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From Bytes to Business:

Mobile Broadband, Firm Creations and Digital Divide in Tunisia

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From Bytes to Business: Mobile Broadband, Firm Creations and Digital Divide in Tunisia

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Abstract

This paper investigates the impact of mobile broadband Internet on business creation in Tunisia. Using a rich dataset of Tunisian delegations, the study employs a count model and fixed effects panel data estimation to assess the influence of mobile broadband Internet quality and delegation characteristics on firm creation. The empirical findings demonstrate a robust positive relationship between the density of 4G antennas per 10,000 inhabitants and the number of new business creations (and a positive impact on net business creations). Notably, this relationship is stronger and exhibits later effects in rural areas, particularly on the peripheries of major urban centers, suggesting varying rates of technology adoption and challenging the hypothesis of the "death of distance" that broadband Internet was expected to bring. This research highlights the potential role of mobile broadband in stimulating local economic growth and sheds nuanced light on the economic implications of the digital divide.

JEL Classifications: L96 ; O18 ; O33 ; O47 ; R32

Keywords: Mobile broadband internet ; Firm creation ; Local economic growth ; Digital divide ; Tunisia

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1 Introduction

Digital technology is revolutionizing business operations by dramatically reducing operational costs, including search, reproduction, transportation, tracking, and verification (Goldfarb and Tucker 2019). Broadband Internet[1], recognized as a general-purpose technology, has the potential to have a profound impact on the entire economy (Bresnahan and Trajtenberg 1995,Carlaw and Lipsey 2006, Liao et al. 2016). This technology has been recognized to have a major impact in developed countries (Czernich et al. 2011, Kolko 2012, Briglauer and Gugler 2019), exceeding the influence of other Information and Communications Technologies (Vu 2011). The reduction in costs due to broadband technology not only enhances market efficiency but also broadens the market for firm outputs (Jensen 2007, Aker and Mbiti 2010, Aker 2010). By facilitating better coordination with suppliers and consumers, broadband enables businesses to reach distant markets, improving the matching between firms and markets (Autor 2001). High-speed Internet also accelerates the acquisition of market information, which is essential for swift business decisions and learning. The advent of e-commerce further exemplifies broadband's capacity to revolutionize traditional business models, allowing firms to operate more efficiently and competitively.

The Internet has significant potential to reshape territorial morphology and influence spatial inequalities, primarily by diminishing the importance of geographical distance in economic activities. While one might expect broadband Internet to diminish the significance of agglomeration effects—where the clustering of economic activity offers firms benefits from proximity (Glaeser 2000)—this assumption is uncertain. Among the sources of agglomeration, urbanization economies, which refer to the advantages firms gain from being located in large, diverse cities, could see their importance reduced with the advent of the Internet (Frenken, Van Oort, and Verburg 2007). Early theorists such as Toffler and Alvin, 1980 and Naisbitt, 1996 predicted a reduced dependency on urban centers, positing that advances in information technology could mitigate traditional urban functions by lowering transportation and communication costs, thereby reducing the necessity for face-to-face interactions (Gaspar and Glaeser 1998). For instance, Internet users can access many of the benefits typically associated with urban locations without physically residing in them. This has led to the emergence of theories such as the "death of distance" or the "death of cities," which speculate on the potential reduction of spatial inequalities (Haefner and Sternberg 2020).

However, these potential effects of digitalization are contested. Camagni and Capello, 2005 argue that digitalization fosters both centrifugal and centripetal forces, leading to what Moriset and Malecki, 2009 describe as the "paradoxical geographies of the digital economy." These dynamics suggest that instead of eliminating agglomeration effects, the Internet may, in fact, reinforce them, particularly in larger cities, thereby exacerbating regional inequalities (Wu and Li 2024). Consequently, it is crucial to consider these agglomeration effects when examining the impact of broadband Internet on firm creation. The Internet may serve as a complement to agglomeration economies, particularly in large urban areas, which could lead to increased regional disparities (Chen, Ma, and Orazem 2023).

ICTs are reducing coordination and communication costs in developing countries as well (Aker and Mbiti 2010), particularly cell phones, which are the predominant means of Internet access in

[1]The definition of broadband encompasses high-speed Internet access that is faster than traditional dial-up access. Broadband Internet provides access to high-speed Internet through several types of technologies, including fiber, wireless, cable, DSL, and satellite. The FCC - Federal Communications Commission - technically defines broadband Internet with a minimum speed of 25 Mbps downstream and 3 Mbps upstream.

Africa (Manacorda and Tesei 2020, Aker and Cariolle 2023). In imperfect markets characterized by asymmetric information, cell phones have been shown to enhance the welfare of both producers and consumers (Jensen 2007), and they are even posited as a potential tool for poverty reduction (Corbett 2008). The broadband Internet is increasingly acknowledged for its ability to foster sustainable economic growth, job creation, skill development, and socio-democratic transformation in developing countries (Hjort and Poulsen 2019). However, some specific characteristics of developing countries introduce uncertainty regarding the economic impact of the broadband Internet, as it is unclear whether their economic structure and functioning are well suited to integrate and maximize the benefits of the digital revolution. Additionally, challenges such as a more pronounced digital divide and various infrastructural constraints may further limit the transformative potential of broadband in these regions.

In this paper, we explore the economic impact of mobile high-speed Internet on Tunisia's economy through the lens of business creation. Our hypothesis is that new firms may increasingly seek locations with better connectivity to harness potential competitive effects. We also aim to uncover any thresholds of broadband density under which broadband has no impact on business creation. Finally, we aim to highlight any heterogeneous effects, particularly between rural and urban areas, and their consequence on the digital divide.

Despite the existing disparities in Internet speeds relative to developed countries[2], Tunisia represents an interesting case due to its high Internet penetration rates and substantial investments in telecommunications infrastructure. Demonstrated by its role in hosting the second phase of the World Summit on the Information Society (ITU)[3], Tunisia has positioned ICTs as a central pillar in its development strategy. This commitment is further underscored by the launch of the Tunisia National Digital Strategy 2021-2025, which aims to amplify digital integration across various sectors[4]. Tunisia ranks among the leaders in Internet use within Africa and the MENA region, with 79% of individuals connected to the Internet[5]. However, its Internet speed performance is limited; the country is ranked 101st globally in mobile broadband performance trailing behind Egypt, Morocco, and Senegal in Africa according to Ookla[6]. Despite widespread Internet engagement by both society and the economy in Tunisia, the availability of broadband-enabled services and applications remains comparatively limited (Sadok, Chatta, and Bednar 2016). Additionally, Africa exhibits a significant digital divide, especially notable in the disparity in 4G antenna coverage between rural and urban areas — 93% in urban versus 43% in rural areas in 2023[7] — as well as Tunisia for which it is a major challenge as highlighted by the ongoing efforts in the government's white zone coverage program[8]. The particularities of the Tunisian context pave the way for assessing the transformative potential of mobile broadband on Tunisia's economic activities, in particular through the creation of new businesses.

New business creation is crucial for regional economic development and often indicates future

[2] https://www.gsma.com/get-involved/gsma-membership/gsma_resources/internet-speeds-in-north-africa-are-rapidly-improving-but-still-lag-behind-much-of-the-world/ accessed in May 2024

[3] https://www.itu.int/net/wsis/tunis/index.html accessed in May 2024

[4] https://www.gsma.com/publicpolicy/policy-spotlight-tunisia accessed in May 2024.

[5] https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=TN, accessed May 2024.

[6] https://www.speedtest.net/global-index/tunisia#mobile, accessed in May 2024

[7] https://www.itu.int/itu-d/reports/statistics/2022/11/24/ff22-mobile-network-coverage/ accessed in May 2024.

[8] "Tenders for coverage of white areas for high-capacity communications," Ministry of Communication Technologies and Digital Economy, Republic of Tunisia, July 26, 2017, https://www.mtcen.gov.tn/index.php?id=119&L=1&tx_ttnews[tt_news]=3438&câĂę

growth potential better than current employment data (Carlton 1983, Audretsch, Keilbach, and Lehmann 2006). Using data from the Tunisian national firm census (*Registre National des Entreprises* (RNE)) from 2017 to 2021, we examine the determinants that influence formal business creation in Tunisia[9], focusing on the role of mobile broadband telecommunications infrastructure. We seek to dissect the nuanced effects of mobile broadband on firm creation, highlighting potential disparities influenced by firm-specific attributes and contextual variables. Existing firms, often established before the advent of widespread broadband access, base their location decisions on factors unrelated to current telecom infrastructure quality, and they face higher costs and lower incentives to relocate for better connectivity. In contrast, new firms are more acutely responsive to the current state of local infrastructure, including the availability and quality of mobile broadband. By focusing on new business creations, our study seeks to unravel how the quality of mobile broadband shapes the economic landscape locally, offering insights into how technological infrastructure can be important for regional development. The core of our analysis rests on a count model approach estimated through a Poisson model. We focus on the role of mobile broadband, using the number of 4G antennas per 10,000 inhabitants as a proxy for broadband quality. Beyond the impact on business creation, we analyze the effect of internet access on net business creation to determine whether mobile broadband Internet leads to net destruction or net creation of firms. To this end, we estimate a fixed effects panel data model.

Our findings show a robust positive impact of the density of 4G infrastructure on the rate of new business creation, with a notably stronger effect observed in rural areas. The spatial distribution of this effect is particularly significant: regions located on the peripheries of major urban centers exhibit the most substantial benefits from enhanced 4G infrastructure, while the impact diminishes in areas farther away from these centers. This pattern suggests that a critical minimum threshold of infrastructure density may not be met in more isolated regions, potentially inhibiting the facilitation of new enterprises. Additionally, our results suggest an ambiguous effect on the creation of firms with more than six employees, implying that mobile internet alone may not be a sufficient factor for the establishment of larger firms, which might instead value robust fixed infrastructure. It also appears that an increase in 4G antenna density leads to a net increase in business creation.

The remainder of the paper is organized as follows: Section 2 provides a literature review on our research question. Section 3 outlines the data used to construct variables capturing the determinants of firm creation, particularly emphasizing the role of mobile broadband infrastructure in Tunisia. Section 4 details the methodology employed in the study. Section 5 presents the empirical results, analyzing the differential impact of mobile broadband antenna density on the number of firm creations, with a particular focus on the persistence of the digital divide. Finally, Section 6 concludes.

2 Literature Review

Goldfarb and Tucker 2019 survey the papers dealing with the effects of ICT adoption on the economy, highlighting various channels and encompassing four different levels of impact (country, regional, firm, and consumer). In our brief literature review, we focus on the economic impact of ICT development, particularly broadband technology at the firm and region levels.

[9] We do not capture informal businesses, which by definition are not registered.

2.1 Broadband, firm performance and employment

First, our paper is related to the strand of the literature examining the impact of technological infrastructure on economic growth (Vu, 2011; Czernich et al., 2011; Kolko, 2012) and job creation (Atasoy, 2013; Hjort and Poulsen, 2019). As stated above, we limit our survey to papers dealing with the impact of ICT on firm performance (productivity and employment). Surveys by Brynjolfsson and Saunders 2009 and Draca, Sadun, and Van Reenen 2009 find a positive effect of ICT on firm performance, although Bloom, Sadun, and Reenen 2012 highlight substantial heterogeneity across countries. Using a fuzzy regression discontinuity DeStefano, Kneller, and Timmis 2023 show that broadband increases firm size, particularly in urban areas, but does not affect labor productivity in the UK. Conversely, Canzian, Poy, and Schüller 2019 and Chen, Liu, and Song 2020 find positive effects of broadband upgrades on firms' productivity, respectively, in rural areas in Italy and in China. Their methodologies rely on difference-in-difference frameworks. Furthermore, Cariolle and Le Goff, 2023, analyzing a dataset of 44,073 manufacturing firms across 109 developing countries, demonstrated that the internal adoption of email technology within industries (as opposed to inter-industry usage) has significantly enhanced sales.

Using the same methodology for 12 African countries, Hjort and Poulsen 2019 show that fast internet favors high-skilled job creation. In countries for which the authors have firm surveys, they show that the positive effect of high-speed internet on productivity and firm entry are among the main explanatory factors. Similarly, Atasoy 2013 finds broadband's positive effects on employment, mainly due to firm growth. Caldarola et al. 2023 also find positive effects of mobile internet diffusion in Rwanda. Using differential intensities in lightning strikes across districts as an instrument for mobile coverage, the authors show mobile internet induces skill-biased structural change.

2.2 High-speed internet and firm creation

Given the relatively more isolated nature of rural areas, particularly in large countries, most studies on the impact of broadband on firm creation were concentrated in the rural world. The idea is to test explicitly or implicitly the "death of the distance" hypothesis Cairncross, 1997. Studying the case of Ohio, Mack 2014 highlights a positive correlation between broadband speed and business location in rural areas. Kim and Orazem 2017 confirm these results through a difference-in-difference framework, allowing us to conclude that broadband availability has an impact on establishments' locations in North Carolina. Deller, Whitacre, and Conroy 2022 find similar results using US non-metropolitan county-level data. The authors simultaneously address the availability and quality of broadband aspects, deal with thresholds, and show that the results vary by business industry.

Hasbi 2020 studied the case of the impact of high-speed broadband on business establishments in urban areas in France. Using a count model, she highlights positive, although heterogeneous, effects across sectors and territory, depending on the population's education level. Similarly, using a count framework, McCoy et al. 2018 highlight the existence of a threshold of local education attainment below which we do not observe a significant effect of broadband on firm establishment in Ireland. Bourreau et al. 2022 address the issue of spatial heterogeneity in France. Using a difference-in-difference framework, they show that greater municipalities benefit relatively more from high-speed broadband than commuter municipalities in terms of firm creation, while rural municipalities are not impacted. A dynamic effect is also highlighted in urban areas.

2.3 ICT, inequality and digital divide

Given the positive effect of broadband on productivity, Akerman, Gaarder, and Mogstad 2015 wonder why it does not attract more public investment. They show, in the case of Norway, that broadband growth induces skill-biased technical change. Polarization issues in developed countries may discourage more public involvement in broadband development.

The disparities in the impact of high-speed internet, as analyzed through geographical economics methods, illuminate the prevalent inequalities known as the "digital divide." For instance, research by Wu, Wang, and Sun, 2022 using data from China between 2003 and 2015 demonstrated that variations in Internet penetration rates among cities significantly influence their economic growth rates. These disparities often manifest between urban and rural areas. Whitacre, Gallardo, and Strover, 2014 found that in the USA, from 2001 to 2010, rural areas with higher levels of broadband internet adoption experienced notable positive impacts on economic growth and reductions in unemployment. However, they noted that the availability of broadband had less influence than its actual adoption. As Fox and Porca, 2001 explained, investing in infrastructure in rural areas not only boosts productivity levels but also attracts additional resources, fostering development. Moreover, the impact of such investments tends to be more pronounced in rural areas that are economically integrated. This pattern also holds true for broadband infrastructure, with findings from Kim and Orazem, 2017 indicating that while broadband availability boosts new firm start-ups, the effect is significantly stronger in rural areas that are relatively more populated and closer to metropolitan centers. More recently, Wu and Li (2024) show that the internet favors the agglomeration of producer services in large cities due to their higher intensity in knowledge industries.

3 Data

The number of business creations in an administrative zone results from a series of decisions regarding business location. The decision on where to establish a new business is a strategic choice that significantly influences its success and potential for growth. When companies decide where to locate, they incur fixed costs, making the selection process heavily influenced by cost factors and potential market demand. Key cost factors include the local tax environment, the availability of essential infrastructure like transportation and broadband services, and the cost and availability of labor.

To investigate this topic, we have constructed a panel database that aggregates the number of new firms along with various characteristics of the areas in which they are located, for each administrative unit over a five-year period from 2017 to 2021. We specifically focus on assessing the quality of mobile broadband infrastructures, using mobile antenna data, to discern their influence on firm creation. Table 1 summarizes the variables used in our estimates, and Table 2 provides some basic descriptive statistics for these variables.

3.1 Firm Creations

231,056 companies have been created between 2017 and 2021 in Tunisia, according to the RNE which is a "public database for collecting data and information relating to Tunisian companies and making them available to the public as well as to state institutions". This RNE is managed by the Tunisian Institut National des Statistiques (INS). Our main outcome variables are based on the national busi-

Table 1: Data Table

Variable type	Variable	Spatial Level	Frequency	Source
Firm	Firm location, sector, entry year	Delegation	Annual	Registre National des Entreprises (RNE)
Mobile Broadband	Antennas (2G, 3G, 4G)	Geocoordinates	Annual	OpenCellID
Agglomeration / Competition	Localization - Distance from the nearest biggest urban/economic center	Geocoordinates	2021	OpenStreetMap
	Sector share of total employment	Delegation	Annual	RNE
	Spatial HHI	Delegation	Annual	RNE
Accessibility and outlets	Distance from the nearest post office	Geocoordinates	2021	OpenStreetMap
	Distance from the nearest bank	Geocoordinates	2021	OpenStreetMap
	Population	Delegation	2014, 2020	Census
Labor offer/market (Human capital, labor cost)	Mean level of education	Gouvernorat	2015-2019	Enquête Emploi
	Distance to the nearest university	Geocoordinates	2021	OpenStreetMap
	Mean wage	Gouvernorat	2015-2019	Enquête emploi

ness register. The RNE collects detailed information on various firm characteristics, including sector, number of employees, sales, and the legal and financial conditions at the time of registration, such as the date and location of company creation. This database facilitates comprehensive monitoring of all new company registrations within the formal sector over our study period. Figure 1 displays the distribution of these new businesses by year and sector from 2010 to 2021 (but our study is limited to the years between 2017 and 2021). The data indicates that a significant proportion of new enterprises are predominantly found in the commerce sector, with services and manufacturing following closely. For our analysis, we have defined two types of outcome variables: the first measures the total number of firm creations per administrative unit and year, and the second tracks the number of firm creations by sector within each administrative unit over the same period. The main outcome is shown in Figure 5 for all firm creations in 2018.

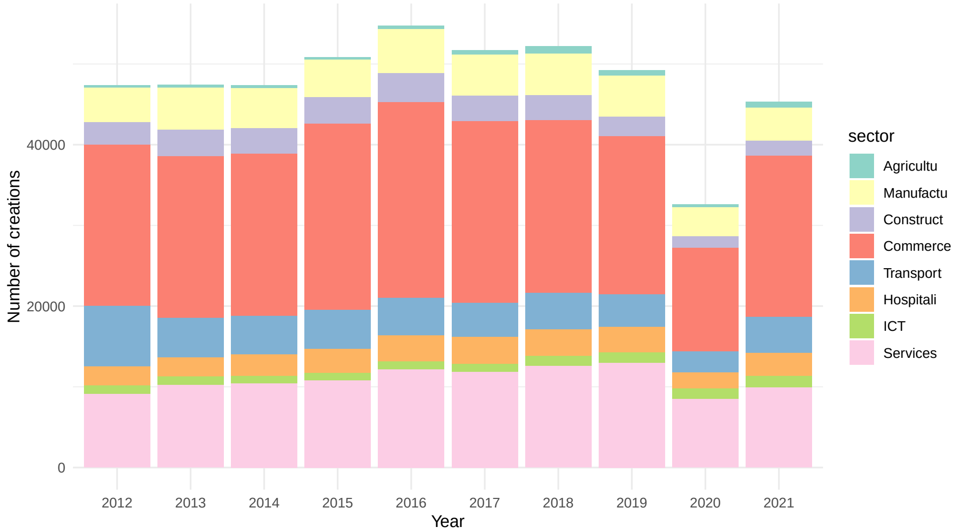


Figure 1: Number of business creation by year and sector

A second outcome variable has been constructed to measure the change in the stock of operating firms within each delegation for each year. This variable is calculated using the following formula:

$$Y'_{it} = N_{it} - N_{it-1}$$

Where N_{it} represents the number of active firms in delegation $i$during year t, and N_{it-1} represents the number of active firms in delegation i during the previous year $t-1$. A negative value of Y'_{it} indicates a decline in the number of active firms in the delegation, suggesting a net reduction in business activity. Conversely, a positive value implies a net increase in the number of firms, indicating net firm creation within the delegation.

3.1.1 The unit of analysis: the delegation

At the time of their creation, each firm declares an address[10]. The available database specifies the region and delegation to which the address corresponds. As shown in Figure 2, there are 24 regions (or governorates) in Tunisia, divided into 264 delegations (or *mutamadiyat*). The delegation covers a limited

[10]Only governorate and delegation IDs are available in the RNE.

area in terms of population (on average, 43,406 inhabitants by delegation) and size (on average, the size of a delegation is 575 km2). The delegation covers a limited area, which is designed to be easily accessible to regional population centers, facilitating access to both public and private services such as hospitals, dispensaries, and secondary schools. Thus, the 264 delegations in Tunisia correspond to as many possible locations for a firm at the time of its creation in our model. For each delegation, we have identified characteristics that business owners might consider when selecting a location. We have classified them into four categories: variables relating to the labor market (human capital and labor costs), variables relating to the functioning of the market at the delegation level (agglomeration and competition), variables relating to accessibility and outlets, and finally variables relating to the quality of the mobile broadband telecom's infrastructure.

Figure 2: Map of Tunisia's Governorates and Delegations.

3.1.2 Labor market (Human capital, labor cost)

To measure the human capital and labor costs that can influence an entrepreneur's profitability and, hence, his choice of location, we rely on two questions from the employment survey (carried out every year in Tunisia). The geographical precision we have access to does not go beyond the governorates.

So, for each governorate (24), we can compute the average level of education of the population (over 25 years old), which appears as a proxy for human capital in the area (an alternative measure is to measure the proportion of the population in each area with a tertiary degree). In parallel, at the level of each governorate, we can calculate an average monthly wage for each year between 2015 and 2019. This provides a proxy for the average labor cost at the area level that an entrepreneur may face.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Creation Year	1,320	2019	1.41475	2017	2021
Number of creations	1,320	175.875	223.2817	0	1786
Distance Big Cities	1,310	52535.48	43409.89	267.5029	239076.6
Distance Banks	1,310	16703.65	15768.33	21.32966	90352.16
Distance Posts	1,310	11298.03	10966.32	139.1864	62334.18
Distance University	1,310	23450.11	22575.99	107.6569	100747.4
Population	1,310	43406.65	27349.06	4102.995	146760.8
GSM Antennas	1,310	73.56412	85.9777	0	637
LTE Antennas	1,310	9.678626	24.34947	0	239
UMTS Antennas	1,310	124.5076	163.2406	0	1048
Urban Rate	1,310	.653678	.215079	.2708181	1
Mean Year of Education	1,310	8.864475	.8055027	7.602976	10.89026
Mean Wage	1,310	634.4573	82.31041	449.5959	990.1528
Mean Unemployment	1,310	.1529381	.0607076	.0370855	.3573184
Rate Diploma Superior	1,310	.0412125	.0266942	.0011971	.1073173
Spatial HHI	1,320	42.95	20.32	17.35	93.9
No. living firms	1,320	3042.246	4038.783	134	36022
Area	1,310	575.6785	1846.432	1.507246	27171.66
Dens 2G	1,320	16.16642	14.74379	0	102.3643
Dens 3G	1,320	25.39955	26.59269	0	196.615
Dens 4G	1,320	1.816077	4.548814	0	54.25253

3.1.3 Agglomeration and competition

We used data from the RNE to measure the effects of agglomeration and competition. To capture these phenomena, we constructed two primary variables: The first variable represents the pre-existing number of firms operating in each delegation per year. This variable aims to capture competitive effects, where a higher concentration of firms may signal market saturation, and agglomeration effects, where clustering yields spillover benefits. The second variable measures the degree of specialization within each delegation using a spatial Herfindahl-Hirschman Index (HHI). The spatial HHI is computed by summing each delegation's squared sectoral employment shares. The sectoral employment share in each delegation is calculated as follows:

$$s_{jit} = \frac{LF_{jit}}{\sum_{j=1}^{J} LF_{jit}} \tag{1}$$

LF_{jit} is the labor force (or number of employees) in sector j in delegation j at year t and $\sum_{j=1}^{J} LF_{jit}$ is the total labor force in all sectors in delegation i at year t. The spatial HHI is then calculated by summing the squared sectoral employment shares in each delegation:

$$HHI_{it} = \sum_{j=1}^{J} (s_{jit})^2 \tag{2}$$

The index ranges from 0 to 100. An index approaching zero indicates a relatively diversified employment structure across sectors, whereas a value approaching 100 signifies significant concentration in a particular sector. This allows us to gauge the extent of specialization and agglomeration in each delegation.

Using these measures, we can distinguish between competitive pressures discouraging new entrants and agglomeration economies attracting new firm formation.

3.1.4 Accessibility and outlets

Access to local markets and outlets is assessed through a series of distance and population variables. Proximity to major urban centers is crucial for leveraging their infrastructure and market access.[11] The distance to these urban centers is calculated from the centroid of each delegation to the centroid of the nearest major city. The distance to the nearest post office (which serves as a proxy for the nearest urban center/markets) is also calculated, as is the distance to the nearest university.

The size of the local market where a company is located can also be crucial. We employ one primary measure for market size: population. Population data are derived from the national censuses conducted in 2014 and 2020.

3.2 Mobile Broadband in Tunisia

Since the 2000s, Tunisia, along with many other developing countries, has undergone a liberalization of its telecom market. This process, closely linked to the privatization of former state monopolies and the establishment of independent regulators, has fostered greater competition and improved

[11] Tunisia's six largest urban areas include Tunis, Sfax, Sousse, Kairouan, Gabès, and Bizerte.

services[12]. The origins of the Tunisian telecommunications market traced back to the promulgation of Law No. 36 on April 17, 1995, which established the Office National des Télécommunications[13], known as Tunisie Télécom, and came into effect on January 1 of the following year. In 1998, Tunisie Télécom launched its first GSM line. In 2002, the first private competitor, Tunisiana (now Ooredoo), entered the market. Initially launched as a mobile phone operator, Tunisiana transitioned under the Qatari flag in 2014 and expanded its services by acquiring Internet service provider Tunet in 2011. Orange Tunisie became the third major player in mobile telephony after acquiring a global license in 2009. Upon commencing commercial operations in 2010, the company provided mobile telephony, mobile data, fixed telephony, and fixed data services.

New Mobile Network Operators (MNOs) can only operate in a market once the regulator grants them a license, which often coincides with the introduction of a new generation of mobile technology. These licenses facilitate the allocation of spectrum, a scarce resource shared among operators. The deployment of mobile antennas is primarily guided by economic profitability factors, including the market size served, the cost of licenses, and access costs to civil engineering and fiber optic infrastructure[14]. As shown in Figure 4, 4G antennas are located where the population is most concentrated. For this reason, the allocation process of licenses is typically accompanied by a series of regulatory obligations, such as a minimum percentage of population coverage or mandatory coverage of specific rural areas.

In Tunisia, mobile phones appear to prevail over fixed-line broadband Internet access. The disparity between mobile Internet penetration (76.1% in 2020) and fixed Internet penetration (11.5% in 2020) suggests a clear preference for mobile data in Tunisia, possibly due to the low penetration of fixed-line phones for ADSL and optic fiber networks limiting fixed broadband use[15]. Following the issuance of 4G licenses in 2015, the rollout of 4G antennas was rapid, covering 54% of the population by 2016 and reaching 70.4% by 2021[16]. Additionally, the number of 4G antennas in Tunisia recorded in OpenCellID increased significantly, rising from 2,129 antennas in 2016 to 4,344 in 2020, as illustrated in Figure 3.

3.2.1 Data on mobile broadband Internet in Tunisia

For each business created, we cannot know the quality of the mobile network to which it has access. To answer this question, we have constructed one indicator of the availability and quality of mobile

[12] This process has had significant positive effects on the rate of fixed and mobile equipment usage and the quality of service in countries benefiting from a truly competitive environment (Wallsten 2001)

[13] `https://www.pist.tn/jort/1995/1995F/Jo03395.pdf`, accessed in May 2024.

[14] https://intt.tn/upload/files/Consultation%20publique%204G%20-%20Synth%C3%A8se%20des%20contributions.pdf, accessed in May 2024

[15] Two surveys conducted by the National Telecommunications Authority (INT) support this observation. The first survey, conducted in 2019 and titled "Field Survey on the Level of Satisfaction and Use of Telecommunications Services in Tunisia," covered a sample of 5,112 individuals, representative at the delegation level. The survey found that 70.8% of respondents used the Internet, meaning that the portion of the study focused specifically on Internet usage covered 3,621 individuals. Among this sub-sample, 74.2% accessed the Internet via mobile data offers (3G and 4G), far surpassing ADSL and 3G/4G dongles, which were used by 27.5% and 24.7% of respondents, respectively. The second survey, conducted in 2021 and titled "Survey on Internet and Social Media Usage in Tunisia," followed a similar methodology and covered a sample of 5,816 individuals. According to the survey, 73.7% of respondents used the Internet. In this sub-sample, mobile data (3G and 4G) accounted for 70% of access types, while Wi-Fi and ADSL were present in 50.2% and 47.8% of responses, respectively.

[16] https://www.speedchecker.com/products/cellular-coverage-datasets.html, accessed in May 2024

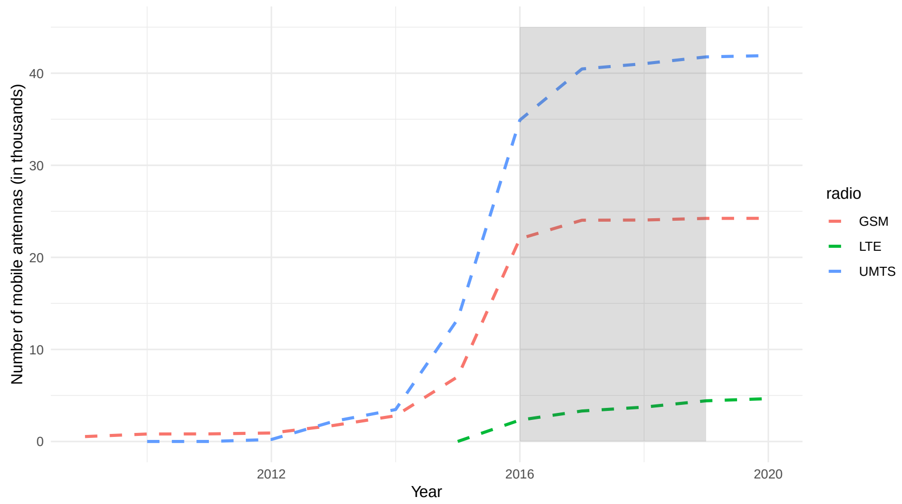


Figure 3: Evolution of the number of antennas by technology and year in Tunisia (OpenCellID). Each curve shows the cumulative growth of new antennas referenced in the OpenCellID database, categorized by technology. GSM (Global System for Mobile Communications) represents 2G technology, UMTS (Universal Mobile Telecommunications System) represents 3G technology, and LTE (Long Term Evolution) represents 4G technology.

broadband infrastructures. This measure aims to capture the main sources of variation in the quality and cost of broadband Internet access across Tunisia. The main data source required to construct the mobile broadband quality indicator was OpenCell-ID.

OpenCell-ID[17] is an open cellular dataset where the data is obtained from project contributors; it gives the location of antennas and the creation of new antennas. This database, in addition to giving the date of entry of the antenna in the database, which can be used as a proxy for the date of commissioning, allows us to know the technology of the antenna (GSM, UMTS, LTE[18]) and the owner operator. The quality of the mobile broadband infrastructure is measured by the number of 4G mobile antennas per 10,000 inhabitants by delegation i at time t, following this formula :

$$MBB_{it} = \frac{Number\ of\ 4G\ antennas_{it}}{Population_{it}/10,000} \tag{3}$$

This measure is predicated on the rationale that a greater number of antennas is indicative of enhanced network coverage, increased data transmission capacity, and higher connection speeds, which are crucial for robust broadband service. The quantity of spectrum by technology and by operator being limited, a higher density of antennas typically leads to better mobile network signal coverage, ensuring that more people in a given area have access to a stable and strong connection. This is particularly significant for maintaining service quality in areas with high network demand, as more antennas can alleviate congestion and improve the overall user experience through reduced latency and fewer dropped connections.

However, this proxy has limitations. While the number of antennas is a useful indicator of net-

[17] https://opencellid.org/

[18] GSM (Global System for Mobile Communications) to 2G technology, UMTS (Universal Mobile Telecommunications System) to 3G technology, and LTE (Long Term Evolution) to 4G technology.

work availability and potential quality, it does not directly measure user experience or the actual speed and reliability of the broadband service. Factors like maintenance quality, network architecture, and the physical environment can also affect service quality, aspects not captured by antenna density alone. Furthermore, the proxy may not fully reflect the network's readiness for future technological advancements and increasing data demands. Despite these constraints, this proxy provides a valuable, albeit indirect, metric to assess the quality of mobile broadband infrastructure, which is a key determinant in the location choices of new firms, especially in areas where direct measures of network performance are challenging to obtain.

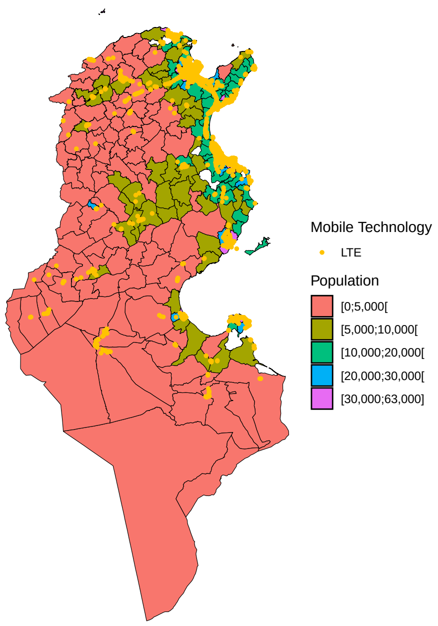


Figure 4: Population by Delegations and 4G antennas location

4 Methodology

The economic literature has two main methods of analyzing firm location: discrete choice models and count models. Our study employs count models, a preferred methodology for analyzing firm location when dealing with a high frequency of zeros in the outcome variable and a large choice set. Count models are particularly relevant in scenarios where the outcome of interest is the occurrence of an event, such as the establishment of new businesses.

In this research, we analyze the influence of mobile broadband telecommunications infrastructure on new business creation. Our unit of analysis is geographical areas (the delegations) over specific time periods (years from 2017 to 2021). The model aims to predict the number of new firms in these areas based on their characteristics, including location, time-fixed effects, and factors like agglomeration forces, accessibility, and labor market dynamics (human capital and labor costs).

This approach has been used in developed countries to understand the role of broadband Internet infrastructure in firm creations (Jofre-Monseny, Marín-López, and Viladecans-Marsal 2011, Bhat, Paleti, and Singh 2014, McCoy et al. 2018, Hasbi 2020). Our study focuses on Tunisia, counting the

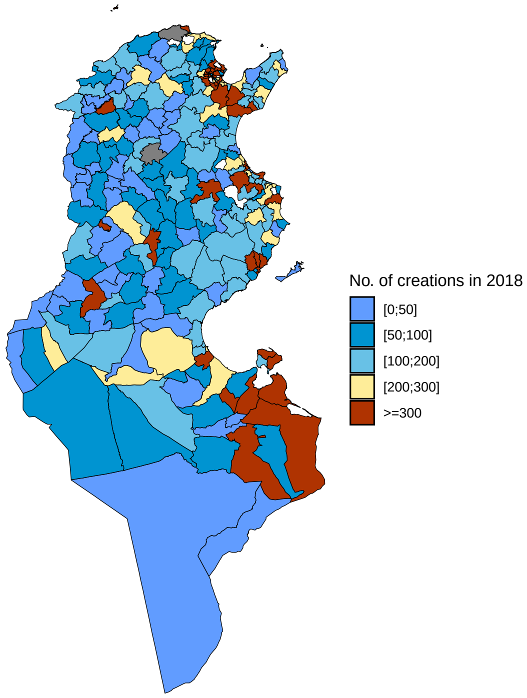


Figure 5: Number of firm creations by delegations in Tunisia in 2018

annual number of new formal businesses established in each delegation and sector. This count assumes that firms prefer locations offering the highest profit potential[19].

We confront several methodological issues. Primarily, we estimate our model using a Poisson regression, which is well-suited for discrete and non-negative data, like our count of new business creations. The Poisson model effectively captures the likelihood of new business creation in various areas. To ensure a thorough understanding of the distribution of our dependent variable (firm creation), we included histograms in Figure 9 in the Appendix that depict the distribution of firm creations across two categories (firms with less than 6 workers and those with 6 workers or more).[20] A critical challenge in our analysis is the potential endogeneity of broadband's impact on firm creation and economic growth. To mitigate this, we argue that broadband networks more significantly affect existing businesses than new startups (McCoy et al. 2018). Therefore, our model focuses on new firms, considering the existing business landscape in each area. We also address potential reverse causality by lagging our explanatory variables by two years, acknowledging that household migration and recruitment opportunities may influence firm location choices.

Additionally, we opt for a Poisson model with fixed effects over the Negative Binomial with Fixed

[19] The information available in the national business register corresponds to the delegation in which the company has registered. However, it is important to note that the company may conduct its activities partially or entirely outside of this delegation, which introduces a potential bias that should be considered.

[20] These histograms reveal the characteristics of the data, particularly the distribution of the number of firm creations. The observed distributions, skewed with a significant number of zeros and a heavy right tail, align with the typical assumptions of count data models. This justified our choice to employ Poisson model estimation, which is well-suited for modeling count data where the variance is roughly equal to the mean.

Effects (NBFE) model [Allison and Waterman 2002, Guimarães 2008, Bosquet and Boulhol 2014].[21] The Poisson model is robust to various relationships between variance and mean and doesn't require overdispersion correction[22]. This choice also helps tackle another endogeneity concern: omitted variables. For instance, mobile operators might prefer to deploy infrastructure in areas with higher demand or favorable tax regimes. Our methodology is thus designed to provide a nuanced understanding of how mobile broadband impacts business creation in Tunisia, considering various economic and demographic factors.

Our empirical analysis exploits a comprehensive database covering 262 delegations across Tunisia over a five-year period from 2017 to 2021 and involves the estimation of the following a Poisson model:

$$log(Y_{it}) = \alpha + \beta MBB_{it-2} + X_{it-2} + Z_{it-2} + \mu year_t + \eta_i + \epsilon_{it} \quad (4)$$

Y_{it} represents the count of new establishments created in delegation i at time t. MBB_{it-2} is the variable of interest, serving as a proxy for the quality of mobile broadband Internet in delegation i at time $t-2$.[23] The primary outcome measure is the number of 4G antennas per 10,000 inhabitants. X_{it-2} is a matrix of location-specific characteristics for delegation i at time $t-2$, which includes variables related to agglomeration, competition, and accessibility. Z_{it-2} comprises a matrix of labor market characteristics for municipality i at time t, incorporating proxies for human capital and labor costs. μ denotes fixed effects that capture year-specific influences. η_i represents time-invariant fixed effects that control for inherent differences across delegations. Finally, ϵ_{it} is the standard error clustered at the delegation level, capturing unobserved factors.

To conduct our sectoral analysis, we estimate the following Poisson model using the same dataset:

$$log(Y_{sit}) = \alpha + \beta MBB_{it-2} + X_{sit-2} + Z_{it-2} + \mu year_t + \eta_i + \epsilon_{sit} \quad (5)$$

In this specification, Y_{ist} represents the count of new establishments in sector s created in delegation i at time t. MBB_{it-2} is the variable of interest, serving as a proxy for the quality of mobile broadband Internet in delegation i at time $t-2$. The primary outcome measure is the number of 4G antennas per 10,000 inhabitants. X_{ist-2} is a matrix of location-sector-specific characteristics for delegation i at time $t-2$, which includes variables related to agglomeration, competition, and accessibility and particularly the number of existing firms in sector s and sector share of employment of sector s in delegation i in $t-2$. Z_{it-2} comprises a matrix of labor market characteristics for municipality i at time t, incorporating proxies for human capital and labor costs. μ denotes fixed effects that capture year-specific influences. η_i represents time-invariant fixed effects that control for inherent differences across delegations. Finally, ϵ_{it} is the standard error clustered at the delegation level, capturing unobserved factors.

For a more detailed analysis of the effects of mobile broadband on economic activity, we estimated a second panel data model with fixed effects for both location and year.

$$Y'_{it} = \alpha + \beta MBB_{it-2} + X_{it-2} + Z_{it-2} + \mu\, year_t + \eta_i + \epsilon_{it} \quad (6)$$

In this model, Y'_{it} represents the change in the stock of active businesses in delegation i during

[21] The Negative Binomial with Fixed Effects model is used as a robustness test.

[22] `https://www.statalist.org/forums/forum/general-stata-discussion/general/1539401-testin-overdispersion-in-negative-binomial` accessed in March 2024.

[23] Other lags of this variable are utilized as a robustness test.

year t. This approach allows us to capture the dynamic impact of mobile broadband quality on the net creation or destruction of firms over time, taking into account both fixed-location characteristics and year-specific effects.

5 Results

5.1 Main findings

Our study's findings reveal several key insights into the factors influencing new business establishment, with a particular focus on the influence of mobile high-speed broadband connectivity. As illustrated in Table 3, the study explains the link between the availability and quality of mobile high-speed broadband and the creation of new firms in Tunisia depending on the size of the firms. Column (1) summarizes the analysis conducted across the entire sample.[24]

The results from the first column of Table 3 elucidate a significant positive relationship between the proliferation of 4G antennas — as a proxy for mobile high-speed broadband quality — and the rate of new business creation. Specifically, a unit increase in the density of 4G antennas per 10,000 inhabitants increases by 0.9% the rate of new business establishment, as represented by the incidence rate ratio ($e^{0.009}$).[25] To ensure the robustness of these findings, we employed several estimation methods. As documented in Table 9 in the Appendix, we utilized two additional methods: a panel data model with fixed effects in column (2) and a negative binomial model with fixed effects in column (3). Across these methods, the results consistently demonstrate significant and similar impacts. We also controlled for the density of 2G antennas per 10,000 inhabitants. As shown in Table 10 in the Appendix, the results remain robust, and the impact of 4G antenna density continues to be significant and positive.[26] By estimating the model (6), it also appears that there is a positive effect of 4G antenna density on net business creation. Specifically, increasing the density of 4G antennas by one unit per 10,000 inhabitants in a delegation results in an average increase of 7.13 in the number of active businesses in that delegation. These findings suggest that improving mobile telecommunications infrastructure can play a significant role in local entrepreneurial dynamism, promoting not only the creation of new businesses but also the sustainability of existing ones. These finding underscores the critical importance of high-quality mobile broadband networks in influencing the creation of new businesses.

We also observe that the positive effect of 4G antenna density is recognized by both small firms with fewer than six employees—many of which are individual enterprises— (column 2) and larger firms with more than six employees (column 3). Specifically, a one-unit increase in 4G antenna density per 10,000 inhabitants within a delegation results in a 4.6% increase in the rate of new firm creation for firms with more than six employees ($e^{0.0173}$). However, as shown in table 10in Appendix, when

[24] In these principal analyses, the effect of mobile broadband telecom infrastructure quality, along with all other explanatory variables, is assessed using a two-period lag.

[25] The incidence rate ratio converts regression coefficients into more interpretable percentages.

[26] Incorporating the density of 2G antennas as a control variable serves to isolate the specific impact of 4G infrastructure on firm creation. This approach allows us to account for the potential influence of existing older-generation mobile networks, ensuring that the observed effects can be more confidently attributed to the quality of 4G broadband infrastructure rather than to broader telecommunications coverage. By controlling for 2G density, we mitigate the risk of omitted variable bias, thereby reinforcing the validity and robustness of our findings concerning the economic impact of 4G technology.

Table 3: Summary of Estimation Results from Different Models

Variables	**(1)**	**(2)**	**(3)**
4G Density	0.009***	0.009***	0.017***
	(0.002)	(0.002)	(0.006)
Mean Educ	0.087**	0.088**	-0.050
	(0.040)	(0.040)	(0.217)
Mean Wage (100 dinars)	-0.086***	-0.087***	-0.002
	(0.023)	(0.023)	(0.120)
Mean Unemployment	0.022***	0.022***	0.061**
	(0.004)	(0.004)	(0.027)
Population (1000 hab)	-0.0004	-0.004	-0.018
	(0.005)	(0.005)	(0.028)
N. Firms (1000 firms)	-0.071***	-0.070***	-0.213*
	(0.021)	(0.021)	(0.112)
Spatial HHI	0.00001	0.0014	0.0162
	(0.00002)	(0.0015)	(0.0124)
Year FE	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes
N. Obs	1310	1310	770
Delegations	262	262	154

Note: The first column represents results from the Poisson Fixed Effects model for all delegations. The second column provides estimates for firms with less than 6 workers using the same model. The third column includes results for firms with more than 6 workers. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

the density of 2G antennas is included as a variable, the effect of 4G antenna density on the creation of firms with more than six employees becomes non-significant. This suggests that for larger firms, the quality of mobile telecommunications infrastructure alone may not be sufficient; the quality of fixed infrastructure also plays a crucial role.

To conduct a threshold analysis and reinforce our initial findings, we replaced the continuous measure of 4G antenna density per 10,000 inhabitants with several binary variables representing different 'treatment levels' within our model. Figure 6 illustrates how the coefficient of interest evolves

Table 4: Net Firm Creations

Variables	(1)	(2)	(3)
4G Density	7.131***	-0.347	7.219***
	(2.343)	(0.338)	(2.430)
Mean Educ	155.691***	-1.536	156.495***
	(21.560)	(1.643)	(22.000)
Mean Wage (100 dinars)	-17.942**	-0.870	-17.246*
	(9.024)	(0.646)	(8.860)
Mean Unemployment	2.442	0.221**	2.328
	(1.540)	(0.095)	(1.537)
Population (1000 hab)	26.014***	0.141	25.330***
	(3.625)	(0.381)	(3.754)
N. Firms (1000 firms)	-241.081***	-340.314***	-230.670***
	(30.837)	(75.366)	(31.576)
Spatial HHI	0.525	-0.086**	0.643
	(0.541)	(0.035)	(0.530)
N. Obs	1310	1268	1310
Delegations	262	259	262

Note: The table presents the first column from each of the three original tables, summarizing the results for the mean, firms with more than 6 workers, and firms with less than 6 workers. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

across varying density levels. This analysis reveals that firms require a minimum threshold of mobile broadband infrastructure quality to assign it a positive value. Specifically, on average, a baseline density of more than two 4G antennas per 10,000 inhabitants significantly impacts firm creation, with this impact intensifying as antenna density increases[27]. For instance, when the density exceeds 2.25 4G antennas per 10,000 inhabitants, the number of new businesses rises by 5.45% ($e^{0.0531}$) on average. Furthermore, surpassing a density of 3.25 4G antennas per 10,000 inhabitants leads to an 8.39% increase in the number of new firms ($e^{0.0805924}$). Our analysis supports the findings of Kim and Orazem, 2017, McCoy et al., 2018, and Hasbi, 2020, reinforcing the notion that, on average, regions outfitted with broadband infrastructure tend to be more attractive. These findings also underscore the pivotal role of high-quality mobile broadband networks in stimulating economic development, as they significantly contribute to the growth and expansion of business activities across various regions.

We can go further by analyzing the coefficients associated with other variables. If we look at

[27] This indicates that a certain threshold must be reached for companies to recognize and value the benefits of 4G mobile infrastructures at the time of their establishment, with their valuation progressively increasing as infrastructure density grows.

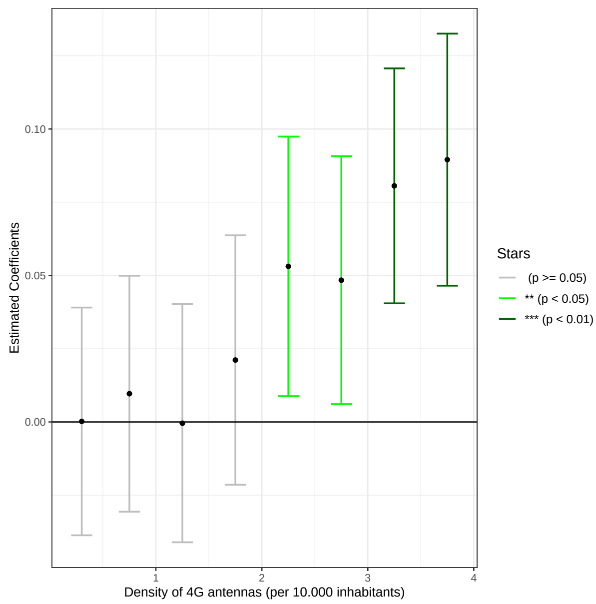


Figure 6: Estimations by 4G antennas density

the variables we have identified as agglomeration variables, we notice that firms negatively value the prospect of strong competition when establishing their operations. Indeed, it appears that delegations with a large number of pre-existing firms are less attractive to new firms. As measured by population, market size does not seem to affect firm creation when the whole sample is considered, suggesting that this factor may be captured within the fixed effects. Moreover, the average number of years of education plays an important role in firm creation. Increasing the average number of years of education in a delegation by one unit increases the rate of new firm creation by 9%. It appears that human capital is key for entrepreneurship, and then the choice of location of new firms. Finally, labor costs emerge as a significant determinant as well. The relative cost of labor, assessed via the average income within a delegation, appears to have a negative impact on business creation (Delbecque, Méjean, and Patureau 2014). Conversely, higher unemployment rates are observed to affect business creation positively. This finding aligns with the research presented by McCoy et al., 2018, yet stands in contrast to Hasbi, 2020's conclusions. The positive correlation with unemployment may reflect a potential downward pressure on wages, making starting a business a more attractive option in areas with higher unemployment rates. One possible explanation for the significant role of the unemployment rate in influencing firm creation is that, for some unemployed individuals, starting a business may be a viable solution to escape unemployment. When examining column 3 of table 3, which presents estimates for firms with more than six employees, it becomes evident that although the significance of the unemployment coefficient is somewhat reduced when considering only the creation of larger firms, the coefficient remains significant. This suggests that larger firms may indeed be motivated by the pursuit of lower labor costs.

5.2 Exploring the Digital Divide

Our research primarily concentrates on one level of the digital divide, which addresses the economic and social inequalities in access to ICT equipment and infrastructure[28]. To address the variability in rural and urban contexts, columns (2) and (3) of Table **??** partition the data into two distinct sub-samples, categorized by the degree of 'rurality' of the regions examined. The second column analyzes regions characterized by a predominantly rural population — specifically, areas where less than 65% of the inhabitants are urban. Conversely, the third column explores regions with a predominantly urban demographic, where over 65% of the population is urban. When estimating model 6 for the rural and urban sub-samples, Table 7 shows that there is no significant effect of 4G antenna density on net business creation in rural areas, while the effect is significant in urban areas. Rural areas may not yet have reached the threshold where mobile broadband can significantly drive net business creation, either due to lower demand for digital services or due to other infrastructural and economic limitations.

The comparison between these columns reveals the difference in valuation between rural and urban areas. Columns 2, 4, 6 focuses on a subset of rural delegations. Here, an expansion in the density of 4G antennas per 10,000 inhabitants by one unit increases the rate of business creation by 4.9%. We further find that regardless of firm size, as indicated in table 5, the impact of 4G antenna density remains consistently stronger in rural areas compared to urban areas. This observation gains further support from the threshold analysis illustrated in Figure 7, indicating a critical density level of 4G antennas of 1.5 per 10,000 inhabitants at the density of 4G antennas starts to positively impact firm creation. These results may be interpreted through the lens of the "death-of-distance" or "death-of-cities" hypothesis (Toffler and Alvin 1980; Cairncross 1997 ; Naisbitt 1996;Gaspar and Glaeser 1998), which posits that broadband Internet enables rural firms to function as substitutes for urban centers by significantly reducing communication and transaction costs. Indeed, these findings highlight the pivotal role of mobile telecom infrastructure in rural development, mirroring the observations of Kim and Orazem, 2017, who found a positive correlation between broadband accessibility and the tendency for new firms to establish in rural areas of the U.S. The substantial impact of mobile broadband infrastructure in rural settings can be attributed to its amplified benefits in these regions. For instance, Bahia et al., 2020 demonstrated the profound influence of broadband on rural labor markets in Nigeria. Similarly, Kolko, 2012 found a stronger effect of broadband Internet on local growth in sparsely populated areas. Moreover, these findings align with Atasoy, 2013, who observed a more pronounced impact of broadband services on employment in rural and remote areas. Likewise, research by Canzian, Poy, and Schüller, 2019 revealed that broadband positively affects revenue and productivity in rural areas.

The influence of mobile broadband infrastructure on business establishment may be particularly pronounced in rural areas near urban centers. To explore this, we defined the centroids for Tunisia's six largest urban areas: Tunis, Sfax, Sousse, Kairouan, Gabès, and Bizerte.[29] Surrounding each centroid, we established three concentric buffer zones to delineate varying degrees of urban influence: the

[28] According to Ben Youssef, 2004, there are four degrees of digital divide: the first is linked to ICT equipment; the second is linked to usage, which refers to digital literacy; the third concerns the effectiveness of usage; and finally, the fourth concerns learning methods in a knowledge-based economy.

[29] The major urban agglomerations are as follows: Tunis has a population of 728,453, which expands to 2,083,000 when including the Greater Tunis area; Sfax is home to 265,131 residents, growing to 500,000 with the inclusion of Greater Sfax; Sousse has 173,047 inhabitants, increasing to 400,000 in Greater Sousse; Kairouan includes 117,903 residents; Gabès consists of 116,323 inhabitants, which rises to 170,000 for Greater Gabès; and Bizerte has 114,371 residents, expanding to 150,000 when including Greater Bizerte.

Table 5: Digital Divide: Comparison Between Rural and Urban Areas

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
4G Density	0.049***	0.005***	0.049***	0.005***	0.162**	0.018***
	(0.009)	(0.001)	(0.009)	(0.001)	(0.071)	(0.005)
Mean Educ	0.057	0.090**	0.053	0.091**	1.966***	-0.188
	(0.096)	(0.044)	(0.096)	(0.044)	(0.641)	(0.223)
Mean Wage (100 dinars)	-0.192***	-0.041*	-0.191***	-0.041*	-0.769***	0.104
	(0.027)	(0.024)	(0.027)	(0.025)	(0.207)	(0.121)
Mean Unemployment	0.021***	0.028***	0.021***	0.028***	0.128**	0.052*
	(0.006)	(0.005)	(0.006)	(0.005)	(0.050)	(0.030)
Population (1000 hab)	0.031*	-0.011**	0.031*	-0.011**	0.084	-0.036
	(0.017)	(0.004)	(0.017)	(0.004)	(0.054)	(0.030)
N. Firms (1000 firms)	-0.187***	-0.036*	-0.187***	-0.034*	-0.117	-0.306***
	(0.038)	(0.019)	(0.038)	(0.019)	(0.229)	(0.097)
Spatial HHI	-0.000006	0.000045	-0.0007	0.0045	0.024	0.013
	(0.000002)	(0.000028)	(0.0016)	(0.0027)	(0.018)	(0.019)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes	Yes	Yes	Yes
N. Obs	600	710	600	710	235	535
Delegations	120	142	120	142	47	107

Note: The table presents the estimation results focusing on rural (columns 1, 3, 5) and urban (columns 2, 4, 6) areas. Rural areas only include delegations in governorates where less than 65% of inhabitants are considered urban, and urban areas include delegations in governorates where more than 65% of inhabitants are considered urban. The results are shown for the entire sample (columns 1 and 2), for firms with fewer than 6 workers (columns 3 and 4), and for firms with more than 6 workers (columns 5 and 6). Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

"center" zone, a 20 km radius circle encapsulating the urban agglomeration; the "periphery" zone, which includes all delegations situated between 20 and 50 km from the centroid; and a third zone that encompasses all delegations beyond 50 km from the centroid.

As depicted in Table 6, when we applied the same model estimations as in model (4) to these three sub-samples, we found that the impact of mobile broadband infrastructure density is significant only within the "center" and "periphery" zones, with no observable effects in regions beyond 50 km. Importantly, the influence is particularly substantial in the "periphery" areas: a one-unit increase in the density of 4G antennas per 10,000 inhabitants correlates with a 3% increase in the rate of business creation. This aligns with the observations by Fox and Porca, 2001, who noted that infrastructure investments tend to yield the most substantial impacts in economically integrated and intermediate

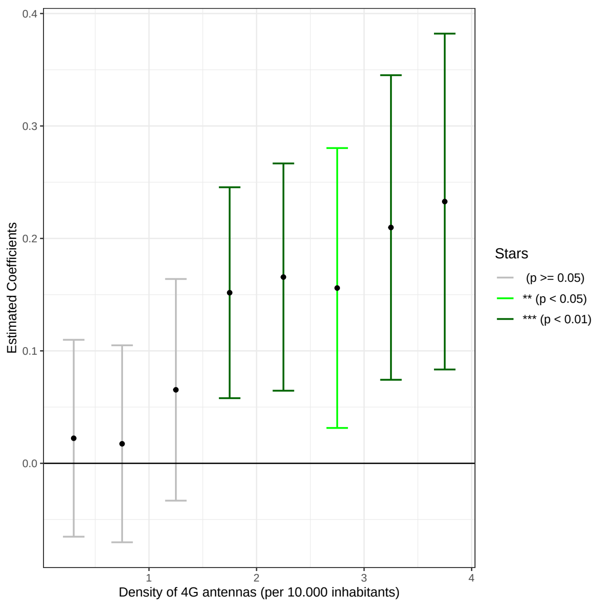


Figure 7: Estimations by 4G antennas density in Rural Areas

rural areas. This can also be attributed to the high concentration of knowledge in large cities, where the synergy between online and offline interactions is more pronounced (Wu and Li 2024), facilitated by proximity to markets and suppliers. Furthermore, when we varied the lags associated with the proxy variable for mobile broadband infrastructure quality, the average effect remained significant and positive on business creations. However, the analysis reveals a nuanced effect between rural and urban areas. Specifically, when the lag is limited to one year, the positive impact in rural areas is no longer significant, as shown in column (2) in Table 11. This suggests potential challenges such as market incompleteness and the relative difficulty of establishing businesses in rural settings. To investigate this, we introduced an interaction term between the density of 4G antennas per 10,000 inhabitants and the distance to the nearest post office. As illustrated in Table 13, the interaction term is negative for a one-year lag, indicating that the value attributed to high-speed mobile broadband diminishes as one moves farther from urban centers, where essential services like banks and administrative offices are more readily accessible. Similarly, Kim and Orazem, 2017 documented that local broadband availability significantly promotes new firm establishment, especially in rural counties proximate to urban agglomerations. These findings emphasize the vital role of geographic proximity to urban centers in maximizing the efficacy of mobile broadband infrastructure to foster business activity. Consequently, our results suggest that the "death-of-distance" hypothesis, which posits that geographic distance becomes irrelevant in the face of digital connectivity, does not hold universally. The significant locational distinctions in the effectiveness of broadband infrastructure underscore the continued relevance of geographical proximity to urban economic centers.

5.3 Sectorial Analysis

To deepen our understanding of mobile broadband's impact on local economies, we analyzed new business creation across different sectors, categorized according to the Nomenclature d'Activités Tunisi-

Table 6: Digital Divide (Groups of distances)

variables	**(1)**	**(2)**	**(3)**
4G density	0.006***	0.030***	0.014
	(0.001)	(0.006)	(0.014)
Mean Educ	0.073	0.200**	0.034
	(0.054)	(0.096)	(0.104)
Mean Wage (100 dinars)	-0.057*	-0.267***	-0.143***
	(0.033)	(0.063)	(0.044)
Mean Unemployment	0.022***	0.031***	0.029***
	(0.646)	(0.814)	(0.824)
Population (1000 hab)	-0.006	0.0346*	-0.0002
	(0.005)	(0.020)	(0.026)
N. Firms (1000 firms)	-0.056***	-0.303***	-0.072
	(0.021)	(0.096)	(0.131)
Spatial HHI	0.000087*	.000019	0.000006
	(0.000044)	(0.000031)	(0.000018)
Year FE	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes
N. Obs	345	310	635
Delegations	69	62	127

Note: Column (1) includes only delegations located within 20 km of the centers of Tunisia's six biggest cities (Tunis, Sfax, Sousse, Kairouan, Gabès, and Bizerte). Column (2) includes delegations between 20 km and 50 km from these economic centers, while Column (3) encompasses delegations farther away. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

ennes (NAT).[30] We constituted eight distinct sectors: agriculture and mining, manufacturing, construction, commerce, transport, hospitality, ICTs, and services.[31]

[30] This classification aligns with the International Standard Industrial Classification of All Economic Activities (ISIC Rev3) by the United Nations and the Statistical Classification of Economic Activities in the European Community (NACE Rev 1).

[31] Utilizing the first two digits of the NAT sectoral codes, which are typically assigned at the creation of most companies, allowed us to form these sectoral groups. See: https://ins.tn/nomenclatures/nomenclature-dactivites-tunisiennes-nat for more information.

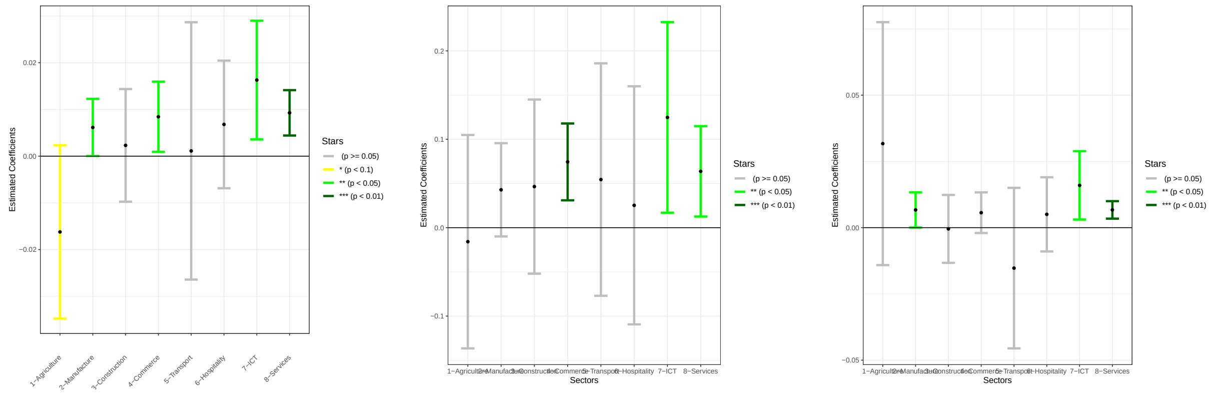
Table 7: Digital Divide: Net Firm Creations (All, Urban, Rural)

Variables	**All (1)**	**Urban (2)**	**Rural (3)**
4G Density	7.131***	8.209	7.447***
	(2.343)	(5.810)	(2.674)
Mean Educ	155.691***	93.023***	180.618***
	(21.560)	(17.727)	(29.873)
Mean Wage (100 dinars)	-17.942**	-21.704***	-4.229
	(9.024)	(6.848)	(14.688)
Mean Unemployment	2.442	-0.027	6.919**
	(1.540)	(1.451)	(2.919)
Population (1000 hab)	26.014***	33.814***	24.055***
	(3.625)	(9.482)	(4.105)
N. Firms (1000 firms)	-241.081***	-232.966***	-246.253***
	(30.837)	(50.727)	(39.574)
Spatial HHI	0.525	0.411	0.643
	(0.541)	(0.650)	(1.229)
N. Obs	1310	600	710
Delegations	262	120	142

Note: The table presents the estimation results for net firm creations across all delegations (Column 1), urban delegations (Column 2), and rural delegations (Column 3). Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The sectoral breakdown presented in Figure 8 highlights the varying impacts of mobile broadband network quality on business creation across different sectors. These results are derived from estimating model (5) using a Poisson estimate, which incorporates sector-specific variables, particularly the number of firms already operating in sector s within delegation i at time $t-2$, as well as the employment share of sector s in delegation i during the same period.

The tertiary sector, which includes transport, commerce, ICT, and services, is expected to derive the most significant benefits from robust mobile broadband infrastructure. Figure 8 illustrates a positive and significant impact for the creation of establishments in the manufacture, commerce, ICT and services sectors. The commerce, ICT and services sectors intrinsically depend more on ICT for their operations. Specifically, in the commerce and services sectors, a one-unit increase in the density of 4G antennas per 10,000 inhabitants boosts the establishment of new businesses by 0.85% in commerce and by 0.9% in services. The ICT sector experiences an even more pronounced effect; here, the same increase in 4G antenna density leads to a 1.7% rise in the rate of new ICT business establishments. This is also the finding of Kolko, 2012, who identifies that the relationship between broadband and local growth is stronger in industries that are more dependent on information technology. This ef-



(a) Mean (b) Rural Areas (c) Urban Areas

Figure 8: Estimation by sector

fect is in line with what had already been observed by Freund and Weinhold, 2002 and Kneller and Timmis, 2016. The positive and significant effect of mobile broadband antenna density on the creation of manufacturing firms can be attributed to the increasing reliance of the manufacturing sector on digital technologies for improving operational efficiency, supply chain management, and accessing broader markets, but we can see that this effect is only significant in urban areas.

Furthermore, the observed negative effect of mobile broadband density on business creation in the agricultural sector when considering the whole sample can be attributed to several sector-specific economic factors. First, the agricultural sector is typically less reliant on digital technologies, then the benefits of mobile broadband may not translate directly into increased agricultural business creation. Instead, mobile broadband may facilitate the consolidation of existing agricultural operations or encourage efficiency improvements that reduce the need for new enterprises. Additionally, mobile broadband can open up more lucrative opportunities in non-agricultural sectors, leading to a reallocation of entrepreneurial efforts and resources away from agriculture.

These findings underscore the significant role that robust digital infrastructure plays in sectors heavily reliant on information and communication technologies, such as commerce, ICT, and services. Conversely, the limited or negative effects observed in agriculture suggest that mobile broadband alone may not be sufficient to drive new business creation in sectors less dependent on digital technologies.

6 Conclusion

In this study, we employed a count model methodology and a panel fixed effects estimation to evaluate the impact of mobile broadband Internet on firm creation at the delegation level in Tunisia, analyzing data from 2017 to 2021. We categorized these delegations by their rurality or proximity to major urban centers and estimated these models for each category. We assessed the impact of mobile broadband on firm creation and net creation depending on the size of firms and across eight different sectors of the Tunisian economy.

Our findings indicate that the density of 4G mobile antennas significantly influences firm creation overall, with a notably stronger impact in rural areas, albeit with delayed effects. Specifically, a unit increase in the density of 4G antennas per 10,000 inhabitants results in a 0.9% increase in the rate of new business establishment on average (this effect is stronger for firm creations with more than 6 workers), while in rural areas, this effect rises to 4.9%. However, when examining the impact on net business creation, this effect remains significant only for urban delegations. Also, a more pronounced effect near major urban centers challenges the 'death of distance hypothesis.' Additionally, the impact of 4G mobile infrastructure density on firm creation varies across sectors, showing positive and significant effects, particularly in the manufacturing, services, commerce, and ICT sectors. The findings also suggest that certain minimum density thresholds are necessary for mobile broadband telecom infrastructures to impact business creation rates significantly.

While our research provides valuable insights, it also encounters certain limitations. While useful, our proxy for broadband quality, the number of 4G antennas per 10,000 inhabitants, may not fully capture the nuances of network quality and user experience. Future research could employ alternative proxies, such as data from network performance testing platforms like Ookla. One key area for improvement is the exploration of other potential sources of heterogeneity in the broadband-economic growth relationship. This could include examining variations in broadband's impact based on different demographic or socio-economic factors.

Our study underscores several implications for public policy. We have demonstrated that while robust mobile broadband infrastructure is crucial for some sectors, it alone is insufficient for fostering firm creation without the additional support of proximity to urban centers and access to essential services. Furthermore, our findings suggest a necessary minimum level of investment in mobile infrastructure to influence local economic growth significantly. While our analysis focuses on mobile infrastructures predominantly utilized in Tunisia, we anticipate that the impact of high-quality fixed broadband infrastructures, such as fiber optics, could be even more substantial (Sadok, Chatta, and Bednar 2016). Addressing the digital divide, as highlighted in our research, requires more than merely closing the infrastructure gap. It also necessitates tackling other related issues, such as enhancing digital literacy. By addressing these multifaceted challenges, policymakers can harness the potential of mobile broadband to promote sustainable and inclusive economic growth across Tunisia.

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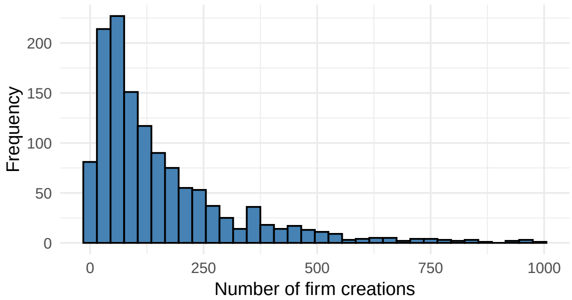
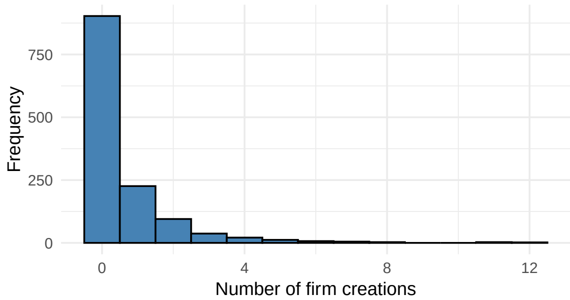
7 Appendix

Table 8: Number of firm creation by Year and Sector (2010-2021)

Year	Agriculture	Manufacturing	Construction	Commerce	Transport	Hospitality	ICT	Services	Total
2010	376	5,131	2,688	20,981	5,136	2,191	1,282	10,927	48,712
2011	344	4,702	2,769	17,676	7,859	2,191	1,177	8,153	44,871
2012	312	4,250	2,850	19,931	7,523	2,332	1,080	9,094	47,372
2013	366	5,235	3,244	20,048	4,906	2,326	1,097	10,198	47,420
2014	366	4,972	3,183	20,106	4,782	2,608	932	10,426	47,375
2015	353	4,622	3,325	23,021	4,877	2,970	894	10,813	50,875
2016	444	5,449	3,616	24,217	4,661	3,207	991	12,165	54,750
2017	608	5,046	3,164	22,497	4,223	3,354	973	11,863	51,728
2018	889	5,162	3,109	21,370	4,504	3,344	1,240	12,556	52,174
2019	657	5,110	2,372	19,631	4,011	3,189	1,269	12,971	49,210
2020	417	3,554	1,446	12,807	2,641	1,994	1,306	8,469	32,634
2021	715	4,079	1,902	19,933	4,521	2,807	1,464	9,889	45,310



(a) Firm Creation with Less Than 6 Workers



(b) Firm Creation with 6 Workers or more

Figure 9: Distribution of the outcomes

Table 9: Various estimation methods (Poisson FE, Panel FE, Negative binomial FE)

variables	**(1)**	**(2)**	**(3)**
4G density	0.009***	2.824***	0.005*
	(0.002)	(0.924)	(0.003)
Mean Educ	0.087**	21.415***	0.163***
	(0.040)	(6.496)	(0.031)
Mean Wage (100 dinars)	-0.086***	-9.957***	-0.173***
	(0.023)	(2.664)	(0.014)
Mean Unemployment	0.022***	0.027***	0.016***
	(0.371)	(52.526)	(0.288)
Population (1000 hab)	-0.004	-2.571*	0.002
	(0.005)	(1.376)	(0.002)
N. Firms (1000 firms)	-0.07***	-84.073***	0.03**
	(0.021)	(11.245)	(0.014)
Spatial HHI	0.014	-0.463	0.015
	(0.015)	(1.757)	(0.012)
Year FE	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes
N. Obs	1310	1310	1310
Delegations	262	262	262

Note: The sample consists of 262 delegations over a 5-year period. Column (1) presents the estimation results of the Poisson model for the entire sample. Column (2) uses the same sample but applies a panel data estimation with fixed effects. Finally, column (3) shows the estimation results using a Negative Binomial model. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10: 2G Density Variable

Variables	**(1)**	**(2)**	**(3)**
4G Density	0.010***	0.010***	0.004
	(0.002)	(0.002)	(0.007)
2G Density	-0.001	-0.001	0.012*
	(0.001)	(0.001)	(0.006)
Mean Educ	0.094**	0.095**	-0.130
	(0.039)	(0.039)	(0.240)
Mean Wage (100 dinars)	-0.082***	-0.082***	-0.063
	(0.024)	(0.024)	(0.149)
Mean Unemployment	0.022***	0.022***	0.055**
	(0.004)	(0.004)	(0.026)
Population (1000 hab)	-0.005	-0.005	-0.014
	(0.005)	(0.005)	(0.029)
N. Firms (1000 firms)	-0.067***	-0.066***	-0.255**
	(0.021)	(0.021)	(0.127)
Spatial HHI	0.001	0.001	0.018
	(0.001)	(0.001)	(0.013)
N. Obs	1310	1310	770
Delegations	262	262	154

The sample includes 262 delegations observed over a 5-year period. Column (1) presents results for all delegations using the total count of firm creations as the outcome. Column (2) focuses specifically on firm creations with fewer than 6 workers, while Column (3) examines firm creations with 6 or more workers as the outcome. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 11: One year-lag (All, Rural, Urban)

variables	**(1)**	**(2)**	**(3)**
4G density	0.007***	-0.004	0.004*
	(0.003)	(0.017)	(0.002)
Mean Educ	0.076*	0.024	0.084*
	(0.041)	(0.094)	(0.044)
Mean Wage (100 dinars)	-0.074***	-0.143***	-0.031
	(0.023)	(0.031)	(0.023)
Mean Unemployment	0.021***	0.019***	0.028***
	(0.004)	(0.006)	(0.005)
Population (1000 hab)	-0.009*	0.013	-0.014***
	(0.05)	(0.024)	(0.004)
N. Firms (1000 firms)	-0.043**	-0.112**	-0.015
	(0.021)	(0.048)	(0.015)
Spatial HHI	0.015	-0.002	0.046
	(0.016)	(0.015)	(0.028)
Year FE	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes
N. Obs	1310	600	710
Delegations	262	120	142

Note: The sample consists of 262 delegations over a 5-year period. The 4G density variable is one year lagged. Column (1) includes all delegations, while column (2) includes only delegations in governorates where less than 65% of inhabitants are considered urban, classified as rural delegations. Column (3) includes only delegations in governorates where more than 65% of inhabitants are considered urban, classified as urban delegations. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 12: Three years lagged Digital Divide (All, Rural, Urban)

variables	**(1)**	**(2)**	**(3)**
4G density	0.006***	0.025**	0.003**
	(0.002)	(0.010)	(0.001)
Mean Educ	0.098**	0.037	0.096**
	(0.040)	(0.096)	(0.045)
Mean Wage (100 dinars)	-0.079***	-0.16***	-0.034
	(0.021)	(0.029)	(0.023)
Mean Unemployment	0.022***	0.021***	0.029***
	(0.004)	(0.005)	(0.005)
Population (1000 hab)	-0.006	0.024	-0.012***
	(0.005)	(0.019)	(0.005)
N. Firms (1000 firms)	-0.057***	-0.16***	-0.023
	(0.02)	(0.045)	(0.018)
Spatial HHI	0.000014	-0.005	0.045
	(0.015)	(0.016)	(0.028)
Year FE	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes
N. Obs	1310	600	710
Delegations	262	120	142

Note: The sample consists of 262 delegations over a 5-year period. The 4G density variable is three years lagged. Column (1) includes all delegations, while column (2) includes only delegations in governorates where less than 65% of inhabitants are considered urban, classified as rural delegations. Column (3) includes only delegations in governorates where more than 65% of inhabitants are considered urban, classified as urban delegations. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 13: Digital Divide (All, Urban, Rural) - Interaction 4G Density and distance to post

variables	**(1)**	**(2)**	**(3)**
4G density × Distance Post	-0.0019***	-0.0029**	-0.0009
	(0.0005)	(0.0014)	(0.0009)
Mean Educ	0.084**	0.032	0.087*
	(0.040)	(0.093)	(0.045)
Mean Wage (100 dinars)	-0.072***	-0.145***	-0.032
	(0.023)	(0.030)	(0.023)
Mean Unemployment	0.021***	0.018***	0.028***
	(0.371)	(0.553)	(0.490)
Population (1000 hab)	-0.007	0.019	-0.013***
	(0.005)	(0.021)	(0.004)
N. Firms (1000 firms)	-0.048**	-0.138***	-0.017
	(0.021)	(0.041)	(0.016)
Spatial HHI	0.0167	-0.0911	0.0461
	(0.0156)	(0.0016)	(0.0282)
Year FE	Yes	Yes	Yes
Delegation FE	Yes	Yes	Yes
N. Obs	1310	600	710
Delegations	262	120	142

Note: The sample consists of 262 delegations over a 5-year period. The interaction term represents the one-year lagged 4G density variable interacted with the distance to the nearest post office (in kms). Column (1) includes all delegations, while column (2) includes only delegations in governorates where less than 65% of inhabitants are considered urban, classified as rural delegations. Column (3) includes only delegations in governorates where more than 65% of inhabitants are considered urban, classified as urban delegations. Standard errors clustered at the delegation level are presented in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.