifications we use also allow effects to differ depending on the education level of the emigrants. Presumably, those with less education are more likely to be employed as manual laborers that need to work onsite whereas those with more education can perform their duties from a distance. To this extent, these technologies would have more negative effects on the emigration of higher educated individuals. However, the internet could also spur migration of all groups to the extent it facilitates acquiring general information or applying for visas. One can again consider these technologies complements or substitutes for other channels of information. Presuming that those with higher levels of education are more knowledgeable about conditions and procedures in other countries, a more positive effect of these technologies for higher educated individuals would suggest the internet complements these other sources and channels. If the impact of these technologies is more positive for lower educated individuals, however, then such a result would suggest that these technologies are substituting for other sources of information.

Our results show that the internet dissuades migration from *i* to the OECD whereas mobile phones encourage it. The internet does not affect low skilled migration from low and middle-income countries. However, the magnitudes of the effects are not large, suggesting that telecommunications technologies are not the main driving force of international migration. We also find substitution effects between these technologies and past migration.

The remainder of the paper is organized as follows. Section 2 provides a literature review. Section 3 describes the empirical methodology, including the data we use. Section 4 presents results, and Section 5 provides concluding discussion.

2. Literature review

Several studies consider the internet's various effects. Vu [32], Choi and Hoon Yi [12], and Czernich et al. [14] find that the internet increases economic growth. Ackerman et al. [5] find that the internet increases demand for skilled workers. Freund and Weinhold [19] report that the internet boosts trade. Choi [10,11], Fink et al. [18], and Barbero and Rodriguez-Crespo [6] consider how the internet promotes trade. Choi [10] studies the effects of the internet on inward foreign direct investment (FDI) using bilateral data, hypothesizing that internet usage can lower search costs and improve transparency between countries.

International migration provides another global link that could have been influenced by the increasing use of the internet. Winkler [33] finds that higher internet penetration in source countries decreases emigration. More recent studies use survey data to study the impact of internet use on migration plans. Pesando et al. [27] report that those who often use the internet are more willing to migrate and have more seriously considered doing so. Merisalo and Jauhiainen [24] report that social media usage affects asylum-related migrants' location choices and migration experience. One possible reason is that social media use could form a type of social tie with similar effects as diasporas [15].

In addition to international migration, other studies consider intranational migration. Using the Panel Study of Income Dynamics, Cooke and Shuttleworth [13] report that the internet hindered interstate migration in the U.S. Vilhelmson and Thulin [31] surveyed young adults in Sweden who often stated that considerations regarding the internet not only influenced the decision to move but also the destination.

Of course, the internet is not the only technology that has contributed to communication and the flow of information. The explosion of mobile phones provides another potential determinant of migration.[1] Muto [26] finds that members of Ugandan households with cellphones were more likely to migrate from rural to urban areas. The effect was stronger for ethnic minorities that might have had fewer connections away from home, providing evidence that the effect of mobile phones is stronger for those who are otherwise informationally disadvantaged. In this sense, mobile phones provide a substitute for other types of information gathering. Aker et al. [3] also find that access to mobile phones increases the probability of migrating. Schaub [28] reports that mobile phones increase migration from Central Africa to Morocco.[2]

Our study differs in three important ways from those above. First, we examine the association between mobile phones and *international* migration as opposed to within-country-migration although Schaub [28] is an exception. Second, we compare how each of these two technologies influence emigration.[3] Adoption of the two technologies is correlated and so not controlling for one when examining the effect of the other could bias results. However, since these technologies are not perfect substitutes, effects need not be the same, either. In fact, the above discussion anticipates such a result as past studies report a negative association between internet adoption and emigration while other studies find a positive association between mobile phone adoption and emigration. Of course, the magnitudes of these coefficients could still be skewed by the omission of the other variable in the regression model. Finally, we consider to what extent these two technologies could substitute or complement other linkages. For example, does the effect of these technologies become stronger or weaker when a large stock of immigrants from the same source country already resides in the destination country? The lack of immigrants already living in destination countries could serve as an informational disadvantage for potential immigrants in the future. Do technologies like the internet and mobile phones help to overcome these disadvantages?

3. Empirical methodology

3.1. Econometric models

Our first specification does not consider the particular destination of emigrants from country i as long as this destination is an OECD country. The empirical model is:

[1] Researchers have also examined other effects of cell phone adoption. Min et al. [25] examine how the greater prevalence of smart phones in rural China impacted decisions to work off the farm as well as diversify across crops. Sekabira and Qaim [29] find that cell phone adoption contributes to greater income, female empowerment, and better nutrition in Uganda. Klonner and Nolan [22] find that the spread of cell phones increased employment in rural South Africa with greater effects for women. Aker et al. [4] and Aker and Ksoll [2] found that access to mobile phones test scores in Niger.

[2] Of note is that these studies more than a decade old mostly consider mobile phones before they became "smart" phones providing easy access to the internet.

[3] Other studies also allow for separate effects from these two technologies although not on migration. Iqbal et al. [21] consider the effects of each on broad measures of "human development". Donou-Odonsou [17] considers their effects on economic growth in Africa. Shabbir et al. [30] examine effects on corruption.

$$M_{i,t}(s) = \alpha_i + \delta_t + \beta * INTERNET_{i,t-5} + \mu * MOBILE_{it-5} + \gamma * X_{i,t-5} + \varepsilon_{i,t} \quad (1)$$

where $M_{it}(s)$ denotes the stock of immigrants in OECD countries from country i at time t of education level s. *INTERNET* denotes the fraction of the population reporting access to the internet as described above. *MOBILE* denotes the fraction of the population having a mobile phone. The matrix X denotes time-varying country-level characteristics that could operate as push factors from country i. These controls include: GDP per person (*GDP*), total population (*POP*), the fraction of the population under 45 years of age (*YOUNG*), an indicator of political rights (*POL*), and the trade share (*TRADE*). *GDP* accounts for the level of economic development. Not only does income influence the desire to emigrate but income also matters for technological adoption. More populous countries can produce more emigrants and could also be a factor for the prevalence of the internet or mobile phones, especially since companies providing these services could target larger countries. Younger populations are more likely to adopt new technology as well as emigrate. Political rights could again influence the desire or ability to emigrate as well as matter for a government's encouragement or even allowance of its citizens to use these technologies. Finally, *TRADE* controls for other types of openness that could be associated with emigration. Time invariant push factors are captured by the country fixed effect, α_i. Because the specific destination of emigrants within the OECD is not relevant in this first examination, we do not include destination specific pull factors. The time fixed effect, δ_t, captures global effects identically impacting emigration from all countries.

A potential concern stems from the possible endogeneity of *INTERNET* and *MOBILE*. Ideally, one could instrument for them although we do not do so given the difficulty of finding suitable instruments. Nevertheless, the above specification takes several steps to diminish endogeneity concerns. For one, all right-hand-side variables are lagged one five-year period. Second, the inclusion of country fixed effects eliminates the potential for time invariant factors to drive both emigration and the adoption of new technology. Finally, the inclusion of economic, political, and demographic controls covers a wide array of factors that could drive both emigration and technological adoption. Nevertheless, we acknowledge that endogeneity concerns remain and so results should be tempered accordingly.

Our second specification considers source-destination (*i-j*) bilateral pairs and so can examine to what extent internet accessibility in source country i has differing effects depending on the country of destination j. This specification can address whether these technologies complement or substitute for other sources of informational linkages between i and j. We consider the following model:

$$M_{i,j,t}(s)\ M_{i,j,t}(s) = \theta_{i,t} + \eta_{j,t} + \pi_{i,j} + \rho * Total_{i,j,1990} * INTERNET_{i,t} + \nu * Total_{i,j,1990} * MOBILE_{i,t} + \gamma * X_{ij,t} + \sigma_{i,t} \quad (2)$$

where $\theta_{i,t}$ captures all push factors in source country i and time t, $\eta_{j,t}$ captures all pull factors in destination country j at time t, and $\pi_{i,j}$ captures all time-invariant characteristics linking i and j. Time-varying characteristics are included in matrix X and will be discussed below.

The key variables are the two interactive terms where $Total_{i,j,1990}$ denotes the number of immigrants from source-country i in destination-country j in 1990, the start of the sample period. We focus on a predetermined stock of immigrants since this parsimoniously controls for other factors such as historical or cultural links between i and j that influence migration from i to j. That is, we presume that the effects of such links can be captured by a measure of past migration from i to j. Moreover, the year 1990 mostly predates the internet and mobile phones and so this past migration from i to j is *not* driven by these technologies. Finally, a large stock of immigrants from i would likely provide a source of information and network for future migrants. In summary, this initial stock of immigration from i in j parsimoniously controls for many factors that link i and j, that could matter for subsequent migration, and that was not driven by the technologies we consider here. A positive ρ implies that the internet complements this link thereby reinforcing connections between the two and promoting integration whereas a negative ρ implies that the internet substitutes for this other link. The interpretation of ν is analogous.

The advantage of the specification in (2) is that the θ's and η's capture all country-level push and pull factors. These inclusions are especially important to the extent that these technologies proxy for the degree of economic and social development that could also influence emigration.

3.2. Data

For migration, we take data from Brücker *et al.* [9], hereafter referred to as the IAB data ta from Docquier *et al.* [16]. IAB data include the stock of migrants who are 25 years of age and older, migrating from non-OECD countries to an OECD country (as the OECD was constituted in 2000) .[4] Migrant status is defined by birth country instead of citizenship (whether one is 'foreign born'.) IAB also provides migration data based on educational attainment, classifying those with primary (completed less than upper-secondary education), secondary (completed upper-secondary education), and tertiary education (completed a post-secondary education.). The IAB data begins in 1980 although we begin our sample in 1990 as public accessibility to the internet was sparse during the 1980′s. IAB data is not available annually but in five-year increments.

$INTERNET_{it}$ denotes the number of internet users per 100 people in the migrants' origin country in year t. The data was compiled by the International Telecommunication Union made available by the World Bank. "Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc." $MOBILE_{it}$ represents mobile cellular subscriptions per 100 people in the migrants' origin country in year t. The data measures "subscriptions to a public mobile telephone service that provide access to the PSTN [public switched telephone network] using cellular technology" and includes postpaid as well as prepaid accounts. Data on $INTERNET_{it}$ *and* $MOBILE_{it}$ was compiled by the International Telecommunication Union made available by the World Bank.

Instead of taking natural logarithms of the migration variables, we use the Inverse Hyperbolic Sine (IHS) transformation since zeros comprise 17% of the bilateral migration data, M_{ijt}. In order to be consistent, the same transformation is used for the total migration variable, M_{it}, in (1) as well as for the right-hand-side variables in (1) and (2) even when no cases of a zero arise.[5,6]

Table 1 provides more specifics regarding data sources and Table 2 provides summary statistics.

4. Results

4.1. Emigration aggregated across all OECD countries

Table 3 presents two sets of results. For each set, we consider the total number of emigrants from country i living in any OECD country, the number of low skilled emigrants (primary education), and the number of high skilled emigrants (tertiary education). The first set (columns 1–3) considers all countries as source countries and the second set (columns 4–6) considers only low and middle-income countries (as classified by the World Bank) as source countries.

[4] We use stocks of emigrants instead of flows due to greater data availability.

[5] An exception to using the IHS transformation is for POL since it is an ordinal variable. Instead, we re-normalize it so that it spans 0-1.

[6] Results are robust using the log transformation and are available upon request.

Table 1
Data Sources.

Variable	Definition	Source
$TOTAL_i$	Total stock of emigrants from country i living in an OECD country	IAB
LOW_i	Total stock of "low skilled" emigrants from country i living in an OECD country	IAB
$HIGH_i$	Total stock of "high skilled" emigrants from country i living in an OECD country	IAB
$INTERNET_i$	Internet users per 100 people in country i	World Bank
$MOBILE_i$	Number of cell phone subscribers per 100 people in country i	World Bank
GDP_i	Country i GDP Per Capita, constant 2005 international $	World Bank
POP_i	Total Population of country i	Work Bank
POL_i	Political Rights Index for country i	Freedom House
$TRADE_i$	Trade Share in i, sum of imports & exports as share of GDP	World Bank
	Bilateral Data	
$TOTAL_{ij}$	Total stock of emigrants from country i living in country j	IAB
LOW_{ij}	Total stock of "low skilled" emigrants from country i living in country j	IAB
$HIGH_{ij}$	Total stock of "high skilled" emigrants from country i living in country j	IAB
$LANG_{ij}$	= 1 if i and j share the same official language, = 0 otherwise	CEPII
$TOTAL_{ij,1990}$	Total stock of emigrants from country i living in country j in 1990	IAB

Table 2
Summary Statistics.

	count	Mean	sd	min	max
Summary Statistics before IHS Transformation					
TOTAL	604	347,140	736,992	144	9,369,078
HIGH	604	124,293	237,233	42	1,899,893
LOW	604	126,972	378,060	32	5,322,509
INTERNET	598	16.41	23.39	0	93.39
MOBILE	603	40.12	44.76	0	190.81
POP	604	3.90e+07	1.40e+08	75,304	1.34e+09
GDP	604	16,441.93	18,145.58	630.70	107,703.5
POL	604	0.61	0.35	0	1
TRADE	603	83.21	48.52	0.020	420.43
YOUNG	604	36.13	4.41	27.59	70.73
Summary Statistics after IHS Transformation					
TOTAL	604	12.08	1.945	5.66	16.75
HIGH	604	11.09	1.92	4.43	15.15
LOW	604	10.86	1.98	4.16	16.18
INTERNET	598	2.24	1.76	0	5.23
MOBILE	603	3.12	2.02	0	5.94
POP	604	16.49	1.89	11.92	21.71
GDP	604	9.77	1.20	7.14	12.28
TRADE	603	4.98	0.55	0.02	6.73
YOUNG	604	4.27	0.11	4.01	4.95

IHS denotes the Inverse Hyperbolic Sine Transformation.

Several findings emerge. First, if mobile phones and the internet were both capturing the same general, underlying level of technology of the source country, then collinearity issues would prevent finding strong results. Instead, we find strong coefficients for both types of technology in columns (1) – (3). More importantly, the coefficients have opposite signs, coinciding with findings from the aforementioned studies that considered each technology separately. The prevalence of the internet is negatively associated with emigration from country i to an OECD country whereas the prevalence of mobile phones is positively associated. Such a finding could arise given that these technologies are imperfect substitutes – again, even more so before 2010 – and so capture distinct aspects of technology. The positive coefficient for mobile phones could indicate that the ability to stay in touch with family and friends encourages people to emigrate. However, this finding with mobile phones is stronger when considering all source countries versus only low and middle-income source countries. This finding suggests a greater marginal impact of mobile phones in high-income source countries. This could arise given the greater similarity between high income source and destination countries. With more similar characteristics, any difference in the prevalence of mobile phones could have a greater marginal impact.

More generally, results for both types of technologies are stronger for the full set of countries than for those coming from low and middle-income countries. This is not surprising given that moving to an OECD country from a poorer country could comprise greater overall benefits (and perhaps greater costs as well) than does migrating from one OECD country to another. As before, the relative importance of access to various communication technologies in the source country in the decision to migrate could be lower in a poor country where many characteristics differ between the low-income country and an OECD one.

The smallest (in magnitude) coefficient in columns (4)–(6) is that on *INTERNET* for low-educated emigrants. Such individuals are most likely to sell manual labor when emigrating to an OECD country and so their jobs are less reliant on the internet.

But even when statistically significant, coefficient magnitudes are not large. Consider a one-standard deviation increase in *INTERNET* (−1.7). With the coefficient on *INTERNET* of about -0.1, this increase associates with a 0.17 decrease in *TOTAL* or roughly just 9% of a standard deviation of *TOTAL*. The analogous magnitude for mobile phones is just a 4.8% = (2 × 0.046/1.9) of a standard deviation increase in *TOTAL*. Although these technologies matter to some extent, they do not appear to be the key driving forces of emigration, either. These small magnitudes also coincide with previous findings. Winkler [33] found that a 10% increase in *INTERNET* leads to about 4.4% decrease in bilateral migration stocks.

Looking at the control variables, the coefficients on *POL* and *POP* are not significant. This does not mean that political rights are unimportant. The inclusion of country fixed effects means that the coefficients on the right-hand-side variables are driven by within-country variation. If *POL* does not change much over time and *POP* changes at steady rates, then finding smaller coefficients on these variables is not surprising. The negative coefficient on *GDP* indicates that fewer emigrate when incomes are rising. A country opening up as measured by trade sees more emigrants. Surprisingly, the coefficients on *YOUNG* for low and middle-income countries is negative, suggesting that countries with younger adults send fewer emigrants to OECD countries.

4.2. Emigration to specific OECD countries

We now consider migration to specific OECD countries as captured in (2) and present results in Table 4. Panel A includes no separate time-varying controls except for the source-year and destination-year dummies. Panel B presents results for $TOTAL_{1990}$*$INTERNET$ and $TOTAL_{1990}$*$MOBILE$ when other interaction terms are included, namely when all the source country characteristics like GDP_{it} in Table 3 are also interacted with $TOTAL_{1990}$. Variables like GDP_{it} are not included separately since they are captured by the *i-t* fixed effects. The inclusion of these "extra" interaction terms help ensure that the coefficients on $TOTAL_{1990}$*$INTERNET$ and $TOTAL_{1990}$*$MOBILE$ are capturing how an initial stock of immigrants in country influences the effects of these

Table 3
Results aggregating across all OECD countries.

	Emigrant Source Countries					
	All			Low and Middle Income		
	(1) *Total*	(2) *High*	(3) *Low*	(4) *Total*	(5) *High*	(6) *Low*
INTERNET	−0.0985***	−0.0986***	−0.1132***	−0.0484**	−0.0769***	−0.0352
	(0.0172)	(0.0158)	(0.0204)	(0.0201)	(0.0204)	(0.024)
MOBILE	.0525**	.0378*	.062**	.0662**	.0491*	.0695**
	(0.0219)	(0.0198)	(0.0239)	(0.0295)	(0.0276)	(0.0316)
POP	.0697	−0.0416	.0809	−0.1504	−0.3066*	.035
	(0.1961)	(0.1834)	(0.2128)	(0.1866)	(0.1762)	(0.2369)
GDP	−0.2977***	−0.247***	−0.3041***	−0.3359***	−0.2747***	−0.3585***
	(0.0621)	(0.058)	(0.0691)	(0.0622)	(0.0561)	(0.0746)
POL	.0655	.0834	.0524	.0176	.0575	−0.004
	(0.0989)	(0.0855)	(0.1128)	(0.0896)	(0.0836)	(0.1015)
TRADE	.0671	.0528	.0894	.0969*	.0818	.1128*
	(0.0521)	(0.0464)	(0.062)	(0.0577)	(0.0544)	(0.0649)
YOUNG	−0.0371	.2945	.1308	−1.254***	−0.5703	−1.332***
	(0.3418)	(0.3175)	(0.3665)	(0.4429)	(0.4177)	(0.4805)
# of countries	165	165	165	120	120	120
N	604	604	604	438	438	438
R^2	.7015	.8433	.365	.7587	.8628	.4849

All regressions contain year and country fixed effects. All six right-hand-side variables listed above are lagged. Standard errors in parentheses. *, **, *** denotes statistical significance at the 10%, 5%, and 1% levels. # of countries refers to the number of source countries. # of countries denotes the number of source countries.

Table 4
Results for Source Country – OECD Country Bilateral Pairs.

	Emigrant Source Countries					
	All			Low and Middle Income		
	(1) *Total*	(2) *High*	(3) *Low*	(4) *Total*	(5) *High*	(6) *Low*
	Panel A: No Time-Varying Controls					
INTERNET	−0.0126***	−0.0132***	−0.0154***	−0.0077	−0.0098**	−0.0089**
$*Total_{1990}$	(0.0036)	(0.0034)	(0.0032)	(0.0047)	(0.0045)	(0.0042)
MOBILE	−0.0338***	−0.0265***	−0.0148***	−0.0388***	−0.0312***	−0.0205***
$*Total_{1990}$	(0.0029)	(0.0028)	(0.0026)	(0.0035)	(0.0034)	(0.0031)
# of countries	186	186	186	136	136	136
N	16,188	16,188	16,188	11,623	11,623	11,623
R^2	.9708	.9694	.9735	.9677	.9652	.9707
	Panel B: Inclusion of other interactive terms as controls					
INTERNET	−0.0274***	−0.0233***	−0.0258***	−0.0241***	−0.0207***	−0.0189***
$*Total_{1990}$	(0.0039)	(0.0037)	(0.0035)	(0.0052)	(0.005)	(0.0046)
MOBILE	−0.0104***	−0.0112***	.0025	−0.0151***	−0.0161***	−0.0044
$*Total_{1990}$	(0.0033)	(0.0032)	(0.003)	(0.0041)	(0.004)	(0.0037)
# of countries	166	166	166	120	120	120
N	13,794	13,794	13,794	9818	9818	9818
R^2	.9745	.9732	.9765	.9725	.97	.9747

All regressions contain source-year, destination-year, and source-destination fixed effects. All six right-hand-side variables listed above are lagged. Standard errors in parentheses. *, **, *** denotes statistical significance at the 10%, 5%, and 1% levels. # of countries refers to the number of source countries. The five other interactive terms in panel B take the form $Z_{it}{}^{*}Total_{1990}$ where the Z_{it}'s are *GDP, POP, POL, TRADE*, and *YOUNG*. The coefficients on these other interaction terms are suppressed to ease presentation but are available on request.

technologies on further migration from *i* to *j* and not influences from related facets of development like income. We focus discussion on panel B.

Again, several findings arise. First, coefficients on both interaction terms are negative. A large existing population of immigrants in the destination country lowers the impact of these technologies on subsequent emigration. In this sense, this large pool of immigrants serves as a substitute for these technologies either directly because existing immigrants provides a readily available network for one to access or because this large pool proxies for historical factors that already provided important links between *i* and *j*.

Second, coefficient estimates are smaller in magnitude for mobile phones, meaning less substitutability. A possible explanation is that the internet more strongly provides what a large pool of immigrants in the destination country could also provide, namely information and access. Conversely, consider mobile phones. When using a phone, one generally knows (or at least intends to contact) a specific person. One does not "surf" for information. Having a large stock of compatriots in the destination country might not lessen a desire to contact those at home. On the other hand, if this large stock of compatriots allows for more general information gathering and networking then it could be more greatly substitutable with the services that the internet provides.

Third, coefficient estimates for the internet interaction term decrease slightly in magnitude when one restricts the sample to low and middle-income countries. The same does not hold true for mobile phones where coefficients slightly increase in magnitude. To the extent that social communication is the primary benefit (again, before 2010) of mobile phones, that keeping in contact with people back home is more difficult for those

from low-income countries, and that a large pool of compatriots makes staying in touch with those back home less important – then the presence of prior migrants is more substitutable with mobile phones than with the internet.

Finally, the coefficients for the mobile phone interaction term is higher for highly educated emigrants than it is for those with low education. To the extent that highly educated are more able to bring loved-ones with them or return home to visit, then the degree of substitutability between mobile phones and the stock of immigrants in the destination country should matter less.

5. Conclusion

Our sample period provides a unique opportunity to examine to what extent two (now) prevalent technologies impact emigration. Both the internet and mobile phones allow for greater degrees of communication and information transfer than ever before. Our findings suggest that mobile phones increase emigration to OECD countries, presumably because the ability to leave home while remaining in close contact with those back home encourages people to emigrate. However, the magnitudes are not estimated to be large. The increasing prevalence of mobile phones does not appear to be a large cause of brain drain. The internet, on the other hand, discourages emigration. A priori, this result is not obvious. The internet can be used to gain information, process applications, find employment, and also remain in contact back home. Offsetting effects include the ability to do work remotely and so remain in one's home country while still selling labor services abroad. Our findings suggest that this latter effect dominates although the magnitudes are, once again, not large. They are even smaller for low and middle-income countries, again suggesting that the growth of these technologies is not a driving force for emigration. Such findings lessen concerns of brain drain from a policy making perspective. Taken together, our results imply that the impacts of technological change that one might see as greatly similar could still have different effects on migration.

The second part of the analysis considers to what extent these technologies could complement or substitute for other types of networking or ways to gain information. The influence of these technologies is more negative (less strong) in cases where a large stock of immigrants from one's own country resides. As people from various countries intermix in potential destination countries, then the effects of these technologies curtail subsequent emigration. If (due perhaps to political tensions) migration flows diminish, then the impact of these technologies on emigration would increase. In both cases, the impacts of these technologies do not arise in a vacuum but depend on pre-existing migration stocks, implying that these effects are influenced by the historical and cultural links that have affected past migration patterns.

However, further work is warranted. No instruments were used and so endogeneity concerns persist. A second avenue would more closely examine what attributes about these technologies are most important although disentangling effects from separate attributes is also problematic. Finally, as data become more available, researchers also need to examine the usage of social media impacting global migration on a large scale. More generally, future research needs to re-evaluate the relationships between telecommunications technologies and migration as innovation evolves.

Declarations of Competing Interest

None

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