The Economic Impact of Internet Connectivity in Developing Countries*†

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Abstract

Firms, workers, and consumers in developing countries are increasingly connected to each other and the rest of the world through the internet. Can this connectivity transform poor economies, as technology-optimists hope, or are there more deeply rooted barriers to economic development? Research on the topic is growing rapidly. In this article we provide an overview of existing evidence from 150 studies on the extent to which, and how, internet connectivity affects economic development. Not surprisingly, estimates vary widely with the context, particular outcome, and form of internet studied. Overall the literature points towards sizeable economic impacts in many—though not all—settings.

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1 Introduction

When the internet in a form (somewhat) resembling the one we know today was created in the early 1980s, the world was a different place. Over 40% of the global population lived in absolute poverty: today, less than 10% do so. Countries like China and South Africa exported goods worth 10-20% of their GDP in 1980, but have since seen their export shares more than double. In these and many other ways, economies—especially those of some developing countries—have transformed alongside the spread of internet connectivity. More than 60% of the global population is now online, and estimates indicate that internet use will continue to increase, with saturation being reached roughly three times faster than for steam-power and electricity (Ackermann et al., 2017).

This paper provides an overview of the nascent yet already sizeable body of empirical research on the internet's economic impact in developing countries. Few economists would a priori expect internet connectivity to explain a large share of the remarkable economic progress in recent decades: the complex challenges of the so-called "Global South" appear to extend beyond what even a large technological advance can solve, and in some contexts, Information and Communication Technology (ICT) might even hinder economic development (Rodrik, 2016). Macro time-series show growth accelerating in many parts of the developing world in the 1980s and (even more so) the 1990s, while internet use remained low in the 1990s and started growing rapidly only thereafter, as shown in Figure 1. However, many developing countries prioritize investments in internet infrastructure, with the hope that connectivity can facilitate economic progress: access is growing fast also in low- and middle-income countries.[1] Mobile broadband connectivity is spreading especially fast, but fixed broadband connections are also growing steadily (see Figure 1).

Researchers have documented notable and often large correlations between internet connectivity and aggregate measures of economic progress. Evidence shedding light on causal pathways is more limited, but itself growing rapidly. With access to increasingly granular data; arbitrary variation in local internet access often arising from gradual and partly geography-based roll-out of infrastructure across space and time; and methodological advances, researchers are now better positioned to zoom in on the internet's economic role in different contexts.

We define *internet* to include any technology made possible by internet infrastructure.[2] To organize the literature, we develop a taxonomy of potential mechanisms facilitat-

[1] About 30% of Sub-Saharan Africans; 38% of South Asians; 69% of East Asians; and 73% of Latin Americans now use the internet (see `https://ourworldindata.org/`).

[2] To illustrate with an example: users can transfer mobile money on a non-data-capable ("dumb") phone, but today mobile money *systems* almost invariably run on internet infrastructure. Another example is GPS:

ing economic impacts of internet, differentiating between supply-side and demand-side forces. Supply-side forces of internet impact firm or factor productivity and production costs, affecting labor productivity directly and various other aspects of firm performance. We further divide material on the labor productivity impact of internet into three parts: direct effects on workers' on-the-job productivity; human capital accumulation; and changes in firm-worker matching. Internet may facilitate adoption of (other) technologies, thereby affecting firm level productivity. On the demand side, internet connectivity can enhance economic activity by expanding market access for firms, workers, and consumers, and by reducing or altering information frictions.

To formalize the taxonomy, Section 2 introduces a conceptual framework that illustrates the pathways through which connectivity can influence economic development by integrating internet into a general production function. Designed to broadly represent any production setting—including, for example, farms and the public sector—our stylized framework helps structure the studies we cover.

We begin our overview by summarizing empirical evidence that primarily documents supply-side mechanisms linking internet to economic outcomes.[3] Section 3 summarizes the existing evidence on how internet connectivity affects labor productivity and firm productivity more broadly and Section 4 that on on demand-side effects, with a distinction between market access and information friction channels. In Section 5, we discuss evidence on the role of the internet in public sector productivity. Finally, Section 6 concludes with a review of studies that causally link internet connectivity to broader economic development as measured through consumption or proxies for economic growth.

This paper focuses on research on developing countries, drawing occasionally on comparisons with advanced economies. Some existing overview pieces cover related topics: for example, Goldfarb & Tucker (2019) survey the research on "digital economics" in rich countries and Draca et al. (2007) the micro and macro literature on the impact of ICT on productivity in rich countries. We in contrast focus on features of developing economies that may amplify or reduce the consequences of internet connectivity, such as information frictions (see, e.g., Allen, 2014), and cover studies of relatively direct pathways from connectivity to economic outcomes. Zhuravskaya et al. (2020) survey the literature on the *political* impact of internet connectivity and social media[4], and Aker & Mbiti (2010) and

first-generation technology stored maps locally and coordinates could be shared via sms or a modem, but GPS technology as we know it today typically requires internet.

[3]Our categorization of studies into sections is necessarily loose. Until recently, few studies were able to precisely identify specific underlying theoretical mechanisms due to data constraints and the multi-function nature of the technology itself.

[4]Some promising new research directions relate both to its political and (direct) economic impact: see for example Gunsilius & Van Dijcke (2023) on the economic costs of internet shutdowns and Weidmann et al.

Aker & Blumenstock (2014) that on the impact of mobile phones on economic development in sub-Saharan Africa. Verhoogen (2023) summarizes the literature on firm-level upgrading in developing countries.[5] The World Bank's World Development Report for 2016 provides a more expansive overview of evidence on the causes and consequences of ICT adoption in developing countries with a focus on policy recommendations (World Bank, 2016).

2 Theoretical Background

We present a stylized framework outlining how internet connectivity can affect economic outcomes, using a production function adapted from Verhoogen (2023) to focus specifically on internet impacts.

2.1 Set-up

Consider an economy consisting of many firms, indexed by j, each characterized by the production function:

$$\begin{aligned} Y_j &= F(L_j, M_j, K_j; \theta) \\ &\equiv A_j(\theta) \left(A_j^L(\theta, \nu) L_j(\theta)\right)^{\alpha^L} \left(A_j^M(\theta) M_j(\theta)\right)^{\alpha^M} \left(A_j^K(\theta) K_j(\theta)\right)^{\alpha^K}, \end{aligned} \tag{1}$$

where $\alpha^L + \alpha^M + \alpha^k = 1$.[6] In the production function, Y_j represents output, $L_j(\theta)$, $M_j(\theta)$, and $K_j(\theta)$ are quality-adjusted labor, intermediate, and capital inputs respectively. A_j, A_j^L, A_j^M, and A_j^K are technological parameters. In $A_j^L(\cdot)$, the parameter ν denotes potential firm-to-labor mismatch, where greater extent of mismatch reduces labor productivity. Finally, θ represents the exogenously given level of internet connectivity, i.e., conditioning on internet being available, firms do not selectively adopt the technology in their production. Given (1), internet connectivity, θ, potentially affects firm's total factor productivity and factor-specific productivities. It can further affect labor productivity through firm-to-worker mismatch. Finally, internet connectivity can also impact the set of production inputs available to the firm.

(2016); Ochoa et al. (2022) on forces that influence infrastructure placement and access to the internet.

[5] Atkin & Khandelwal (2020) provide an overview of research on how distortions alter the impact of trade in developing countries. Their overlap with this paper is modest.

[6] We work with a standard Cobb-Douglas production function to illustrate different hypotheses on the impact of internet connectivity. This discussion can be applied more generally.

The factor market is governed by the following supply curves:

$$W_j^L = S(L_j, Z^L; \theta); \tag{2}$$

$$W_j^M = S(M_j, Z^M; \theta); \tag{3}$$

$$W_j^K = S(K_j, Z^K; \theta), \tag{4}$$

where W_j^L, W_j^M, and W_j^K respectively reflect the prices of labor, intermediate material, and other production inputs; Z^L, Z^M and Z^K denote all external factors in their respective markets. Similar to the production function, we allow internet technology θ to affect factor prices.

Firms have the option to sell their output both offline and online, with P_j^{offline} and P_j^{online} denoting the respective prices in these markets. The demand faced by the firm in each market is given by:

$$P_j^{\text{offline}} = D(Y_j^{\text{offline}}, Y_j^{\text{online}}, Z^y, \eta; \theta); \tag{5}$$

and

$$P_j^{\text{online}} = D(Y_j^{\text{online}}, Y_j^{\text{offline}}, Z^y, \eta; \theta), \tag{6}$$

where Y_j^{offline} and Y_j^{online} denote firm's demand in offline and online markets, respectively, Z^y encapsulates all external output market factors, and η measures the extent of information frictions, which may impact perceived product quality versus actual quality, thus affecting demand.

We finally assume that each firm additional faces an entry cost f_j^{entry}, fixed production costs f_j^{fixed}, and internet-specific costs such as a fixed online distribution cost $f_j^{\text{online}}(\theta)$ and variable online shipping costs f_j^{variable}. To maximize profits, firms choose the amount of inputs and the share of output sold online versus offline:

$$\begin{aligned} \max_{L_j, M_j, K_j, Y_j^{\text{offline}}, Y_j^{\text{online}}} \quad \Pi_j \quad = \quad & P_j^{\text{offline}} \cdot Y_j^{\text{offline}} + (1 - f_j^{\text{variable}}) P_j^{\text{online}} \cdot Y_j^{\text{online}} - W_j^L \cdot L_j \\ & - W_j^M \cdot M_j - W_j^K \cdot K_j - f_j^{\text{entry}} - f_j^{\text{fixed}} - f_j^{\text{online}}, \end{aligned} \tag{7}$$

$$\text{s.t.} \qquad Y_j^{\text{online}} + Y_j^{\text{offline}} \leq F(L_j, M_j, K_j; \theta). \tag{8}$$

We end our discussion of the stylized theoretical framework we next use to categorize empirical studies with a note on production in the *public* sector. We have used examples from production in private firms to present the framework, but from its high-level perspective, state entities operate similarly to a firm—they simply make production choices aimed at maximizing another objective function than profit. The framework thus helps interpret evidence on how internet connectivity affects public sector effectiveness too. We summarize such evidence in Section 5.

2.2 Impact of Internet Connectivity

In the framework described above, internet connectivity affects economic outcomes through the production function, the factor market, and the output demand. The former two channels emphasize internet's impact on firm or factor productivity and production costs; we label them *supply-side* forces. The latter is related to a firm's ability to access markets, and is thus interpreted as a *demand-side* force. Most of impacts documented in the literature appear to operate at least in part through these two broad channels.

2.2.1 Supply-side Forces

On the supply side, internet connectivity can improve overall firm productivity, i.e., $\frac{dY_j}{d\theta} > 0.$. This total effect on firm productivity can operate through several channels.

Internet and Worker Productivity

Internet can serve as labor-augmenting or labor-saving technology, directly increasing worker productivity. This can be expressed as a a second-order effect on output through labor productivity, i.e., $\frac{\partial^2 Y_j}{\partial L_j \partial\theta} > 0$. The opposite can also occur, for example due to distraction.

The literature documents multiple forms of internet-worker interactions and illustrates the associated productivity implications. Internet adoption can enhance labor productivity *directly*, through labor-biased technical change. Formally, we have $\frac{\partial}{\partial\theta}\left(\frac{\partial Y_j}{\partial L_j}\right) > 0$. This can be achieved, for example, through an increase in $A_j^L(\theta)$, where $\frac{dA_j^L}{d\theta} > 0$.

Internet access can also facilitate human capital development, for example through on-the-job training or other educational opportunities. This can in turn increase workers' productivity, i.e., $\frac{dL_j}{d\theta} > 0$.

Additionally, internet can improve firm-to-worker matching, particularly in labor markets where worker quality or firm-to-worker match quality is poorly observed. Our framework captures this by $\frac{\partial A_j^L}{\partial\nu} < 0$ and $\frac{\partial^2 A_j^L}{\partial\nu\partial\theta} < 0$, demonstrating that internet may mitigate labor mismatches, thus increasing labor productivity.

Internet and Technology Adoption

Beyond labor, internet can also enhance the productivity of other production factors within a firm. This impact can similarly be expressed as a second-order effect on output through the productivity of materials and production inputs, i.e., $\frac{\partial^2 Y_j}{\partial M_j \partial \theta} > 0$ and $\frac{\partial^2 Y_j}{\partial K_j \partial \theta} > 0$.

In response to such productivity changes, firms may act on the intensive margin—changing the amount of the existing set of production inputs—or the extensive margin, by adopting new technologies or intermediate inputs.

Internet's Other Supply-Side Productivity Effects

Internet connectivity can also affect the firm's total factor productivity (TFP). The model represents this as a direct impact of internet on firm productivity, i.e., $\frac{\partial A_j}{\partial \theta} > 0$.

2.2.2 Demand-side Forces

Internet connectivity can also ease demand-side constraints. We consider two broad forms: market access barriers and information frictions.

Internet and Market Access

Internet can open previously unreachable markets to firms, e.g. through e-commerce. This digital presence also introduces associated costs.

In our model, internet reduces the fixed cost of online sales ($\frac{\partial f_j^{\text{online}}(\theta)}{\partial \theta} < 0$), and increases the total demand for a firm's output online ($\frac{\partial Y_j^{\text{online}}}{\partial \theta} > 0$). It also potentially increases offline demand ($\frac{\partial Y_j^{\text{offline}}}{\partial \theta} > 0$). Such expansions in market reach may generate additional gains through competition effects in general equilibrium. For example, if internet reduces the cost of reaching customers equally across all firms, i.e., $\frac{\partial (Y_j^{\text{offline}} + Y_j^{\text{online}})}{\partial \theta} = \frac{\partial (Y_{j'}^{\text{offline}} + Y_{j'}^{\text{online}})}{\partial \theta}$, $\forall j \neq j'$, then this will lead to allocative efficiency gains for the economy as a whole as the most productive firms are now able to serve more customers.

Internet and Other Forms of Information Frictions

Other forms of information frictions may also characterize the output market, for example buyers may not know all sellers' prices or the relevant match qualities. The parameter η that denotes the extent of such information frictions illustrates this market feature. Better internet reduces these frictions, as represented by $\frac{\partial (Y_j^{\text{offline}} + Y_j^{\text{online}})}{\partial \eta} < 0$ and $\frac{\partial^2 (Y_j^{\text{offline}} + Y_j^{\text{online}})}{\partial \eta \partial \theta} < 0$.

3 The Supply-side Impact of Internet Connectivity

In this section, we discuss empirical literature that focuses primarily on the supply-side mechanisms linking internet connectivity to firm performance and other economic outcomes. We summarize evidence on the impact of internet on labor productivity in Section 3.1 and other aspects of firm productivity in Section 3.2.

3.1 Internet and Labor Productivity

3.1.1 Internet as labor-biased technical change

Internet connectivity can plausibly make workers either more or less productive relative to other factors. Empirically, internet appears to be a labor-biased form of technical change in most developing country contexts. Chiplunkar & Goldberg (2022) examine the employment impacts of *mobile* internet expansion from 2G to 3G networks across 14 low- and middle-income countries.[7] Employing an instrumental variable strategy based on the slower 3G expansion in high-lightening areas, they find that a 10 percentage point increase in 3G coverage increases employment rates by 2.1 percentage points. Caldarola et al. (2023) make use of the same IV approach and similar data but focus specifically on Rwanda between 2002 (with no mobile internet coverage) and 2019. They find that "improvements in the coverage of 3G mobile internet technologies [...] increase the share of employed individuals, among whom are both skilled and unskilled workers, with the former increasing at a faster rate, given their relatively small initial size; [and] sectoral[ly] shift employment towards services and, within the service sector, to some high value-

[7] Internet access itself is surprisingly difficult to measure at low geographical levels. Speed data are increasingly available (for example from Ookla), but they primarily rely on tests users themselves initiate. Improved speed data—for example from tech companies—may enable construction or validation of better local connectivity measures. As of today, the most precise approach is arguably to use direct measures of infrastructure connections to, or internet coverage of, homes and/or businesses from government agencies (see Bhuller et al., 2023; Demir et al., 2023), though such data are rarely available, and in many parts of the developing world mobile connectivity is much more common than fixed-line. Another sensible "direct" measure of connectivity is 3G, 4G, etc, coverage from geographical coverage maps (see e.g. Chiplunkar & Goldberg, 2022; Bahia et al., 2023, 2024; Brunnermeier et al., 2023), but in such maps coverage areas are reported by internet providers themselves. An alternative approach is to define as "connected" the individuals, firms, etc, that are within a certain radius of internet connection points (see e.g. Masaki et al., 2020) or, often preferably, last-mile infrastructure such as towers and antennas (see e.g. Bahia et al., 2024). The challenge with this approach has been that connection point and especially tower/antenna panel data have thus far been available only for particular countries, and often not publicly so. Others have used proximity to upstream backbone cables, whose location is more often publicly known and which also influences connectivity (see e.g. Hjort & Poulsen, 2019; Taha, 2023; Goldbeck & Lindlacher, 2024). A challenge with this approach (and to an extent also with using proximity to connection points or towers) is that "connectivity reach" varies so much with local infrastructure, topology, etc, that defining a technologically-determined expected connection radius is very difficult.

added and skill-intensive industries" (Caldarola et al., 2023, p2).

Another compelling set of results comes from Blumenstock et al. (2024). The authors randomized the placement of towers enabling use of mobile phones (and internet) across rural locations in the Philippines and found evidence of large economic benefits especially for self-employed and those who migrate for work.

Chen et al. (2019) examine a policy reform in China around 2000 that increased internet speeds. Using a difference-in-differences (DiD) approach to compare firms and workers in prefectures that were more versus less intensively exposed, they document significant wage and firm productivity gains in response to the internet-upgrading program. Similarly, Almeida et al. (2017), Tian (2021), and Poliquin (2021) use Brazil's comprehensive administrative data on workers and wages to examine labor productivity changes during broadband infrastructure expansion. They find that broadband access increases workers' wages on average—Poliquin (2021) estimates a 2.2% average increase and no change in wage inequality among rank-and-file workers—with bigger benefits for upper-level employees. Many studies provide more descriptive but otherwise comparable evidence, with similar findings. Khanna & Sharma (2018), for example, use firm-level data from Indian manufacturing sector from 2000 to 2016 and find a positive correlation between labor productivity and IT and R&D investments.

These estimates pointing towards a direct impact of internet connectivity on wages and employment have important implications. A few studies go a step further and relate such labor market impacts to "downstream" welfare proxies. Bahia et al. (2024) for example examine how the roll-out of mobile broadband affects labor market outcomes, household consumption, and poverty in Nigeria (and find quite large beneficial effects on each). They use micro data that combines information from three waves of longitudinal household survey with information on the deployment of mobile broadband services between 2010 and 2016. We return to their findings in Section 6.

The evidence also reveals important heterogeneity in how internet impacts labor markets across different demographic groups. The Chiplunkar & Goldberg (2022) study we discussed above shows evidence that 3G networks increase female labor force participation rates by 4.9 percentage points from a base of 39%, whereas the impact on male participation is minimal or slightly negative. However, the *types* of jobs held by men and women evolve when coverage increases; men tend to move away from unpaid agricultural jobs to running small agricultural enterprises, while women tend to enter unpaid agricultural jobs and start more small businesses across all sectors.

Chun & Tang (2018) study how ICT uptake by Vietnamese firms affects their demand for female and skilled labor. Instrumenting for ICT adoption with provincial ICT "quality", they find suggestive evidence that firms increasing their ICT usage also increase their female labor share, particularly with greater adoption of broadband-connected computers. This is broadly consistent with findings from India (Ho et al., 2024), Jordan (Viollaz & Winkler, 2022), Mexico (Juhn et al., 2013), and Nigeria (Bahia et al., 2024).[8] However, Bahia et al. (2023) find no effect of mobile broadband on overall female labor force participation or wage employment in Tanzania, but instead that it leads high-skilled women to transition from farming to self-employment and family enterprises—findings that are especially interesting in combination with those of Chiplunkar & Goldberg (2022).

Internet technology may be more complementary with (or less substitutable for) higher skilled workers or those specializing in work that usually requires higher education, such as non-routine tasks—a trend often observed in richer countries.[9] Formally, this would imply $\frac{\partial^2 Y}{\partial\theta\partial L_{nonroutine}} > \frac{\partial^2 Y}{\partial\theta\partial L_{routine}}$. The evidence on internet technology's skill bias in developing countries is more mixed. Khanna & Sharma (2018) show descriptive evidence that in India, ICT enhances labor productivity by complementing non-routine tasks. Almeida et al. (2017) find that, between 1999 and 2006 in Brazil, internet technology-intensive industries in cities with earlier access reduced reliance on routine tasks. Chen et al. (2019) find evidence that Chinese firms in more skill intensive industries and with more educated workers benefit more from high-speed internet, and Bahia et al. (2023) that mobile broadband availability particularly boosts labor force participation, wages, and employment among young, educated men in Tanzania.

Conversely, Cariolle et al. (2019)—using a sample of ~30,000 firms in 38 poor countries but a more suggestive empirical approach—show evidence that greater internet use by manufacturers increases employment of production workers more than non-production workers as traditional trade theory predicts. Hjort & Poulsen (2019) find that the gradual arrival of fast internet infrastructure in Africa appears to raise employment rates even among the least educated, similar to results from rural Nigeria by Bahia et al. (2024). Brambilla (2018)'s model of ICT progress and labor markets, which allows for firm heterogeneity and wages that vary across firms, provides a possible explanation of this finding. Marandino & Wunnava (2017) find that in Uruguay, an ICT expansion program that pro-

[8] Using a panel of Mexican establishments, Juhn et al. (2013) show that NAFTA tariff reductions led more productive firms to modernize their technology, reducing physically demanding tasks. Consequently, the relative wage and employment rates of women in blue-collar tasks increased. Instrumenting with the interaction between distance to the nearest 3G tower and pre-roll-out internet access cost, Viollaz & Winkler (2022) find that a 1% increase in internet access in Jordan increases female labor force participation by 0.83 percentage points, primarily through enhanced online job searching. We return to Ho et al. (2024)'s evidence from India in Sub-section 3.2.1.

[9] See e.g. Autor et al. (1998); Acemoglu & Autor (2011); Forman et al. (2012); Michaels et al. (2014); Akerman et al. (2015); Barrero et al. (2021). Katz & Autor (1999) and Bond & Van Reenen (2007) survey the literature on skill-biased technical change from rich countries.

vided laptops to families increased income by 27% for households with below median income, likely due to enhanced internet access. Overall the evidence so far suggests that the skill bias of internet technology varies considerably by context, highlighting the need for further research.

3.1.2 Internet and human capital development

We have so far discussed evidence suggesting that internet connectivity often enhances labor productivity by making each "efficiency unit" of a worker more productive, i.e., $\frac{\partial}{\partial \theta}\left(\frac{\partial Y}{\partial L}\right) > 0$. In some contexts, the technology can also increase human capital itself: $\frac{dL}{d\theta} > 0$.

One possibility is that internet connectivity facilitates on-the-job training. Hjort & Poulsen (2019) find some evidence consistent with this—in six African countries, firms connected to faster internet via submarine cables appear to be more likely to provide on-the-job training—but flag this part of their analysis as suggestive. Mouelhi (2009), using data from Tunisian manufacturing firms, also finds suggestive evidence of ICT complementing investments in workers' human capital.

A related and more developed body of research examines the human capital development effect of internet at home or in schools. Bianchi et al. (2022) analyze a massive educational technology initiative in China that connected more that 100 million rural students to urban teachers via satellite internet. Exposure to the program significantly improved academic and labor market outcomes, although it slightly negatively affected noncognitive traits. They estimate a remarkable reduction in urban-rural education and earnings gaps of 21 and 78%, respectively (see also related results from Italy in Carlana & La Ferrara (2024)).

Exploiting the gradual roll-out of internet infrastructure in Peru, Lakdawala et al. (2023) present evidence that internet connections in schools moderately enhance math test scores in the short run, with effects intensifying for subsequent cohorts. Derksen et al. (2022), in an experiment in Malawi, found that giving students access to Wikipedia boosted their test scores, especially for lower achievers.[10] In contrast, Malamud et al. (2019) and Bessone et al. (2023) find no significant improvements in educational outcomes from home or mobile internet in Peru and Brazil, respectively—Malamud et al. (2019) find gains in digital proficiency, but home internet was used for entertainment rather than learning. Jain & Stemper (2023) find that 3G coverage is associated with *declines* in test scores in PISA countries, and suggestive evidence that such declines may be bigger in

[10] Choi et al. (2024) describe initial findings from a study giving *teachers* in Sierra Leone access to an AI chatbot designed to assist them, findings encouraging forms of use.

middle- than high-income countries.

Internet access can also affect educational achievement indirectly. Oster & Steinberg (2013) show that the establishment of ICT service centers in India—which provide desirable jobs and require reliable internet—encourage nearby primary school enrollment. Siebert et al. (2018) study a social media-based teacher-parent feedback program in rural China and find positive effects on test scores.

3.1.3 Internet and firm-worker matching

Internet connectivity can play a crucial role in improving labor productivity through firm-worker matching, particularly where search frictions are considerable and assessing worker and job match quality is difficult. As outlined in Section 2, better connectivity can expedite the arrival rate for a worker-firm match, represented by a decrease in the mismatch parameter, ν_{ij}, leading to $\frac{\partial^2 A_j^L}{\partial \nu_{ij} \partial \theta} < 0$.

The most direct evidence on such a mechanism comes from rich country labor markets. Bhuller et al. (2023) link the plausibly exogenous roll-out of broadband infrastructure in Norway with faster hiring processes, higher starting wages, and longer employment duration for workers. Lederman & Zouaidi (2022) take a different but related approach and attempt to quantify the relationship between the "incidence of the digital economy"—internet usage—and long-term frictional unemployment across countries, finding a robust negative relationship between the two and suggestive evidence that the relationship may be more negative in poor countries.

So far no studies from developing country settings have to our knowledge systematically and directly linked firm-worker matching to internet connectivity as in Bhuller et al. (2023), but quite a few help inform what to expect. Abebe et al. (2021), using a randomized experiment, demonstrate that reducing application costs in Ethiopia leads to better job matches, especially among higher cognitive ability applicants. Wheeler et al. (2022) ran a randomized evaluation of training job-seekers to join an online professional networking platform in South Africa. They find that training increased employment from 70% to 77% and the effect persisted for at least twelve months.

Other results are less encouraging. Kelley et al. (2024) find that online job portal access in India leads to higher reservation wages and prolonged job searches. The results suggest that portal access can aggravate matching frictions through a form of voluntary unemployment. Fernando et al. (2023) also study online hiring in India, but start from the observation that few users successfully hire through the collaborating portal. They then use an RCT to show that a combination of expanded advertising and a tool that verifies jobseekers' identity enables firms to fill 11% more vacancies; that portal-based hires appear to be good matches; and that portal-based hiring does not reduce hiring through traditional networks.

Internet connectivity can also affect firm-worker matching indirectly by influencing market entry or exit and firm and worker location decisions. Kim & Orazem (2017) find evidence of a positive relationship between broadband availability and new firms entering rural U.S. areas.[11] Hjort & Poulsen (2019) show evidence of an increase in net firm entry, notably in ICT-intensive sectors like finance, following the arrival of submarine internet cables in South Africa. Houngbonon et al. (2022) also show evidence that fast internet significantly increases non-farm business operations among households in Africa.

Alfaro & Chen (2015) show that countries with better internet connectivity are more likely to attract multinationals—even conditional on a wide range of country characteristics—and that the marginal effect of internet and other forms of ICT accessibility appears to be larger in developing countries (see also Rauch & Trindade, 2003). This finding is important given the significant benefits that suppliers and workers in some contexts gain from working with or for multinationals (e.g., Alfaro-Urena et al., 2022; Méndez & Van Patten, 2022). How internet connectivity influences the economic role of multinationals in developing countries is a promising area for future research.

Porcher et al. (2024) use data on internal migration in Brazil to show that substantial and heterogeneous information frictions shape migration decisions: in particular, that expected wages are important drivers of migration choices; that information precision decreases with distance; but that potential migrants in regions with higher internet access have more precise wage information. Strazzeri (2021) uses a similar research design to Hjort & Poulsen (2019) with data on *individuals'* location decisions and finds a large positive effect of access to fast internet on out-migration in Nigeria. The response is particularly strong for migration out of Africa and is greater for less wealthy individuals, pointing to important changes in labor supply across space when fast internet becomes available.[12]

[11] The estimated broadband effect is largest in more populated rural areas and those adjacent to a metropolitan area, suggesting that this effect may increase with agglomeration economies, possibly via labor market pooling, similarly to Tian (2021)'s findings in Brazil.

[12] Hjort & Poulsen (2019) find few signs of job displacement across space within African countries with the arrival of fast internet in "connected" areas, but Strazzeri (2021)'s analysis uses a longer post-cable arrival data window.

3.2 Internet and Firm Productivity

3.2.1 Internet and Technology Adoption

Internet connectivity may interact with production factors other than labor and facilitate technology adoption. Such interactions manifest as a second-order effect on output through productivity of materials and other intermediate production inputs, i.e., $\frac{\partial^2 Y_j}{\partial M_j \partial \theta}$ and $\frac{\partial^2 Y_j}{\partial K_j \partial \theta}$. Firms may then act on the intensive margin—changing how they utilize existing inputs—or the extensive margin, by adopting new inputs or technologies previously inaccessible or unprofitable. We categorize technology adoption into two types: changes in the use of tangible inputs like machines and materials, and changes in intangible inputs such as management, organizational practices, and services.

Though plausible, evidence on take-up of new, tangible production inputs in response to internet connectivity is limited. A clear example is D'Andrea & Limodio (2023). They use the staggered arrival of submarine internet cables across African countries to document a significant, relative change in the activities of banks in "treated" countries—in particular more private lending—with access to high-speed internet.[13] Mensah & Traore (2024) follow a similar empirical approach to show that fast internet in Africa is associated with an 18 and 12 percentage point increase in the probability of FDI in financial and technology services sectors, respectively. The effect is largely concentrated in countries with reliable electricity, highlighting important infrastructure complementarities. Houngbonon et al. (2022), also using similar research design, show evidence that individual firms in Africa are 20 and 12 percentage points more likely to undertake process and product innovation, respectively, with access to fast internet.[14] Digitizing business functions—sales, distribution, marketing—are prominent examples of process innovation.

Atiyas & Dutz (2021) show suggestive but informative evidence of a relationship between use of internet-related digital technologies (smartphones and inventory control/point of sales software) and higher levels of labor productivity, sales, and employment among Senegalese micro firms. Cirera et al. (2021) find that Senegalese firms exhibit low and heterogeneous adoption of general-purpose information and communications technologies (computers, the internet, and cloud computing), with a positive correlation with size and influenced by access to finance, knowledge, and market competition.

Internet, perhaps not surprisingly (see e.g. Garicano & Rossi-Hansberg, 2006; Hansman et al., 2020), also appears to influence how firms organize production and related pro-

[13]Related evidence has been found in rich countries. For example, Malgouyres et al. (2021) document that broadband expansion in France increases firm imports, particularly of capital goods, by around 25%.

[14]Taha (2023) shows through a similar empirical approach that African universities produce ∼65% more publications after gaining access to fast internet (see also Agrawal & Goldfarb, 2008; Dutz et al., 2012).

duction decisions . Tian (2021) uses the gradual roll-out of broadband infrastructure across Brazilian cities and micro level data on firms to show that internet access allows firms in urban areas to produce with more collaboration and greater division of labor, thus increasing worker productivity. Bloom et al. (2014) examine the effect of working from home on call center workers' productivity through a randomized experiment at a 16,000-employee Chinese travel agency. A subset of employees who preferred to work from home were randomly selected to do so. This group was 13% more productive, worked longer hours, devoted more time to each task (call), and had lower turnover rates compared to those who worked at the office. Ho et al. (2024) investigate how online work-from-home opportunities affect female labor force participation through an experiment in West Bengal. They find 15% take-up of office-based job offers and 48% for very similar jobs that can be done more flexibly from home. Work-from-home does not adversely affect the quantity or quality of work done, though workers work less efficiently from home. Perhaps most importantly, flexible online jobs appear to work as a labor market gateway, making women who were initially out of the labor force more likely to take up more conventional, future outside-the-home jobs.[15]

Similar to Bloom et al. (2014), Jensen et al. (2020) find, using an experiment in Kenya, that increased monitoring visibility improves remote workers' performance, in their case on task not directly compensated for. However, de Rochambeau (2021) reports mixed effects from GPS monitoring in a Liberian trucking experiment. Monitored drivers increased speed but managers often declined free GPS installation, suggesting potential productivity drops when remotely monitoring some groups of workers. Kelley et al. (2023) find more uniform evidence of improved driver performance from a a similar technology.

There is some, albeit quite limited, evidence that internet's effect on communication and coordination frictions can also influence firms' organizational structures and make-or-buy decisions. In their experiment in Kenya, Kelley et al. (2023) show that owners of minibuses change their workers' contracts so as to elicit higher effort and lower risk-taking when internet-enabled monitoring devices become available. Other existing empirical evidence is mostly descriptive and comes from advanced economies. Using elevation of local terrain to predict broadband quality, Jiao & Tian (2020) show evidence that U.S. firms are more likely to build subsidiary plants in locations with better internet connectivity, which reduces bilateral communication frictions. Abramovsky & Griffith (2006) show that, in the U.K., internet-technology-intensive firms purchase more services outside of the firm and offshore (see also Gokan et al., 2019). The impact of internet connectivity on

[15] The EBRD's Transition Report 2021-22 showed regression discontinuity evidence that the arrival of 4G coverage in Russia "was associated with a 19% increase in the number of people employed by service-sector firms with fewer than 50 employees" (European Bank for Reconstruction and Development (2021): p. 57).

organizational choices and the type and extent of production that takes place in developing countries is a promising area for future research.

3.2.2 Internet, Firm Productivity, and Performance

We are not aware of evidence of direct causal links between firms' physical productivity and internet connectivity in developing countries but several studies provide evidence of a positive relationship between internet access and firm performance, or $\frac{dY_j}{d\theta}$, operating through internet-augmented production functions. Agarwal et al. (2024) focus on farms. They show that the introduction of 4G increases agricultural productivity (as inferred from remote-sensing data), fertilizer use, credit uptake, and ultimately farmer incomes. They argue that browsing patterns across areas with better vs. worse "value, reliability and accuracy of information" indicate that 4G improves access to information.[16]

Hjort & Poulsen (2019) show evidence from estimating production functions that Ethiopian manufacturing firms became more productive after the arrival of submarine internet cables. In earlier work, Commander et al. (2011) establish a strong positive relationship between "internet capital" and firm productivity in Brazil and India. More descriptively, Cariolle et al. (2019) document a positive and large association between internet usage and firm performance across 30,000 firms in 38 developing countries.[17] Abreha et al. (2021) study the transition from 2G to the 3G broadband network in Ethiopia in 2008 and find results consistent with increased competition, reduced markups, and growth in productivity, wages, and employment.

These findings highlight the need for further research into *how* internet connectivity affects firm productivity and performance. Unobserved or hard-to-measure ways in which internet connectivity improves labor productivity, management practices, or the organization of production—as discussed in sub-section 3.1 and 3.2.1—are plausible possibilities. However, firms might also leverage internet access to enhance product quality or improve marketing efficiency, a possibility we discuss in the next section.

[16] The authors also argue that, in India, "internet-based information access dominates traditional call or text-based information access by circumventing frictions associated with trust in the state" (Agarwal et al., 2024, p. 1).

[17] Cariolle et al. (2019) instrument for firms' internet access with their geographical exposure to seismic shocks affecting submarine cables, finding that 10% greater access is associated with 36% higher sales, 26% higher sales per worker, and 12% more permanent workers employed at the firm (see also Paunov & Rollo, 2015)

4 The Demand-side Impact of Internet Connectivity

This section discusses empirical research on how internet affects economic development through demand-side forces.

4.1 Internet and Market Access

Internet connectivity can enable firms to reach new markets. We expect online sales to increase with connectivity such that $\frac{\partial Y_j^{\text{online}}}{\partial \theta} > 0$. E-commerce is for example technologically possible only with relatively fast internet.

E-commerce expansion appears to lower prices and increase product variety (at least) for some consumers. Dolfen et al. (2023) show that, in the U.S., the gains stem mostly from accessing online merchants not available locally.[18] Couture et al. (2021) combine survey and administrative microdata with a pioneering experiment to assess China's national e-commerce initiative. The program expands service to internet-connected villages by subsidizing nearby entrepôts, and the authors randomized roll-out among 100 villages. They find no significant impact on production or income. Consumption gains arise from reduced logistical barriers to shipping goods; they are modest in magnitude overall.

However, Couture et al. (2021) find larger consumption gains in more remote markets. Fan et al. (2018) also find that more remote and smaller cities in China see greater benefits from e-commerce. Fan et al. (2018) analyze e-commerce's role in inter-regional trade and spatial inequality in China, by estimating a general equilibrium model of intercity trade and disciplining the parameters using stylized features of the data. They find that e-commerce leads to welfare gains by lowering prices and nominal wages, increasing overall inter-regional trade while potentially decreasing offline trade. Dolfen et al. (2023) show that in the U.S., consumers in denser counties gain the most from e-commerce.

There is also growing evidence on how e-commerce affects consumption inequality. The consumption gains that Couture et al. (2021) document in rural China are concentrated among richer households, and Dolfen et al. (2023) observe similar trends among higher-income U.S. consumers.

There is some, albeit still quite limited, evidence that internet connectivity tends to more generally reduce entry and fixed operational costs, broadening output and input market access. Freund & Weinhold (2004) present a model with imperfect competition and market specific fixed costs of trade in which internet enhances export growth and show descriptive supportive evidence. There is some evidence that internet in rich coun-

[18] Similar findings in Japan are reported by Jo et al. (2022).

tries appears to have limited effects on exports but to increase importing substantially (Malgouyres et al., 2021; Akerman et al., 2022). Exploiting its staggered roll-out, Malgouyres et al. (2021) show that broadband expansion in France between 1997 and 2007 increased imports by around 25%.

Hjort & Poulsen (2019) find suggestive evidence of increased exporting following the arrival of submarine internet cables in Africa.[19] Clarke & Wallsten (2006) find some evidence of a link between internet penetration in developing countries and exports to developed countries. In contrast, Cariolle et al. (2019) find no impact of internet adoption on firms' exports in developing countries.[20] More research is needed.

One way in which internet technology can increase output market access is by improving firms' ability to communicate with and appeal to new types of buyers. Hjort et al. (2024) show that the (large) impact in Liberia of a short training program teaching "information-poor" suppliers how to sell to new types of buyers—in particular large, growth-conducive buyers who procure inputs through tenders and formal contracts—is concentrated among firms with internet access (see also Cirera et al., 2023).

In the next sub-section we discuss evidence that internet access can expand firms' access to inputs by facilitating search and communication between trade partners. Gertler et al. (2024) and D'Andrea et al. (2024) uncover another way in which it can do so: increasing access to credit by facilitating the use of collateral. Gertler et al. (2024) study contracts in which households acquire a physical asset (such as solar panels) through an initial down payment followed by frequent, small payments made via a mobile payment system. The distinguishing feature of such PAYGO technologies is that the lender can remotely and digitally lockout the household from use if payments aren't made. The authors show theoretically that decoupling asset recovery and -access can especially facilitate lending in contexts with high cost of repossession but small assets. Observationally, this appears not only to facilitate on-credit sales of small assets, but also follow-on loans secured against those assets. An experiment in Uganda shows that users randomly chosen to receive a "digital collateral" follow-on loan rather than an unsecured loan are more likely to take up, repay, and to use the loan to cover school expenditures.

D'Andrea et al. (2024) combine variation from a land reform and incidental 3G availability in Rwanda to show that the two together help borrowers move from microfinance to commercial banks, use land as collateral, and improves loan terms. Internet's role in

[19]Similarly, Hinson & Adjasi (2009) find, using data from 43 African countries for the period 1996 to 2006, a positive relationship between internet connectivity and exports, which they attribute to internet reducing the market entry and search costs associated with exporting.

[20]The same authors have also shown evidence that a submarine cable connection between two specific countries can increase bilateral exports from the richer country but decrease bilateral exports from the poorer country (Imbruno et al. (2022) and see also Cariolle & da Piedade (2023)).

the impact of Rwanda's land reform is an example of increased state effectiveness, which we return to in Section 5. Together, Hjort et al. (2024) and D'Andrea et al. (2024) suggest that interactions between traditional market access barriers (such as trade restrictions or inadequate physical infrastructure) and internet access is a promising area for future research.

Internet's market access effects appear to ultimately reduce *gravity* in e-commerce—the negative relationship between distance and trade—that is $\frac{\partial f_j^{\text{variable}}(\theta)}{\partial \theta} < 0$. Using data from China's leading e-commerce platform, Fan et al. (2018) show that the distance elasticity for online trade is only about one-third of that for offline trade. Lendle et al. (2016) find that geographic distance affects trade 65% less on eBay compared to traditional trade. Hortaçsu et al. (2009) also show that trade through online platfroms like eBay and MercadoLibre is less influenced by distance.

Blum & Goldfarb (2006) emphasize that gravity nevertheless holds also in the case of digital goods consumed online, in particular for "taste-dependent" digital products such as music and games. Interestingly, some evidence suggests that, beyond e-commerce, internet access can make demand *more* responsive to traditional trade costs and distance by expanding choice sets (Akerman et al., 2022). Duch-Brown et al. (2021) find that European online consumer electronics markets are not more integrated than their offline counterparts.

4.2 Internet and Information Frictions

Information frictions are pervasive in developing countries' input and output markets. Allen (2014) for example shows that roughly half the observed regional dispersion in the prices of agricultural goods in the Philippines is due to information frictions (see also Hansman et al., 2020; Startz, 2024). Information frictions can take many forms—sellers may for example not know potential market prices or buyers can lack information about product quality—and many a priori appear amenable to internet-based technological solutions or work-arounds. In our framework, η_j measures the extent of information frictions, such as discrepancies between actual and perceived product quality. Better internet connectivity can potentially enhance market search and communication, thus increasing demand, illustrated by $\frac{\partial^2 (Y_j^{offline} + Y_j^{online})}{\partial \eta \partial \theta} < 0$ (see Derksen & Souza, 2023). Several influential studies find evidence consistent with this prediction for technological "predecessors" of the internet: the introduction of the transatlantic telegraph in the 19th century reduced information frictions, leading to more stable prices and increased trade flows (Steinwender, 2018); mobile phone infrastructure significantly reduced price dispersion among fishermen and wholesalers in Kerala, India, and in agricultural markets in Niger, improving overall market performance and benefiting consumers (Jensen, 2007; Aker, 2010); and a text message service providing daily price information to market participants reduced geographic price dispersion and accelerated price convergence nationwide in India (Parker et al., 2016).

We are not aware of direct evidence of internet connectivity causally affecting price dispersion and allocative efficiency. Most closely related is Goyal (2010). In contexts where buyers have monopsony power, internet connectivity can provide sellers with an outside option, thereby potentially increasing local prices and encouraging greater production. Goyal (2010) examines how internet kiosks allow farmers in India to bypass middlemen. The kiosks provide daily wholesale price information and were introduced in a subset of rural districts. The author uses a difference-in-differences approach to show evidence that they increase soy prices, cultivated areas, and sales volumes. Ritter & Barreto (2014) analyze a subsidized internet access program that similarly increased the prices farmers receive for their products in remote areas of Peru.

Internet connectivity may also reduce uncertainty over product quality. Luca et al. (2023) find that establishing an online presence and being added to an online review platform increases restaurants' revenue by 5% in the U.S. Chen & Wu (2020) evaluate the impact of the Alibaba online trading platform's reputation system on t-shirt exports. Their analysis suggests that online reputation systems like Alibaba's can reallocate business towards highly-rated "superstar" sellers and thereby increase overall exports by 20%. Dickstein & Morales (2018) estimate a model of export participation showing why *sellers'* information can have similar effects in international markets.

Internet connectivity can also expand the choice set of sellers and buyers by facilitating search for and communication with trade partners. Akerman et al. (2022) demonstrate this in a trade model with variable elasticity of demand, emphasizing that internet adoption expands choice sets (see also Rauch & Trindade, 2003).[21] Fernandes et al. (2019) combine firm-level production data with province-level internet penetration information across Chinese provinces from 1999 to 2007, finding that internet aids sellers' communication with both clients and input suppliers, enhancing firm's online visibility and improving overall performance.[22] Lendle et al. (2016) connect the reduced impact of distance on eBay to lowered search costs, overcoming language and institutional barriers. Most recently, Demir et al. (2023) exploit a period of massive investment in Turkish optical fibre

[21] Using data and variation from the roll-out of broadband access points in Norway, Akerman et al. (2022) validate these predictions empirically.

[22] Similarly, Hjort et al. (2024) show that Liberian firms with internet access more effectively "convert" contract-bidding knowledge into sales.

networks and rich firm-to-firm transaction data to study how fast internet access affects input sourcing and economic growth across locations. They find that firms reallocate their purchases towards suppliers with better internet and diversify their input sources. These findings are interpreted through a spatial equilibrium model that incorporates rationally inattentive input sourcing by firms. Model estimates show that internet connectivity reduces costs related to obtaining information about potential suppliers and facilitates synchronous communication with them. Several of the studies discussed in this paragraph make clear that internet can also affect information frictions on firms' supply-side, for example enabling them to find the "right" suppliers (see also Malgouyres et al., 2021).

Though internet appears to lower entry barriers and communication costs, adverse counteracting forces have also been documented. Bai et al. (2024) explore how information frictions affect the firm dynamics of exporters operating on Aliexpress—a platform that connects small and medium-sized firms to international markets—and market congestion. They show that current sales, rather than product quality, predicts future sales, and that sales history itself affects firm dynamics, suggesting that visibility (when misaligned with quality) can lead to misallocation on the platform. However, Bai et al. (2024)'s results also suggest that further reducing information frictions and the number of competing firms can improve allocative efficiency online.

5 Internet and Public Sector Effectiveness

Economic development rarely occurs where the state is ineffective, and internet technologies increasingly shape public service delivery and government operations.

One branch of the growing body of research on internet applications in the public sector focuses on using internet technologies to improve government service delivery. Banerjee et al. (2023) show experimental evidence that replacing in-kind food transfers with electronic vouchers improved program adherence and reduced poverty substantially among the poorest households in Indonesia, while Dodge et al. (2023) find that an e-management app reduced processing time in government transfers to individuals in India. Banerjee et al. (2020) show that digitizing an Indian workfare program's records curtailed fund leakages and improved participation but increased the administrative load without raising wages. Chi et al. (2022) develop microestimates of wealth and poverty for all 135 low and middle-income countries at low (2.4km) resolution, in part by using connectivity data from Facebook.[23]

[23] There is also a rapidly growing literature on use of digital technologies to target delivery of humanitarian assistance (see e.g. Aiken et al., 2022).

Internet also appears to facilitate other government operations. Blumenstock et al. (2023) show that an initiative by the Afghan government to modernize its payroll system—requiring teachers to biometrically register and receive salary payments via mobile money—significantly reduced delays and improved educational outcomes and financial inclusion, but did not decrease payments to non-existent "ghost" workers. Lewis-Faupel et al. (2016) investigate whether electronic procurement mechanisms reduce entry barriers ($\frac{\partial f_j^{\text{entry}}(\theta)}{\partial \theta} < 0$) and fixed operational costs ($\frac{\partial f_j^{\text{fixed}}(\theta)}{\partial \theta} < 0$) in public works projects across states in India and Indonesia. Using a DiD approach, they find evidence that higher quality contractors win tenders under e-procurement. Prices do not fall, but e-procurement improves road quality in India and reduces delays in Indonesia. Deininger et al. (2023) analyze a 2021 reform in Ukraine mandating "collusion-proof" online auctions for public agricultural land leases and report large revenue increases. Callen et al. (2020) and Dal Bó et al. (2021) show that IT tools can improve public sector workforce performance and accountability through better effort monitoring.

Internet-based technologies may also improve tax collection in countries with limited state capacity. Okunogbe & Pouliquen (2022), Dzansi et al. (2022), and Knebelmann et al. (2023) provide compelling, experimental evidence from Tajikistan, Ghana, and Senegal. Knebelmann et al. (2023) for example show that using an algorithm to assess property taxes in Senegal reduces regressive undervaluation compared to assessments done with full discretion by bureaucrats.

Despite its importance, the study of how internet connectivity influences public sector productivity is still underdeveloped, presenting an important opportunity for future research.

6 The Overall Impact of Internet Connectivity

Our discussion thus far has centered on channels—*how* internet connectivity affects economic activity. The ultimate impact likely varies substantially across different developing country contexts. For instance, improvements in internet connectivity might transition workers from informal to formal employment, with impacts varying by the initial prevalence of of informality. Evidence from rich countries also associates ICTs with changes in the economy that have potential adverse consequences, such as increased market power for "superstar" firms, declining labor shares, and increased access to "temptation goods" (see e.g. Autor et al., 2020; Koenig, 2023).[24] Ultimately it is, for many reasons, not clear a

[24] The evidence presented in Ramdas & Sungu (2022) suggests that smartphone users in India are willing to pay to limit their usage to avoid "bingeing" on mobile data.

priori that increased internet connectivity necessarily raises welfare.

This paper distinguishes between broad mechanisms by which internet connectivity influences economic development, discussing research that primarily informs supply-side mechanisms in Section 3, demand-side mechanisms in Section 4, and state effectiveness in Section 5. This section highlights empirical studies that additionally and relatively directly examine how "downstream" measures of economic development itself, like consumption or local income growth, respond to internet connectivity.

Quite a few studies convincingly estimate the effect on consumption of specific internet-enabled technologies (rather than internet connectivity itself) through model-based approaches[25], and others do so more directly. Jack & Suri (2014) show that access to mobile money decreased consumption poverty by two percentage points in Kenya, and Batista & Vicente (2023) find similar benefits in in Mozambique (see also Brunnermeier et al., 2023).[26] In contrast, Couture et al. (2021) finds that expansion of e-commerce in China has little effect on income for rural producers and workers. Brynjolfsson et al. (2023) quantify welfare gains from 10 popular digital goods by conducting large-scale online choice experiments involving nearly 40,000 representative users of Facebook digital services in 13 countries. They find that digital goods generate over $2.52 trillion annually in average consumer welfare across these countries, equivalent to roughly 6% of their combined GDP, with relatively larger welfare gains for low-income individuals and countries.

The available evidence—most of which is from Africa—suggests that internet connectivity improves aggregate economic outcomes in many developing countries, though the difference-in-differences and synthetic control methods that have been used do not always allow firm conclusions on causality and aggregate impacts versus spatial reallocation. Simione & Li (2021) and Goldbeck & Lindlacher (2024) use variation in submarine cable arrival timing to show evidence of large effects of internet penetration on economic growth and productivity in Sub-Saharan Africa. Hjort & Poulsen (2019) find similar effects from the later arrival of fast internet. RTI International has similarly evaluated the economic impacts of submarine fiber optic cables in each of six African countries—D.R. Congo, Kenya, Mozambique, Nigeria, South Africa, and Tanzania. Their findings gener-

[25] For example, Dolfen et al. (2023) build a general equilibrium model to quantify a consumer gain of about 1% in the U.S. from e-commerce expansion, while Fan et al. (2018) through a similar approach estimate a 1.6% welfare gain from e-commerce in China.

[26] Jack & Suri (2014) use household survey data and a DiD approach to show that mobile money, which is accessible on basic phones but typically requires internet for broader infrastructure, helped users better manage negative income shocks. This particularly benefited those in the lowest income quartile. Suri (2017) reviews the broader impacts of mobile money in developing countries. Brunnermeier et al. (2023) discuss the trade-offs between competition and financial inclusion in mobile money markets, noting that while platform interoperability reduces fees and may lower network coverage, it can also negatively impact financial inclusion metrics.

ally indicate large, positive aggregate economic impacts, but the magnitude varies substantially across countries.[27]

The most compelling evidence on how internet infrastructure affects incomes to date includes studies by Demir et al. (2023), Bahia and coauthors (Bahia et al., 2024; Masaki et al., 2020; Bahia et al., 2023), Blumenstock et al. (2024), and Agarwal et al. (2024). Except for Blumenstock et al. (2024), they all estimate the causal effect of connectivity by exploiting gradual roll-out of infrastructure.[28] Demir et al. (2023) find that fiber connections increased real incomes in the median Turkish province by about 2%[29], and Agarwal et al. (2024) that 4G availability in India increased agricultural households' incomes by 14%. As briefly discussed in Sub-section 3.1.1, Bahia et al. (2024) find that the gradual roll-out of mobile broadband in Nigeria between 2010 and 2016 increased labor force participation, employment, and household consumption (by ∼6%), and decreased poverty. Masaki et al. (2020) document a similarly striking result. Combining household expenditure surveys with data on the location of fiber-optic transmission nodes and coverage maps of 3G mobile technology, they show that 3G coverage is associated with a 14% increase in total consumption and a 10% decline in extreme poverty in Senegal.[30] Finally, Bahia et al. (2023) use a similar empirical approach to study the effect of mobile broadband roll-out in Tanzania, finding a comparable increase in household consumption and decline in poverty. Blumenstock et al. (2024), as discussed in Sub-section 3.1.1, randomized the location of new mobile towers in the Philippines. They find a 17% increase in household incomes and a 13% improvement in food security, with gains stemming from both local self-employment and employment outside the village.

An innovative recent study by Suri & Bhattacharya (2022) takes a different approach, focusing directly on individuals' *use* of internet, specifically among the poor. They collaborate with a Kenyan telecom to provide free phone data to poor subscribers who had not used data in the previous year but owned a data-capable phone. The study randomly selected recipients and found that, while data usage moderately increased, there were

[27] See e.g. O'Connor et al. (2020) and the summary press release citing the reports on each of the other countries here: `https://www.rti.org/impact/analysis-economic-impact-subsea-internet-cables-sub-saharan-africa?utm_campaign=SSES_SSES_ALLSubseaCables&utm_medium=website&utm_source=press_release`

[28] Agarwal et al. (2024) also use the staggered introduction of Rights of Way (RoW) policies meant to promote the growth of telecom infrastructure in India.

[29] The authors point out that while this effect is large, it is smaller than that of comparable improvements in transport infrastructure. Björkegren (2019) estimates that the Rwandan cell phone network generated consumer surplus equal to about 1.5% of Rwandan GDP from 2005-2009—before mobile internet became (commonly) available and when only a fraction of Rwandans had phones.

[30] While more descriptive than Bahia et al. (2024), Masaki et al. (2020)'s findings are robust to controlling for household demographics and spatial characteristics, and to an instrumental variable approach based on proximity to 3G coverage in adjacent areas.

no significant changes in economic outcomes like employment or consumption. These findings suggest that subsidizing and encouraging use of existing mobile internet access among priced-out (or reluctant) individuals is unlikely to be effective in settings like Kenya.[31]

The findings of Suri & Bhattacharya (2022) are especially interesting in light of those from Roessler et al. (2021). They present results from an experiment in Tanzania which gifted randomly chosen women with either a basic phone, a cash grant, or a smartphone. Smartphones increased household per capita annual consumption by 20%—an effect three times greater than basic phones and 3.6 times that of cash grants. This highlights the role of internet access, with smartphone use and occupational changes being key drivers of increased consumption in Roessler et al. (2021)'s findings.

Finally, Gunsilius & Van Dijcke (2023) provide the first compelling evidence on the economic costs of internet shutdowns, which are increasingly common in many parts of the world. They estimate that a shutdown in India reduced economic activity by by 25–35%.

7 Conclusion

This paper summarizes existing research on the economic impact of the rapid and continuing spread of internet connectivity in developing countries. We start with a stylized framework in Section 2 that outlines different pathways through which economic impacts arise, and then present the corresponding empirical evidence. Section 3 reviews studies focusing primarily on supply-side mechanisms. Section 4 covers research focusing primarily on demand-side mechanisms, such as internet influencing firms', workers', and consumers' ability to access markets or search for and communicate with each other. Section 5 examines evidence on the effect of internet connectivity on state effectiveness, such as efficient delivery of government services and tax collection. Finally, Section 6 summa-

[31] In the U.S., subsidizing internet access for low-income families has shown positive impacts. Zuo (2021) is to our knowledge the first study that convincingly estimates how subsidized internet causally affects welfare-proxies in rich countries. He demonstrates that discounted broadband access significantly increases earnings and employment rates among qualifying low-income families in the U.S. Beem (2021) and Johnson & Persico (2024)—like the studies of internet's impact in Africa by Hjort & Poulsen (2019); Bahia et al. (2024); Masaki et al. (2020); Bahia et al. (2023); Goldbeck & Lindlacher (2024)—focuses on internet infrastructure. Beem (2021) does so by using variation in U.S. broadband deployment facilitated by the FCC's Connect America Fund Phase II (CAF II). He finds persistent gains in the number of firms, establishments, entrepreneurs, employment levels, and average annual wages, and concludes that the benefits of CAF II are 42 times greater than its costs. Johnson & Persico (2024) find that U.S. "Counties with increased access to broadband internet see reductions in poverty rate and unemployment rate [and] increases in the numbers of employees and establishments [and] the positive effects are concentrated in the working age population, those between 25 and 64 years old" (Johnson & Persico, 2024, p. 1).

rizes studies that attempt to estimate how internet connectivity ultimately affects downstream measures of economic development itself. These studies and the research they build on in sum point toward substantial economic impacts of internet connectivity in many, though not all, developing country contexts.

We highlight some promising future research directions throughout the paper. These include better understanding:

- contextual determinants of the skill bias of internet technology
- how internet affects search and matching frictions in highly frictional labor and firm-to-firm markets
- how the economic role of multinationals changes with internet connectivity
- how the internet shapes firms' organizational choices and the type and extent of production taking place in developing countries
- whether internet connectivity can boost service exports from lower-income countries and the sustainability of such growth
- the mechanisms through which internet affects firms' productivity
- the contexts in which internet connectivity increases or hinders educational attainment
- how access to internet technology changes the way states organize their production

We hope and expect that it will not be long until much more is known about these and the many other important questions surrounding the role in poor economies of what many believe to be our time's most profound technological innovation.

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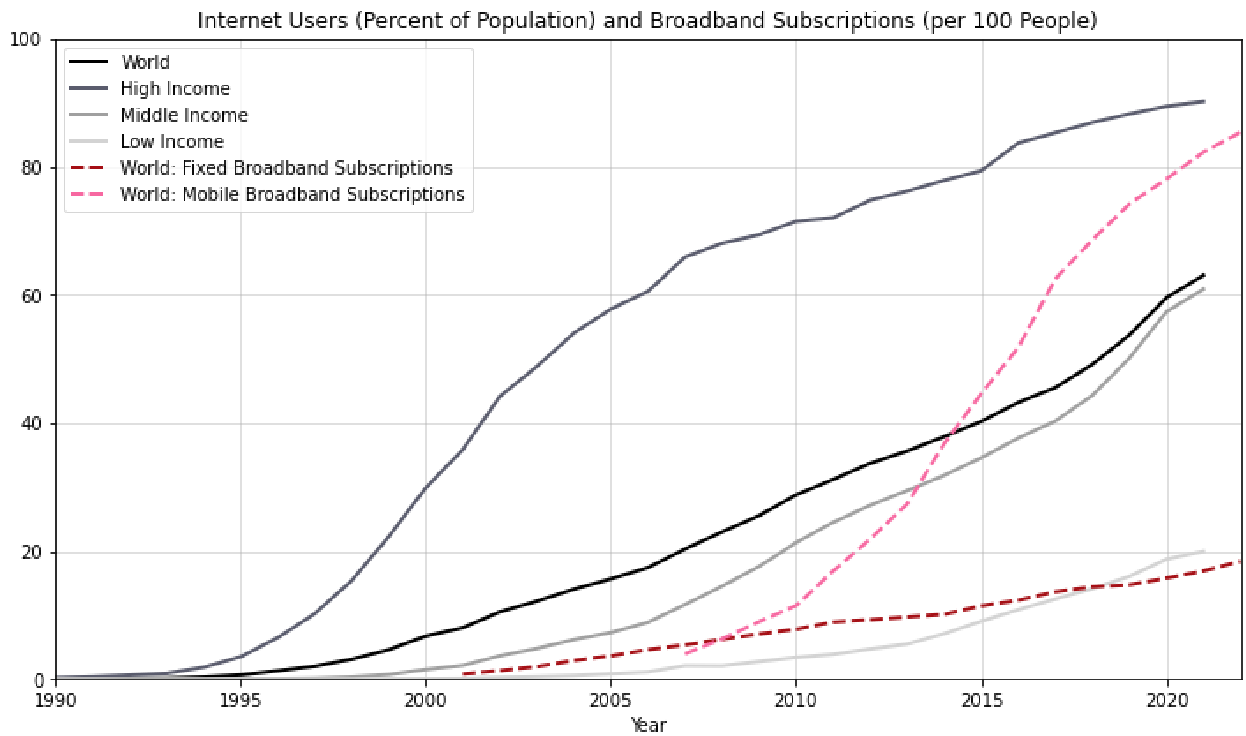
FIGURE 1
GLOBAL INTERNET ADOPTION AND TECHNOLOGY PENETRATION (1990-2023)



Source: The International Telecommunication Union and The World Bank

Notes: Income levels are based on the income classifications of The World Bank. The fixed and mobile broadband subscription rates are represented as the number of subscriptions per 100 people. Fixed broadband subscriptions refer to fixed subscriptions to high-speed access to the Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s. Mobile broadband subscriptions refers to the active handset-based and computer-based (USB/dongles) mobile-broadband subscriptions that allow access to the Internet.