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Mobile Access Expansion and Price Information Diffusion

Firm Performance after Ethiopia's Transition to 3G in 2008

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Abstract

This paper investigates whether enhanced access to mobile communications, including internet, primarily through smart phones, increases competition as price information is more widely available to customers—both households and firms. The exogenous shock to identify these impacts is the transition from 2G to the 3G broadband network standard in 2008, and the induced changes in the geographic variation across districts of data plan availability for households. The operational mechanism is that better household and firm telecommunications access can close information asymmetry gaps between buyers and sellers, with increased competition leading to improved firm performance. Lower markups and reduced price dispersion can result from better incentives for firms to preserve and grow market share. And as price competition squeezes profit margins, there are more incentives for firms to reduce costs—inducing higher total factor productivity growth. Improved firm performance can generate jobs and economic transformation. Indeed, faster productivity growth, due to enhanced access for buyers to mobile telecommunications, can translate into higher formal employment and wages. One open question is whether the potential competition, driven by the increased mobile telecommunications access of buyers, which help them have the best alternative prices at their fingertips, will also impact export-oriented companies. The prior is that the firm performance improvement effect would be more salient for firms mostly focused on local markets. The primary data sources are manufacturing firm census data and household expenditure survey data across woredas (districts or counties) in Ethiopia. First, the paper investigates the relation between expanded access with the 3G network to price information through mobile phones (measured at the woreda level as share of households with substantive expenditure to access data through smartphones) and firm performance measures (markups, total factor productivity, labor productivity, wage growth, wage gaps and employment growth.), across districts with different shares of mobile telecommunication and data plan penetration subscription. The paper estimates models with difference-in-differences and triple differences. The evidence is consistent with competition intensification after the improvement in access to mobile communication due to the 3G network rollout. In particular, markups were reduced and there was higher growth in productivity, wages, and employment.

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1. Introduction

In this paper, we explore how manufacturing firm performance changed after the upgrading of broadband communication infrastructure – enhancing data flows and access to internet – in Ethiopia in 2008, when the 3G network was introduced. Our conjecture is that the possibility of improved mobile communication – both voice and multimedia, including internet-based – potentially closed gaps in price-information asymmetries between buyers and sellers. Through this demand-side channel, improved internet access increases competition. The reduction in the price dispersion of selected intermediate inputs and final products can boost firm performance. Intensified competition can lead to higher TFP and lower markups due to better incentives to preserve and grow market share, as well as reduced intermediate input prices improving firm performance. In particular, manufacturers exposed to intensified competition will have more incentives to lower production costs as they attempt to preserve their profit margins. Indeed, increased information availability of competitor prices can make enterprise market selection more stringent.

In low-income countries, price information asymmetry, yielding price dispersion, is rather common because of market remoteness and missing or low-quality communications infrastructure. This poses significant challenges to better information for decisions by economic agents and overall market development of less advanced countries. For example, the living standards of most households engaged in the primary sector (agriculture, fishery, natural resource extraction and forestry) in these countries are heavily impacted by commodity prices (Jensen, 2007). As a result, market distortions are amplified along value chains in a way that severely affects the well-being of the most vulnerable. In this respect, communication technology improvements – and more specifically mobile phone access – can substantially facilitate information flows, enhance market efficiency and improve household welfare.

According to Aker and Mbiti (2010), mobile phone coverage expansion influences the economic behavior and performance of producers, traders and consumers in Africa. This argument extends to mobile phone network upgrades that improve access to data flows. First and foremost, mobile phone communication – both voice and multimedia – reduces costly information search, and hence improves access and flow of price data that translates into enhanced market efficiency and coordination among economic agents. Buyers and sellers incur these costs in search of information on input and output prices and other market and non-market information. Second, it allows better management of the supply chains and thereby improves producers' productive efficiencies. Third, it is associated with job creation potential – not just for telecom related services but much more widely. Fourth, improved information exchanges that come with mobile phone communication enable better assessment of shocks and mitigation of related risks across households and market makers. Lastly, beyond the demand-side channels emphasized here whereby less price information asymmetry boosts competition and firm performance, there are supply channels that also enhance productivity through relaxation of financial constraints, better functioning factor markets (including the labor market), as well as cheaper and better inputs.

Recently, there is a growing body of literature that examines the effect on economic behavior and outcomes of improvements in information communication technology (ICT) using micro level data. For example, Jensen (2007), based on microlevel survey data from fishing industry in India, reports substantial price reduction as well as welfare gains because of adoption of mobile phones by producers and wholesalers. Based on survey data from Southeast Asian countries (Thailand, Vietnam, the Lao People's Democratic Republic and Cambodia), Hubler and Hartje (2016) document an economically large positive and significant positive effect of smartphone ownership on household income. Evidence from Sub-Saharan African studies points in the same direction. Muto and Yamano (2009), using data from households in Uganda, find that mobile phone network expansion has led to increased market participation of farmers as well as sales of perishable crops in remote areas. Indeed, sales of a perishable crop (banana) increased relative to a storable one (maize).

These results are attributed to decline in marketing costs of agricultural products because of increased flow of information that comes with the mobile phone network coverage. Furthermore, the results indicate that simple expansion of mobile phone coverage itself (not necessarily ownership and usage of mobile phone) gave rise to better market participation and revenue outcomes for producers of perishable products.

Aker (2010) attributes 10-16 percent of the grain price reduction in Niger to the introduction of mobile phones between 2001 and 2006. This effect is more pronounced in markets that are remote and less well-connected. The results also suggest network externalities but find no evidence of spillover effects (to untreated units, markets with no mobile phone coverage) and collusive behavior. In an earlier work, Aker (2008) also found that reduction in search costs and cross-market price variation is positively related to improved welfare—traders (roughly 29 percent rise in profits) and consumers (about 5 percent decrease in prices and substantial increase in quantity consumed due to lower relative grain prices).

In a related study on Niger, Aker and Fafchamps (2014) examine the effect on producer price dispersion and uncover that mobile phone coverage led to a decline in cross-market and intra-annual price variation for a semi-perishable product whereas no significant products that are less perishable and storable. Most of these studies predominantly focus on the agricultural sector, rural households and commodities. To fill this gap in the literature, our study investigates the effect of mobile phone coverage in the manufacturing sector by taking a step further by directly addressing the implications of 3G internet.

Manufacturing is different from other sectors in several important ways. The customer bases of manufacturing plants (perhaps as opposed to most service sector activities) may not necessarily be individual consumers and households. Rather, it is other firms, wholesalers, and retailers. This is particularly true for medium and large-sized manufacturing establishments. In addition, as compared to agriculture, manufacturing has different production structure and product characteristics (e.g., value to weight ratio, perishability, and product downstreamness).

Furthermore, there are potentially two opposing effects when it comes to increased access of price information. That is, more price information reduces prices because consumers are better equipped to make alternate choices through the demand side channel we focus on. On the contrary, most agriculture-based studies document that the effect is usually reflected in higher commodity prices (see, for example, Goyal, 2010), and operates through the supply side.

Another effect could be that if the 3G network expands the variety of inputs to which manufacturers have access that can induce higher quality and productivity. On this, see for example Kugler and Verhoogen (2009), who document how Colombian manufacturers are better able to engage in quality upgrading and technology adoption when they access wider varieties of imported inputs.

The development economics literature that analyzes empirically the impact of better telecommunications tends to focus on the supply side, and especially how technology upgrades improve the efficiency of suppliers in their operations as better information emerges to improve sales (e.g. about weather, input market conditions, local market prices, labor market trends), as better credit options materialize through fin-tech (e.g. wider banking service access, easier credit ratings), and also as knowledge spillovers disseminate faster – within firms, industry-wide and along value chain through both backward and forward linkages.

Notably, Hjort and Poulsen (2019) find that the availability of fast internet connection through submarine cables in Africa has resulted in large positive employment effect regardless of the skill profile of workers, and the positive employment effect is attributed to higher rate of firm entry, productivity gains and exporting that have come with the arrival of fast internet connection. In addition, Dutz et al. (2012) study how establishments' innovation activities affect their employment growth using enterprise-level data from a large sample of countries, including 11 Sub-Saharan African countries. Their results show that innovating establishments registered significantly faster employment growth compared with their non-innovating counterparts, and this relationship is more pronounced when establishments use internet; it is shown that internet usage is a positive correlation of more innovation and higher productivity. Using Brazil's staggered internet rollout, Dutz et al. (2017) also show that in the manufacturing sector, internet access induces positive employment and wage effects in both medium- and high-skill occupations.

In addition to our focus on manufacturing, another distinctive feature of the paper is the exploration of the demand channel whereby internet affects the behavior of producers through providing broader access to price and product information to customers rather than through technological impact on the production function or access to lower-cost inputs.

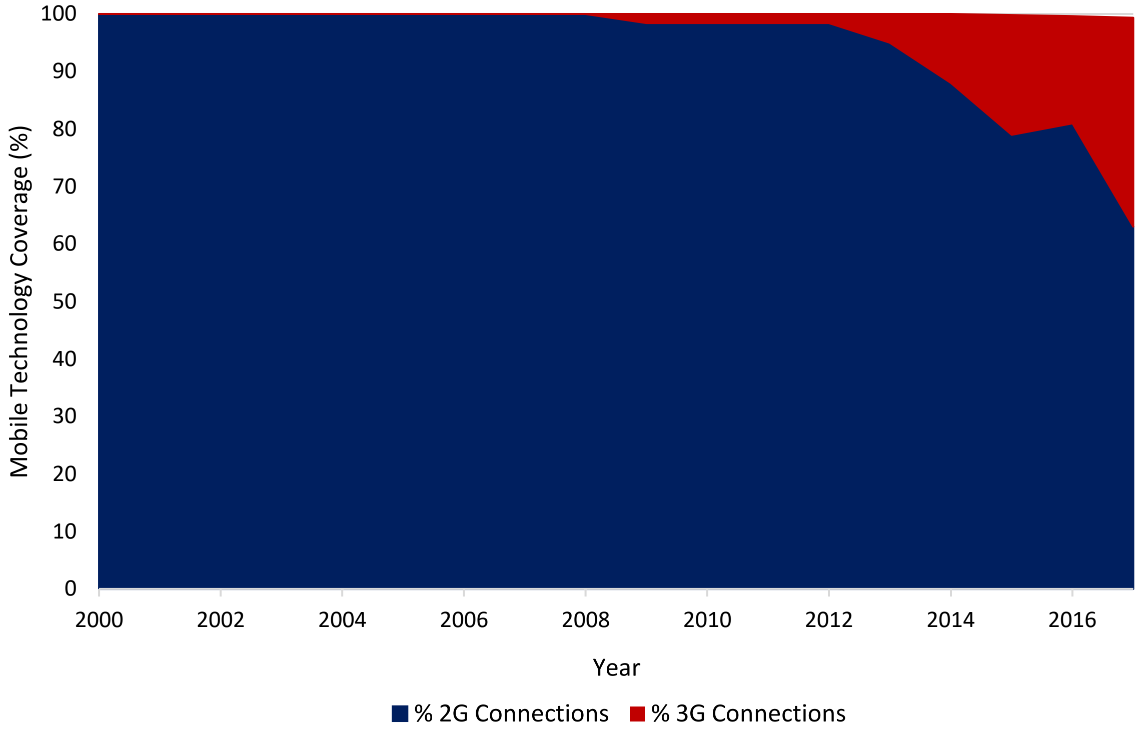
We investigate the relation between improved access to price information through the transition from 2G to 3G network (measured at the woreda level as share of households accessing data through smartphones) and firm performance measures (e.g., TFP, labor productivity, markups, wage growth, employment growth, etc.), which vary across districts with different shares of mobile penetration use over time.

Our exogenous shock to identify these impacts is the transition from 2G to 3G broadband network, with the rollout starting in 2008, and the induced changes in the geographic variation across districts of data plan take-up. Our story focuses on changes on the demand side primarily as customers access more extensive information about prices and entertain purchasing from a wider set of potential providers.

2. Context: Transition from 2G to 3G in Ethiopia

Ethiopia was an early adopter of telecommunication services with the introduction of long-distance telephone lines between Addis Ababa and Harar in 1894, along the newly launched railway line, followed by an expansion between 1902 and 1913 across various sub-regions of the country. Internet service was introduced in 1997 and cellular mobile service was launched in 1999. The growth of the sector has long been stalled, however, until the late 2000s with the re-organization of the national monopoly, formerly the Ethiopian Telecommunications Corporation (ETC) into Ethio Telecom. Subsequently, the Ethiopian mobile market has experienced rapid growth, though from a very low base. The introduction of third generation (3G) mobile technology was one of the important developments that launched a rapid growth in the sector, with possible implications on the growth of the manufacturing sector and hence economic growth. The national ICT policy first drafted in 2006 notes the centrality of investing in ICT infrastructure to serve as a key driver of a competitive industry and engine of economic growth.

Figure 1: Coverage of 2G and 3G Mobile Technology in Ethiopia (2000-2017)



Source: GSMA, 2020

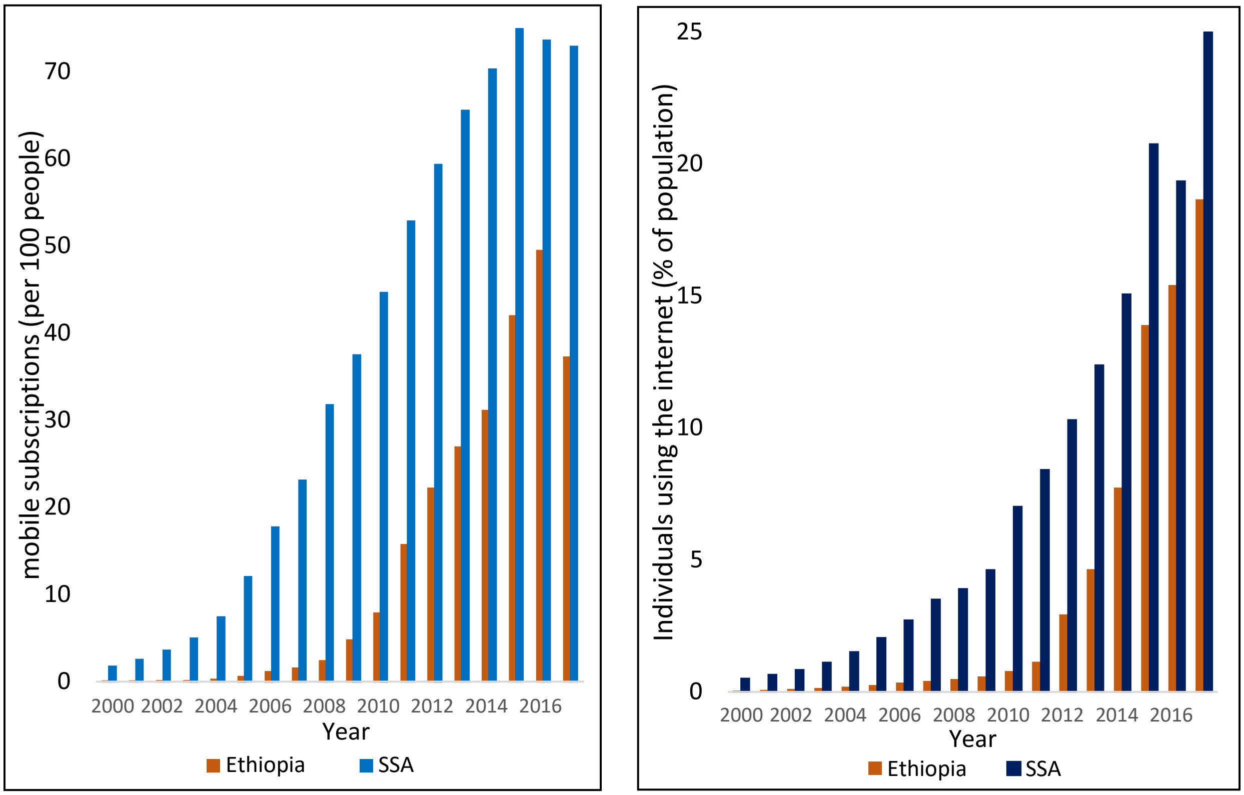
The level of development of the ICT sector in Ethiopia is still one of the lowest in the world. Though a significant share of the mobile networks still employs 2G technologies, following the adoption of 3G technologies in 2008/2009, the country has shown significant growth in mobile broadband technology. In 2007, before the launch of 3G in the country, the proportion of individuals using the internet as a percentage of the population was extremely low at less than half of one percent.

After a decade, in 2017, this has risen to more than 18 percent. Comparable figures for SSA were 3.5 percent in 2007 and 25.4 percent in 2017. The introduction of 3G in 2008/2009 has contributed to rapid growth in internet access compared to most countries in SSA, though still at very low levels. In 2007, 100 percent of the country's mobile connection coverage was 2G, as 3G had yet to be introduced. After a decade, 2G coverage fell to 63 percent, while 3G coverage rose from 0 to 37 percent, narrowing the gap between 2G and 3G coverage (Figure 1).

Despite significant progress, the country still lags in connectivity and adoption of digital technologies relative to countries with similar levels of economic development. This has significantly negative implications for industrial development and economic growth. In 2017, only about 18.6 percent of the population is connected to the internet, lower than the Sub-Saharan African average, and much lower than other countries in the region including Kenya, Nigeria, Tanzania and Senegal. During 2007-2017, both internet subscription and the number of mobile subscriptions has shown significant growth (Figure 2).

Mobile coverage has seen rapid growth during the period, with an annual growth rate of over 50% since 2007. During the study period, the number of mobile SIM card subscribers jumped from a mere 1.2 million in 2007 to 22 million in 2012. Mobile cellular subscriptions (per 100 people) have risen from 1.5 to 37 between 2007 and 2017 while the comparable figure for SSA was 23 and 72 for 2007 and 2017, respectively. The rapid growth both in mobile subscriptions and internet access follows the introduction of 3G technologies. Though Ethiopia has adopted 4th generation (4G) technology in 2015, 3G is expected to remain the dominant mobile broadband technology.

Figure 2: Mobile and internet access in Ethiopia and SSA (2000-2017)



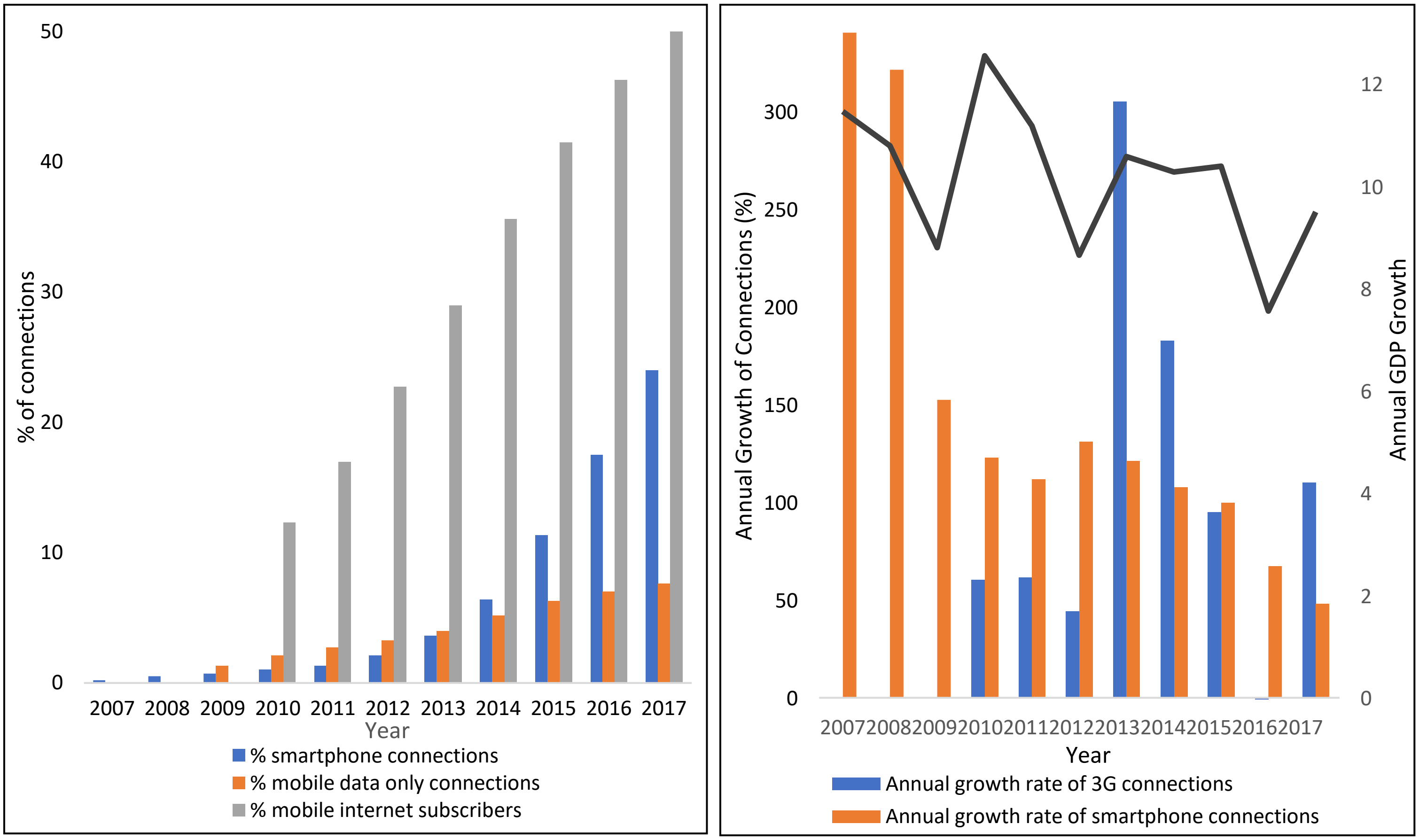
(a) Mobile Subscription (per 100 people) (b) Individuals using internet (% of population)

Source: GSMA, 2020

The transition to 3G is expected to boost the competitiveness of the economy. Indeed, the transition from 2G to 3G is considered a technical leap in terms of the possibilities it creates for firms and consumers by enabling faster mobile broadband connection, expansion of data-enabled phones, and increased flexibility and mobility.

Following the launch of 3G technologies, the percentage of mobile internet subscribers has increased from 0 percent in 2007 to close to 52 percent in 2017, and percentage of smart-phone connections has jumped from 0.2 percent to 24 percent during the same period (Figure 3a).

Figure 3. Growth in Mobile Broadband and Economic Growth in Ethiopia (2000-2017)



(a) Mobile Connections and Subscriptions

(b) 3G Connections and Economic Growth

Source: GSMA, 2020

3G broadband connections allow multiple types of communication services including transmitting either one or all of the following at the same time: simple voice, video, data and other multimedia services. It facilitates communications allowing the spread of information either for firms or consumers, reducing information asymmetries. In most SSA countries including Ethiopia, where fixed broadband communication is limited and there is poor infrastructure in transport and other necessary market infrastructure, the role of mobile broadband connection is far reaching. It would play significant role in reducing information asymmetry particularly with respect to prices and other product characteristics. The easy dissemination of market information reduces transaction costs and information asymmetries by using mobile technologies. For example, the market price for goods or services depends on whether there is information about the prices charged by other similar firms either in the region or in other regions, and whether consumers have access to that information.

In Ethiopian markets, like most of Africa, information asymmetries are widespread. Both consumers and firms must incur search costs, and sometimes other transaction costs, to access reliable information about prices, buyers, sellers, quality of products and quantities supplied or demanded. This introduces inefficiency through costs of bargaining, time and money costs of supervision and enforcement in dealing with prices. The more widespread access to price information changes customer behavior and induces manufacturing suppliers to face intensified competition. As such, their incentives are affected in a way that reduces markups and price dispersion, while also boosting productivity as well as wages and employment. The higher TFP can be a source of faster formal job creation.

The period following the rollout of 3G broadband networks coincides with a more robust growth in Ethiopia, often putting the country among the fastest growing economies in the world. Though, the adoption of broadband technologies itself could be an outcome of this fast growth, it has also played a significant role in facilitating the growth of industries and reinforcing market competition, hence productivity, particularly in the manufacturing sector. This paper examines the impact of access to 3G broadband networks on firm productivity in Ethiopia through its impact in closing gaps and information asymmetries about market prices.

3. Description of Information Sources and Data

This study uses two different sources of data in estimating the effect of expanded mobile communication access in local markets on firm performance in Ethiopia: Large and Medium Manufacturing Industries (LMMI) and Household Consumption and Expenditure Surveys (HCES). LMMI is a firm-level census panel data collected by the Ethiopian Central Statistical Agency (CSA) from 2000 to 2014. The census covers all public and private manufacturing firms that have more than 10 employees and use electricity for production. The data set provides detailed information on sales, production, wages and benefits, number of employees, cost and quantity of raw materials, types of ownership, and location. The firms are categorized into the International Standard

Industrial Classification (ISIC) at the 4-digit level. The total number of firms in the data set across the years is 19,235 and on yearly average the number of observations comes down to 1,282 firms.

In order to measure internet access at the woreda level (equivalent to district or county), this study also uses HCES which is a nationally representative survey collected by the CSA for the years of 2004-5, 2010-11, and 2015-16. The surveys provide extensive socio-economic information about Ethiopian households in individual and household levels. Specifically, the data set includes socio-demographic characteristics of household members such as age, sex, education, health, and labor force participation information. Also, the surveys cover information on household expenditure by main items, housing amenities, assets, and access to infrastructure and service.

For the purpose of measuring internet access at the woreda level, we use household expenditures on communication items including mobile cards and mobile apparatus from HCES. Detailed discussions on construction of the internet access variables will follow in the next section.

The household expenditure data set has the total of 1,496 households across the years and on yearly average, the number of households each year is approximately 499 households. As the firm panel data LMMI only extends until 2014, we use the first two waves from the HCES data, namely 2004-05 and 2010-11.

3.1 Constructing Internet Access Measures at the Woreda Level

The HCES communication questionnaire modules provide household expenditure information on various communication-related items. These include mobile apparatus, mobile cards, telegram, internet, sim cards, fixed line, fax, and email. Of those, we chose mobile cards in estimating a woreda's mobile communication utilization intensity and internet access. As mobile cards are purchased to use data plans on smartphones, this variable is used to gauge what fraction of a woreda's population has mobiles, thereby measuring level of internet access.

As Ethiopia introduced the 3G networks in 2008, thus permitting use of smartphones, the running assumption here is that the household expenditure on mobile cards considerably increased after

2008, indicating wider and better internet access. This suggests that consumers in localmarkets are able to conveniently check and compare prices online instead of having to visit local vendors. The HCES data set shows that the average real term expenditure on mobile cards in 2004-05 was 907.4 birr whereas it surged to 1,436.2 birr in 2010-11.

By using the expenditure levels, we postulate that households in a woreda would have access to mobile internet once the average household expenditures on mobile cards exceed certain points.As the 3G rollout in Ethiopia started in 2008, we compare changes in the expenditure levels between 2004-05 and 2010-11 and assign treated and untreated woredas. Specifically, if changes inreal term average expenditure from 2004 to 2010 in a woreda exceeds the median of the distribution, the woreda is coded as treated (1 in the treatment variable); 0 otherwise. Given the limited publicly available data on internet access in Ethiopia at the woreda level, these binary measures of internet access are the best indicators this study can currently use.

3.2 Firm Performance Measures

In this paper, several firm performance measures are used to estimate the impact of local market's mobile internet access status. The focus is on firm markups and productivity measures. Our measurement of TFP relied upon the methodology developed by Ackerberg et al. (2015) using a structural approach, and the estimation of markups was done without making any assumptions beyond cost-minimization behavior by firms using the econometric framework by DeLoecker et al. (2012 and 2018).

Table 1 – Descriptive Statistics for Main Variables in Manufacturing Panel Data

	N (Obs.)	Mean	s.d.
Avg # of Firms in Woreda	1,916	10	40
Avg Capital per worker in Woreda	1,916	860,107	3,698,632
Avg Sales in Woreda	1,916	252,053,444	968,001,530
Avg Value of Production in Woreda	1,916	249,461,183	954,237,179
Avg Employment at in Woreda	1,916	877	3,746
Avg Book Value of Fixed Assets in Woreda	1,916	94,437,524	331,522,005
Avg Materials in Woreda	1,916	127,692,617	542,969,363
Avg Export Sales Value in Woreda	1,916	15,636,992	105,203,671
Avg Transport Cost in Woreda	1,916	4,091,011	15,846,122
Avg # of Exporter Firms in Woreda	1,916	0.5	2.0
Avg Age of Firms in Woreda	1,912	19.8	10.7
Avg Labor Productivity in Woreda	1,916	228,403	335,585
Avg Markup Materials ACF Cobb-Douglas	1,916	2.0	1.0
Avg TFP ACF Cobb-Douglas w/o constant using phi	1,916	-0.9	1.0
Avg Wage of Firms in Woreda	1,858	1,463,913	4,999,070

Table 1 shows the descriptive statistics for the main variables from the manufacturing panel data, including the overall number of observations (woreda-years), and for each variable we list the mean as well as the standard deviation.

4. Estimation Strategy and Regression Results

4.1 Difference-in-Differences and Triple Differences

As explained earlier, Ethiopia adopted the 3G broadband network in 2008, thereby substantially improving mobile communication access. Taking advantage of the geographic variation of such shock, this study employs the difference-in-differences (DID) methodology in estimating the impact of enhanced local mobile access on firm performance. Specifically, the DID models compare firm performance across treated and untreated woredas before and after the adoption of 3G networks in 2008.

As explained in the previous section, the woredas that experienced above the median increase in real term mobile expenses between 2004 and 2010 are coded as treated woredas. The untreated woredas are the opposite cases. Using real terms, the median values of increase in mobile cards spending in woreda 24.474 birr respectively. Table 2 below describes numbers and percentages of woredas in each treated and untreated group.

Table 2 – Untreated and Treated Woredas

	No.	Percent
Untreated	1,473	56.48
Treated	1,135	43.52
Total	2,608	100

The DID regression specification is here:

$$Y_{ijt} = \alpha + \beta_1 MobileAccess + \beta_2 Post_{ij} + \beta_3 Mobile\ Access * Post_{ij} + \eta_t + \mu_i + \varepsilon_{ijt} \quad (1)$$

where, Y_{ijt} is a set of firm performance measures described in the previous section for firm i in Woreda j in year t. Depending on the measures, Y_{ijt} can take a form of log or change in log. $InternetAccess_{jt}$ is 1 if the Woreda where the firm i operates had above the median increase in the real term mobile expenses between 2004 and 2011 in year t and clustered at Woreda j; 0 otherwise. $Post_{ij}$ refers to 1 for the years 2008 through 2014, which are the years after the introduction of the 2008 3G broadband; 0 otherwise. $MobileAccess_j * Post_{ij}$ is an interaction term of $MobileAccess_j\ and\ Post_{ij}$ which is 1 if firm i in a treated Woreda j for the years 2008 through 2014; 0 otherwise. η_t and μ_i are year dummies and firm fixed effects respectively. Also, ε_{ijt} is an idiosyncratic error term.

In the specification (1), the coefficient of interest is β_3 which estimates the difference-in-differences effect on firm performance due to enhanced mobile access after 2008 in a subset of woredas.

4.1.1 Differences-in-Differences Parallel Trends and Regression Results

This section reports graphical evidence of selected outcome variables that the treated and untreated woredas show similar pre-trends before the adoption of 3G networks in 2008; but display different tendency after 2008.

Also, statistical evidence of the parallel trends is presented. We use the method of Angrist and Pischke (2009, pp.238-239) to test whether the woreda-specific time trends before the treatment (i.e. the introduction of 3G in 2008) do not differ in the treated and untreated woredas. We report joint F-statistics where the null hypothesis is that the coefficients of the woreda-specific time trends are not jointly different from zero. In other words, we test whether $\lambda\lambda$ is jointly different from zero in the following specification,

$$Y_{ijt} = \mu_0 + \lambda_0 t + D_{it}\mu + D_{it}t\lambda + \theta_i + \varepsilon_{ijt} \tag{2}$$

where Y_{ijt} is a set of firm performance measures for firm i in woreda j in year t. μ_0 is a Woreda-specific intercept and λ is a woreda-specific trend coefficient of the interaction term between the treatment D_{it} and time trend t.

Figure 4 illustrates pre-and post-trends of log of markup in treated and untreated woredas. The pre-trends show that firms in the treated and untreated woredas followed moderately similar ups and downs prior to the adoption of the 3G broadband networks in terms of log of productivity. However, after 2008 the firms in the two groups of woredas appear to present slightly different patterns, where log of markup rises faster in treated woredas.

This is consistent with the notion that markups are higher where competition is less intense, e.g. due to lower access to price information through mobile telecommunications. The joint F-statistics of the parallel trends is 0.52 with p-value of 0.7922, suggesting that the parallel trends assumption is satisfied.

Figure 4 – Parallel Trends for Log of Markup (ACF-DLW)

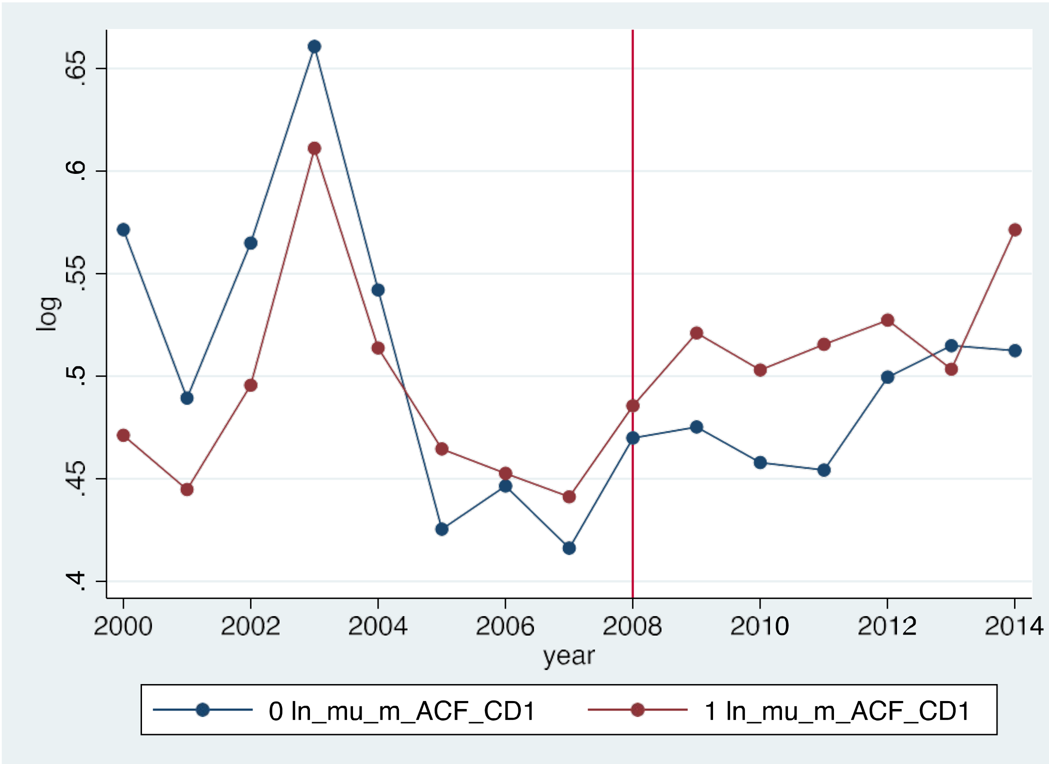


Figure 5 presents parallel trends prior to 2008 in terms of log of employment in treated and control woredas. The pre-trends display that firms in the treated and control woredas move in a fairly parallel fashion in terms of log of employment.

However, the trends change after 2008 where the employment paths diverge and the treated woredas show a peak while the untreated do not in 2010. The joint F-statics of the woreda-specific time trends is 1.50 with p-value of 0.1838, suggesting that the parallel trends assumption is satisfied pre-2008.

Figure 5 – Parallel Trends for Log of Total Employment

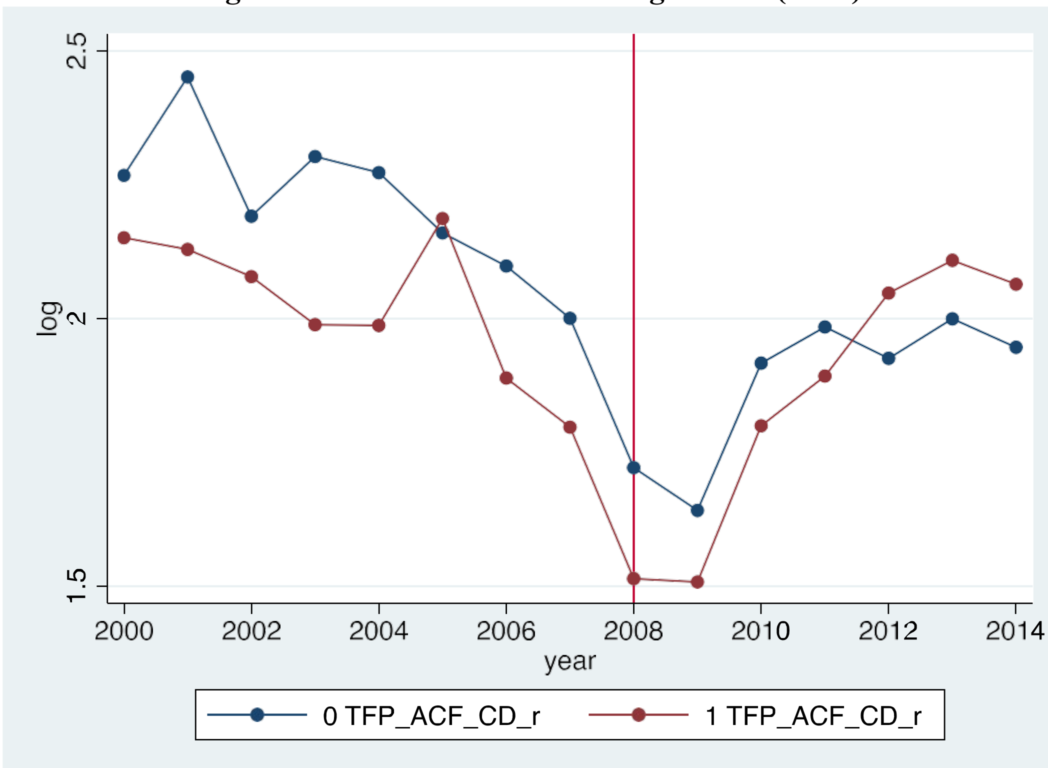
Figure 6 below describes the trends of log labor productivity before and after 2008 in the treated and untreated woredas. The pre-trends appear to follow similar parallel patterns of ups and downs in both groups of woredas until 2008 while the trends diverge after 2008.

The F-statistics of the parallel trends is 2.51 with p-value of 0.0249, suggesting that the parallel trends assumption holds.

Figure 6 - Parallel Trends for Log of Labor Productivity

Figure 7 below portrays pre- and post-trends of log of TFP ACF in the treated and untreated woredas using mobile cards. Similar to other trends so far, the pre-trends here also move together in both groups of woredas.

Figure 7 – Parallel Trends for Log of TFP (ACF)



Then, after 2008 the post-trends deviate from each other. The joint F-statistics of the parallel trends is 1.01 with p-value of 0.4206, suggesting that the parallel trends assumption is satisfied.

4.1.2 Differences-in-Differences Regression Results

Using specification (1), this section reports the results of the DID regression on firm performance outcome variables – log of labor productivity, log of total factor productivity, log of markup, and log of total employment. In the regressions, average mobile apparatus expenses in woredas are used for classifying treatment.

We test whether the channel for 3G rollout to improve firm performance is increased competition by estimating the impact on markups. As shown in Table 3 below, across the specifications, we identify that firms operating in woredas with improved mobile access due to the 3G network inaugurated in 2008 experience 29% decline in markups.

This evidence is consistent with our conjecture that a key channel whereby expanded mobile communication access boosts industrialization is increased competition. Since lower markups are a sign that profit margins are being squeezed by the fact that customers are aware of more alternatives and this exerts downward pressure on prices.

Since the margin in the short run to lower costs is limited, the intensified competition will result in lower markups. The increased availability of price information in nearby markets will induce more widespread sales and underpricing. That is indeed what we find in the specification including firm-level controls.

Table 3 – DID for Log of Markup (ACF-DLW)

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post	-0.290**	-0.290**
	(0.136)	(0.131)
Observations	2,597	2,545
R-squared	0.064	0.172
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

We report in Table 4 that firms operating in woredas with improved mobile access due to the 3G network inaugurated in 2008 experience 23.3% rise in labor productivity. This evidence is consistent with our conjecture that a key channel whereby expanded mobile communication access is through more stringent market competition.

This works through the demand side due to the closing of the gap in price information between buyers and sellers. When information is less asymmetric, customers have more choice, and this induces competition. As a result, profit margins compress, and firms have more incentives to reduce costs through improved productivity.

Table 4 – DID for Log of Labor Productivity

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post	0.0501	0.233*
	(0.152)	(0.137)
Observations	2,334	2,289
R-squared	0.063	0.265
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

With more competition and lower profit margins, the incentives to lower production costs are magnified. This induces firms to attempt lowering production costs to increase profitability. If productivity-enhancing investments are expanded, this can induce both higher labor productivity as well as TFP. In Table 5, we find 17%-18% increase in TFP although moderately significant.

Table 5 – DID for Log of TFP (ACF)

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post	0.185**	0.178**
	(0.0864)	(0.0836)
Observations	2,597	2,545
R-squared	0.085	0.168
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

To the extent that 3G catalyzed competitive dynamics, we expect that the induced acceleration in productivity growth would increase labor demand. This expansion in job creation in manufacturing would be reflected in higher employment.† In Table 6, we find moderately significant employment effect across the specifications, suggesting that firms in the woredas with enhanced internet access tend to hire 23%-26% more than firms in the untreated woredas. the results suggest firms exposed to heavier competition by better mobile communication access expand the size of the firm by hiring more employees. This pattern is consistent with higher labor productivity due to the intensification of competition in woredas with more improvement in telecommunications access.

Table 6 – DID Results on Log of Employment

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post	0.230**	0.267**
	(0.115)	(0.106)
Observations	2,597	2,545
R-squared	0.129	0.276
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

4.1.3 Triple Differences: Non-Exporting Firms

In case there is some time-varying confounder that changes across woredas violating the parallel trend assumption (Wing et al. 2018), this section identifies within-woreda comparison groups that are not exposed to treatment but are exposed to the time-varying confounder — namely, export-oriented firms.

† As the manufacturing firms operate largely in the formal sector, it is likely that formal employment is boosted through the expansion of mobile communication. This could be important evidence in the context of a JET policy agenda.

In particular, if our results were driven by supply-side effects of the 3G network rather than the demand- side effect we emphasize, whereby 3G network services raise competition as price information becomes more widely available, both export-oriented and domestic-market oriented firms would experience similar boosts in firm performance, other things equal. However, if as we posit the pro-competitive effect of 3G is also operating through the demand-side, we expect that the export firms exposed to international competition beforehand will be less impacted in their performance by theexpansion in mobile communication.

The exporting firms are the ones that only export, and account for 974 observations in the panel. On average by year, there are 65 exporting firms. Non-exporting firms – i.e. local firms exclusively dedicated to the domestic market – account for 6,726 firms in the panel data set and on average by year 449 firms.

We compare whether exporting firms that are subject to the same local mobile communication access expansion also experience competition intensification. In particular, since exporting firms have been already exposed to the discipline of global markets, they are not impacted to the same degree as 3G closes the gap in asymmetric information about prices between sellers and buyers. While local firms are more likely to experience intensified competition brought about by enhanced mobile communication access. This section employs the triple differences regression method in estimating different effects on local vs. exporting firms receive from the 3G network rollout.

The specification for the triple differences model is:

$$Y_{ijt} = \alpha + \beta_1 MobileAccess_j + \beta_2 Local_{ijt} + \beta_3 Post_{ij} + \beta_4 MobileAccess * Local_{ijk} + \beta_5 Post_{ij} * MobileAccess_{ijt} + \beta_6 Post_{ij} * Local_{ijt} + \beta_7 Post_{ij} * MobileAccess_j * Local_{ijt} + \eta_t + \mu_i + \varepsilon_{ijt} \qquad (3)$$

where, Y_{ijt} is a set of firm performance measurements of firm i in woreda j in year t. $MobileAccess_j$ refers to a dummy variable for woreda j that have above median increase in share of households with mobile expenses (i.e., mobile cards and mobile apparatus) that are likely associated with smartphones, between 2004 and 2011. $Post_{ij}$ is a dummy variable for firm i in Woreda j in post 2008 (i.e., the treatment group). $Local_{ijt}$ is a dummy variable for firm i in woreda

j in year t that is 0 of there is any engagement export markets, and 1 otherwise. η_t and μ_i are year fixed effects and firm fixed effects respectively. Also, ε_{ijk} is an idiosyncratic error. In the triple difference regression (3), the coefficient of interest is β_7, which estimates the firm type-specific impact from the mobile internet access changes in local markets in woredas.

In comparison to the results from the DID regressions in the previous section, the triple differences regression results are expected to tease out whether different types of firms show different firm performances when facing intensified local market competition. Furthermore, the triple differences method that compares changes over time of local firm performance in woredas with and without enhanced telecommunications access, compared to exporting firms, would produce unbiased results (Wing et al. 2018).

4.1.4 Triple Differences: Regression Results

We analyze triple differences estimates on local firms. Table 7 below reports triple differences estimates on markup using mobile cards in the baseline specifications without controls in Column (1) and with firm-level controls in Column (2).

In Table 7, we report moderately significant evidence of differential markup reduction among non-exporting firms. Across the specifications, the additional markup decline for domestic-oriented firms is 38-41%. This complements the earlier DID evidence reported in Table 3 of an overall markup fall of 29%. The evidence is consistent with the demand-side channel from 3G network introduction being operational as competition increases.

Table 7 – Triple Differences for Log of Markup (ACF-DLW)

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post*Local	-0.414**	-0.383**
	(0.183)	(0.183)
Observations	2,597	2,545
R-squared	0.075	0.095
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

One consequence of stiffer price competition would be increased investments and efforts for productivity enhancement. As profit margins become razor thin, cost cutting is the main way to remain competitive. One key way to achieve lower manufacturing costs is through investments in technology upgrades as well as better organization of production.

Thus, one implication of our conjectured effect of the 3G network is that productivity will go up. We check this hypothesis by assessing if there is a differential positive impact on TFP for non-exporters, other things equal, located in woredas most exposed to 3G network penetration.

In Table 8, we show the evidence from our exploration of the productivity channel through the impact on TFP post-2008 for firms in treated woredas that do not export. There is some evidence that TFP, like labor productivity, was boosted by the introduction of 3G networks for non-exporting firms in woredas with expanded access to mobile telecommunications. The estimated effect of 73.4% is significant at the 1% significance level in the specification with firm controls.

Table 8 – Triple Differences for Total Factor Productivity (ACF)

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post*Local	0.461	0.734*
	(0.437)	(0.421)
Observations	2,597	2,545
R-squared	0.097	0.170
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

An important question is whether the pro-competitive effect of 3G beyond impacting markups and productivity also leads to the creation of more and better jobs. In particular, we posit that as a consequence of higher productivity there is a larger labor demand for firms exposed to intensified price competition. This would result in higher employment and wages. The evidence reported in the appendix Tables A.2 and A.3 appears insignificant but positive effects. Confirming if this channel may operational, whereby increased marginal productivity of labor yields improvements in formal job creation and wages, would require more accuracy and precision that will be sought through lowering measurement error and potential identification enhancements.

5. Conclusion

The overall evidence on a number of outcomes measuring firm performance indicates that in woredas with higher customer mobile communication access, including household internet access, after the rollout of the 3G broadband network in 2008, and especially for firms focused on domestic markets, manufacturers tend to have lower markups, higher productivity and also faster growth in employment as well as wages.

Access to price information through mobile communications, including internet (measured at the woreda level as the share of households accessing data through smartphones), can reduce information asymmetry between buyers and sellers. We conjecture that this would in turn impact the distribution of product unit values across different woredas in Ethiopia. However, we were not able to obtain unit values from the Ethiopian manufacturing panel data to conduct the price dispersion analysis for a substantial number of products. In future research, we plan to also explore whether household survey data analysis could provide evidence on the variation in price information access across years and districts.

One open question is whether the potential competition, driven by the increased internet access of buyers, which helps them find the best alternative prices at their fingertips, yields Bertrand competition (sellers underprice each other to capture higher market share) or vertical differentiation (sellers upgrade product quality to capture higher market share). For example, Kugler and Verhoogen (2012) provide evidence of the role of quality upgrading for manufacturing competition in Colombia. Our prior is that price competition would be more dominant for relatively homogenous goods (e.g., cement, concrete, flour, bricks, cloth, etc.), and that quality upgrading competition would be more salient for heterogenous goods. Indeed, we useCPI survey data to compare the standard deviations of retail prices for selected commodities basedon surveys in 2008 and 2010 for the month of September. We find that the introduction of 3G is associated with the reduction in dispersion in more homogeneous products like cement, mobile phone apparatus, imported rice and some varieties of barley. By contrast, the price dispersions ofitems such as beer, coffee beans, cotton and wheat have increased. See Table A.1 in the appendix.

Although it is standard in the trade literature to emphasize the Rauch (1999) Index as a measure of horizontal differentiation, its focus on product homogeneity is better interpreted as reflecting differentiation more generally (i.e., both horizontal and vertical). Indeed, homogenous goods are those traded on a commodity exchange or those that have a quoted price in industry trade publications. Interestingly, the degree of price information accessibility is directly related by Rauch with limited scope for product differentiation. Hence, we will also explore the differential impact on homogenous good suppliers, operating in markets mainly with price competition, as opposed to suppliers in differentiated product markets, competing as well through quality upgrading.

One additional feature worth studying is small versus large firm size or even more interestingly startups and young firms versus established ones. The established ones have large and strong customer bases and their price information is commonly or more likely known through other channels like social capital. We expect the effect of 3G to be more pronounced in the pricing behavior of the newcomer firms than the established ones.

Finally, conditional on future data access, we plan to investigate the role of road connectivity and other infrastructure variables affecting market integration that could influence geographical variation of product price dispersion and firm performance.

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Appendix A

Table A.1 - Price dispersion for selected products (based on September retail price survey)

Products	**Std. dev. 2007**	**Std. dev. 2008**	**Std. dev. 2010**	**o 2008 -07**	**Δ 2010 -08**
Barley Black Kg	0.73	1.24	1.28	0.51	0.04
Barley Mixed Kg	0.54	1.25	0.98	0.71	-0.27
Barley White Kg	0.77	1.43	1.32	0.66	-0.11
Barley for Beer Kg	0.71	0.79	1.55	0.08	0.76
Beer (Bedele) 330cc	0.38	0.64	0.79	0.25	0.16
Beer (Harar) 330cc	0.34	0.50	0.77	0.16	0.27
Beer (Meta Abo) 330cc	0.30	0.37	0.71	0.07	0.34
Cement/Bag/(Local) 50Kg	15.59	27.33	20.56	11.75	-6.78
Coffee Beans Kg	4.66	4.87	8.80	0.21	3.93
Cotton Kg	2.07	2.45	4.23	0.38	1.78
Maize (White) Kg	0.51	0.89	0.93	0.38	0.04
Mobile Apparatus (Nokia6200) No	175.68	98.49	81.69	-77.20	-16.80
Rice (Imported) Kg	0.63	1.20	1.18	0.56	-0.02
Sugar Kg	0.67	0.71	1.25	0.05	0.54
Wheat Black (Red) Kg	0.68	1.19	1.26	0.51	0.07
Wheat White Kg	0.51	0.89	1.08	0.38	0.19

Source: Central Statistics Agency of Ethiopia.

Table A.2 – Triple Differences for Log of the Wage

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post*Local	0.230	0.673
	(2.186)	(2.116)
Observations	2,597	2,545
R-squared	0.193	0.265
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Table A.2 – Triple Differences for Log of Employment

VARIABLES	(1) Base	(2) Firm-level
MobileAccess*Post*Local	0.314	0.672
	(0.535)	(0.501)
Observations	2,597	2,545
R-squared	0.266	0.372
Year FE	NO	YES

Note: Column (1) is the baseline specification. Column (2) adds firm-level controls, including firm size, firm age, and capital intensity. Robust standard errors are clustered on Woreda. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)