Impact of Very High-Speed Broadband on Company Creation and Entrepreneurship: Empirical Evidence*

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Abstract

The objective of this paper is to analyze to which extend the local presence of very high-speed broadband networks has a causal impact on the creation of new businesses and sole proprietorships. Estimations are performed using micro-level panel data covering almost 5,000 municipalities in metropolitan France, from 2010 to 2015. A count modeling approach with time- and municipal-fixed effects is first developed. It shows that municipalities with a very high-speed broadband network tend to be more attractive for companies, with a positive effect on establishment creation within the tertiary sector: in the commerce, service and transport sub-sector. In addition, these municipalities seem to provide a more favorable environment for entrepreneurship. These results are robust to the use of matching estimators.

Key Words: *Fiber; Very High-Speed Broadband; Local Economic Growth; Company Creation*

JEL Classification: L13, L50, L96

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1 Introduction

Very high-speed broadband networks are seen as a key enabler for socio-economic development. Their roll-out has been made a priority worldwide and is considered as an investment for the future. Over the last few years, many countries, such as France[1], the US,[2] Australia,[3] Japan[4] and Mexico[5] have adopted national broadband plans to ensure the whole coverage of their territory. In the European Union, the Commission has defined in 2013 a Digital Agenda for Europe.[6] In 2016, the Commission reiterated its vision to turn Europe into a Gigabit Society by 2025.[7]

Very high-speed broadband is considered as essential for a firm to remain competitive both at the national and international level. Very high-speed broadband includes both fast and ultra-fast broadband with speed above 30 Mbps.[8] In France, as in most part of the European Union, firms have already adopted broadband technology to conduct their activities.

The contribution of this paper is to analyze whether the presence of very high-speed broadband networks has a causal impact on the creation of new businesses of all non-farm market sectors operating locally. The impact of these networks is also highlighted on entrepreneurship, with a specific focus on the creation of sole proprietorships. It is rather unlikely that an operating firm decides to relocate to an area offering better broadband speeds. The expected benefits stemming from faster broadband use are unlikely to surpass the relocation cost. However, the

[1] "Plan France Tres Haut Debit" February 2013.

[2] "Connecting America: The National Broadband Plan, Federal Communications Commission," March 2010.

[3] "The National Broadband Network" April 2009, modified in 2013.

[4] "E-Japan Strategy" 2001.

[5] "Mexican Digital Agenda" 2011.

[6] "A Digital Agenda for Europe," European Commission, COM(2010) 245, with the objective to provide by 2020 every household with access to at least a 30 Mbps connection and half of the households with a subscription at 100 Mbps.

[7] "State of the Union 2016: Towards a Better Europe - A Europe that Protects, Empowers and Defends".

[8] The Digital Agenda for Europe distinguishes different ranges of broadband speeds: basic broadband (between 256 Kbps and 30 Mbps), fast broadband (above 30 Mbps and up to 100 Mbps) and ultra fast broadband (above 100 Mbps).

presence of a next generation access network may have an impact on the location decision of new firms. Areas in which such very high-speed broadband networks are being deployed may become more attractive to new businesses.

A technology neutral approach is adopted. All technologies delivering very high-speed services are included: fiber optical network (fiber to the Home; FttH) and upgraded cable (fiber to the Last Amplifier; FttLA).[9] This paper contributes to a rather limited number of studies analyzing the role of broadband on entrepreneurship. It adds to the existing literature on broadband and economic growth which mostly investigates the effect of transitioning from dial-up Internet to basic broadband. The results provide policy-makers with better insights on the impact of very high-speed broadband on the local economy.

This study relies on panel data covering 4,933 municipalities located in metropolitan France, representing approximately 75% of the population, over 6 years, from 2010 to 2015. Panel data allow to control for municipal- and time-specific heterogeneity. The three French largest cities, Paris, Lyon and Marseille are excluded from the analysis. These cities are attractive by themselves for companies and households.[10] In addition, only municipalities with at least 2,000 inhabitants are included in the database, as it is rather unlikely that a very high-speed broadband network has been rolled out during the time period of the study.

To estimate the impact of very high-speed broadband networks on local economic growth, a count modeling framework with fixed effects is used. Robustness checks are performed using

[9] since 2013 Orange and other DSL operators have been upgrading their broadband networks to offer VDSL services, which can provide Internet speeds up to 50 Mbps to some consumers. However, the VDSL technology is not included in the study, because the connection speed depends on the copper line length and as such suffer from signal attenuation.

[10] They are the three largest municipalities in terms of population and are the only one decomposed into arrondissements (districts), with their own mayor and municipal council.

matching estimators techniques. These evaluation methods are commonly used to estimate the average effect of a treatment or policy intervention.

The estimations show evidence of the benefits of very high-speed broadband networks for local economic growth. They enhance municipalities attractiveness for new establishments operating in the commerce, service and transport sector, which rely more on ICTs. In addition, municipalities with a very high-speed broadband networks provide a more favourable environment for entrepreneurship, as it has a positive effect on the creation of sole proprietorships. However, I don't find any significant effect on the creation of new businesses in the industry or in the construction sectors.

The remainder of the paper is organized as follows. Section 2 discusses the relevant literature on the effect of broadband on economic growth and deployment. Section 3 presents the data. Section 4 introduces the econometric framework. Section 5 presents the estimation results and Section 6 the robustness checks. Finally, Section 7 concludes.

2 Literature Review

There is a substantial literature on the effect of ICT on GDP and more generally on economic growth at the national and regional level (see Czernich et al. (2014) and Kretschmer (2009) for literature reviews). It is widely accepted that, at the national level, ICT adoption has a positive effect on productivity.

There is an extensive range of macro-level studies which bring empirical evidence on the positive impact of broadband adoption on economic growth (see Bertschek et al. (2013), Greenstein et al. (2011) and Holt et al. (2009) for comprehensive literature reviews). Gruber et al. (2014)

evaluate the net economic benefits that would derive from the achievement of the objectives of the 2020 Digital Agenda for Europe. They find that the economic benefits outweigh the costs of investment. Besides, they show that the economic benefits are only marginally appropriable by firms, as they mostly spill over to users and to the national economy. This result confirms other studies which found a positive impact of broadband availability on consumer surplus (see for example Crandall et al. (2001) and Dutz et al. (2009)). Thus, Gruber et al. (2014) show that there is a rationale for public subsidies in the roll-out of broadband networks. Other studies for the US have found a positive relation between broadband availability and employment (Crandall et al. (2007), Gillett et al. (2006)). However, there is limited empirical evidence of the effect of broadband availability on economic growth at the local level, especially in rural areas.

Usually, studies realized at the local-level assess the impact of ICT on variables of local economic growth (see, for example, Kolko (2012)). There are only few papers focusing specifically on the effect of broadband adoption on local economic growth. Czernich (2011 and 2014) for German municipalities and Jayakar et al. (2013) for eight States in the US find no evidence that broadband availability reduces the unemployment rate. On the contrary, Whitacre et al. (2014) find that broadband adoption, availability and download speeds have an impact on economic growth in rural areas. They use a propensity score matching estimator on local-level data for non-metropolitan US counties for the years 2001 to 2010. They highlight a positive impact on unemployment reduction and on median household income. They also show that rural areas with high levels of download speeds tend to attract more creative class workers and to have a lower poverty level.

As far as firms are concerned, the literature focuses on the impact of broadband on produc-

tivity. Haller et al. (2015) show that on average more productive firms are more likely to have a DSL broadband connection, but they find no evidence of an impact of broadband adoption on firms' productivity or on productivity growth. Similarly, Bertschek et al. (2013) find no effect on labour productivity, but they find a positive effect on firms' innovation activities. Akerman et al. (2015) show that broadband availability and adoption increases the productivity of skilled workers, acting as a skill complement and lowers the productivity of unskilled workers, acting as a substitute for routine tasks.

Only few studies analyse the effect of broadband on the attractiveness of a territory for firms. In her analysis, Mack (2014) finds a positive correlation between broadband speed and the presence of agricultural and rural companies in Ohio. Using local-level data, McCoy et al. (2018) analyse the impact of local infrastructure and broadband networks on new business creation in Ireland, excluding the Dublin city region. They find that on average areas covered by broadband are more attractive for firms.

This paper is related to the latter stream of literature. However, most of the studies on the impact of broadband on local economic growth focus on the impact of old generation broadband technologies, such as DSL or co-axial cable technologies and ignore the new high-speed broadband technologies. I attempt to fill this gap by assessing the impact of very high-speed broadband technologies, including fiber optical technology (Fiber to the Home) and upgraded cable technology (DOCSIS 3.0 or Fiber to the Last Amplifier or FttLA).[11] Besides, though realized at the local level, most of the studies are performed at a more aggregated level, which is either the State or the county.

[11]The FttH technology is also called fiber-to-the-premises (FTTP).

3 Data

Data on the number of establishment creations come from INSEE, the French National Institute for Statistics and Economics Studies. They have been collected for each municipality for the years 2008 to 2015. Information on the three main non-farm market sectors: the industrial sector, the construction sector and the tertiary sector, are available for each year.

The construction sector is essentially an activity of deployment, installation or maintenance on the customer's work-site. The industrial sector regroups all activities combining factors of production (facilities, supplies, work, knowledge) to produce material goods intended for the market. The tertiary sector encompasses a vast field of activities, ranging from commerce to administration, via transport, financial and real estate activities, services to business, personal services, education, health and social services. Therefore, data have been collected for three sub-sectors of the tertiary sector: the commerce, transport and services; the provision of services to companies and the provision of services to households.

Data on fiber deployment in metropolitan France (Corsica excluded) have been extracted from Orange's Information System, SFR's website and Free users' community websites for the years 2010 to 2014. Orange is the historical fixed-line incumbent. It owns the legacy copper network, which is used to provide DSL broadband services. SFR and Free are alternative operators which do not possess their own copper network. They provide broadband services by leasing access to the incumbent's local access network via local loop unbundling (LLU).[12] All data on fiber deployments provide information at the municipal level, with each municipality identified by a unique geographic code (the INSEE code). The information is available for 36,036

[12]Orange, SFR and Free are also the main competitors in the mobile market.

French municipalities out of the 36,192 municipalities counted in metropolitan France in 2014. For each municipality, it is known whether Orange and/or SFR has deployed an FttH network.[13]

Regarding Free, the data have been extracted from an unofficial website updated by Free's users community.[14] The data are consistent with information gathered on other websites, as well as with Free's Annual Reports. For each municipality, it is known whether there are active fiber connections from Free.

Data on cable upgrade have been extracted from Numericable's website for the years 2010 to 2014. Numericable is the French cable-operator.[15] For each municipality, it is known whether Numericable has upgraded its cable network to provide very high-speed broadband services.

Table 5 shows the number of municipalities covered by each of these four main operators between 2010 and 2014. During the period of study, in 2013, the regulatory framework has been modified leading to an acceleration in fiber optical network deployment. In France public authorities are promoting co-investment between private operators in less densely populated areas.[16] Co-investment in the last mile of the network from the optical distribution frame is allowed to alleviate the costs of FttH roll-out.[17] In 2013, the list of very high-density areas has been modified leading to more possibilities for co-investment.

Finally, socio-demographic data comes from INSEE. Data on the average fiscal income per municipality has been collected from the General Direction of Public Finance's website (Gouvern-

[13]The database used in this study is similar to the one used in Bourreau et al. "Unbundling the Incumbent and Entry into fiber: Evidence from France" (Mimeo). Further details upon the database construction and data collection provided on request.

[14]See http://francois04.free.fr/ and http://serge.31.free.fr/.

[15]Numericable's cable network covers 30% of the population, mostly in urban areas.

[16]ARCEP Decision Nr 2009-1106 from the 22nd December 2009.

[17]Operators deploying a fiber optical network in less densely populated areas have to publish a call for co-investment and co-invest with interested operators. Operators can co-invest in 5% of lines or a multiple of 5% of lines (i.e., they can co-invest in 5%, 10%, 15%, etc. of the lines). Ex-post co-investment is also possible, but subject to a risk premium to compensate the commercial risk supported by the first investor.

ment Taxes Services, DGFIP)[18]. Data have been collected for the years 2006 to 2012. Descriptive statistics are reported in the Annex.

4 Econometric Strategy

The choice of a location for a new company to operate is a strategic decision, key to its success. Companies incur a fixed cost when settling down. Its choice is driven by cost factors, such as the tax regime in the locality, the availability of infrastructures, such as transportation and broadband infrastructures, but also by the cost and availability of human capital. In addition, companies consider the potential demand in the market for their products or services.

4.1 Theoretical Assumptions and Settings

The empirical literature on business location decisions is generally based on two approaches: discrete choice modeling and count modeling. The first discrete choice modeling approach is based on the analysis of business location decision as a function of firm characteristics, including the size and the industry sector, and alternative local characteristics, including population, human capital and infrastructures.[19] The unit of analysis is the company, whereas in the second count modeling approach, the unit of analysis is the territory. In this latter approach, the analysis consists in assessing how location characteristics can influence business location in the form of the count of businesses in each territorial unit.[20] The underlying assumption is that the number of new establishments that settle in a locality over a time period is determined by

[18]The average fiscal income is measured in the previous year, as people pay taxes on the year before. In other words, the amount of taxes paid for the year 2015 is calculated on the income received in 2014.

[19]See Arauzo-Carod (2008) and Arauzo-Carod and Manjon-Antolin (2012) for a thorough discussion. For recent studies, see Alama-Sabater et al. (2011) and Siedschlag et al. (2013)

[20]See Jofre-Monseny et al. (2011) and Bhat et al. (2014).

an equilibrium condition between a stochastic supply function representing the willingness of a company to start its business in the territory and a stochastic demand function for new firms in the territory.[21]

Given the type of data available, a count model is implemented to address the main question, which is whether very high-speed broadband networks have a causal effect on the creation of new establishments. The count of new establishments operating in a municipality for each time period is modeled as a function of the local characteristics, with municipal- and time-fixed effects.

Let i $(i = 1, 2, ..., I)$ index the territorial unit of analysis, i.e. the municipality. Let s $(s = 1, 2, ..., N)$ index the sector type. Let k $(k = 1, 2, ..., K)$ index the establishment. Let t $(t = 1, 2, ..., T)$ index the time, i.e. the year. Then, Y_{sit} represents the count of new businesses in sector s in municipality i at time t. By construction, Y_{skit} takes nonnegative integer values. It is assumed that new establishment will locate in an area where its can makes profits.

The profit's level of establishment k depends on the local characteristics in municipality i, which impacts its costs. It's profit level is also determined by the characteristics related to the demand for its products or services.

$$\Pi_{skit} = \alpha + \beta\, X_{skit} + \delta\, superfast_{skit} + \gamma\, D_{skit} + \epsilon_{skit}. \tag{1}$$

With X_{skit} municipality specific local characteristics in year t that are relevant for establishment k operating in sector s. These local characteristics are related to cost and will therefore impact the level of profit the firms can expect in a certain geographic area. The determinants

[21] Following Becker et al. (2000), the equilibrium condition can be represented by a reduced form stochastic distribution for the count of new businesses.

of business location decisions are likely to differ among the different sectors. Therefore the local characteristics relevant for one sector may not be the same as those relevant for another sector. Such characteristics can be related to the market size, the concentration of the market, the presence of local infrastructure and the labor market. Within these local characteristics one is considered to have a positive impact by policy makers and academists, the presence of a very high-speed broadband network.

D_{skit} represents the municipality specific demand function in year t that are relevant for establishment k operating in sector s. It can be considered as a latent demand intensity for new businesses in sector s in local market i at time t. $epsilon_{skit}$ is unobserved random factors that varies across establishments and locations.

Firm k will enter a territorial unit only if it expects to make positive profits.

$$Y_{sit} > 0 \text{ if } E(\Pi_{skit}) > 0. \tag{2}$$

As highlighted in the literature, there is a potential endogenous effect of broadband networks on company creation and more generally on economic activity, see, for example, Kolko (2012), Mack et al. (2011) and McCoy et al. (2018). Economic activities are more likely to thrive in areas with enhanced broadband infrastructures. In the meantime, areas with better broadband infrastructures are more likely to attract economic activities. Therefore, this effect materializes mostly as reverse causality between the number of companies operating locally and very high-speed broadband availability.

In their analysis of the impact of local broadband infrastructures on new business establishment, McCoy et al. (2018) argue that the endogenous relationship that exists between

broadband networks and companies is more likely to affect the stock of existing companies rather than the flow of company creations. To mitigate this endogeneity problem, they restrict their analysis to new firms in each year and control for the pre-existing employment levels for each area and for each time period. I follow their argument and estimate the impact of very high-speed broadband networks on the number of new establishments created in each year. I also control for pre-existing level of companies for each area and each year using 2 years lagged variables. In addition, as the local labor market variables may also suffer from reverse causality, 2 years lagged variables are also used. Households could choose to locate in areas with better job prospects and companies in areas in which they could higher their labor force. Robustness checks are performed with lags of 1 year and 3 years, which give similar qualitative results. Nevertheless, one can suspect that the estimation results might suffer from an upward bias.

Omitted variables may also be a potential source of endogeneity. For example, operators may have higher incentives to deploy a very high-speed broadband network in areas in which they can benefit from a more favorable tax regime or in which there is higher demand for faster broadband services. To mitigate this problem, I follow the econometric literature by using time-varying and time-unvarying fixed effects. Specific time trends are also added at the region/ department levels to control for geographical trend in establishment creation.

4.2 Empirical Models

The model is estimated on a database including 4,933 municipalities over 6 years, from 2010 to 2015. Only municipalities with at least 2,000 inhabitants are included in the database. It is rather unlikely that private operators deploy a very high-speed broadband network in a mu-

nicipality with less than 2,000 inhabitants. The three main French agglomerations, Paris, Lyon and Marseille are excluded as they are the three largest municipalities in terms of population and are the only ones decomposed into arrondissements (districts), with their own mayor and municipal council.[22]

$$Y_{it+1} = \alpha + \delta\ superfastbb_{it} + \beta\ X_{it-2} + \gamma\ Z_{it-2} + \mu\ year_t + \eta_i + \phi_t + \epsilon_{it}. \tag{3}$$

Where :

$$Y_{it+1} = 0, 1, 2, ... \tag{4}$$

Y_{it+1} is the count (or number) of new establishments operating in municipality i at time $t+1$. The variable of interest consists in a dummy variable, denoted $superfastbb_{it}$, which indicates whether a very high-speed broadband network, providing Internet connection of at least 30 Mbps, has been deployed in municipality i at time t. A technology neutral approach is adopted by including all technologies through which very high-speed broadband services can be delivered: fiber optical network (FttH) and upgraded cable network (FttLA).[23]

X_{it-2} is a matrix of location characteristics for municipality i at time $t-2$ and Z_{it-2} a matrix of labor market characteristics for municipality i at time $t-2$. η_i is a time unvarying

[22]Population in 2013: Paris: 2.2 millions inhabitants, Marseille: 855,393 inhabitants, Lyon: 500,715 inhabitants, the fourth largest is Toulouse with 458,298 inhabitants, but even though the municipality size is comparable with Lyon, the density of population is much lower: 3,942 inhabitants per km^2, compare to 10,583 inhabitants per km^2 for Lyon and there is no arrondissement in Toulouse.

[23]Due to data constraints, the effect of very high-speed broadband networks is estimated at time t on the number of new establishments at time $t+1$. The latest data available for establishment creation is 2015. It is only possible to estimate a short-term effect . With longer dataset, it could be possible to estimate a medium or long-term effect.

fixed effect which controls for differences across municipalities that are constant over time. $year_t$ is a dummy variable for each year capturing year specific effects. ϕ_t captures regional or departmental specific time trend.[24] Finally, ϵ_{it} is a standard error clustered at the municipal level, capturing unobserved factors.

Log-transformation are used for better interpretation. Then we have for the number of business creations,[25]

$$\begin{aligned} ln\_new\_establishment_{it+1} = \ & \alpha + \ \delta \ superfastbb_{it} + \ \beta_1 \ establishment_{it-2} \\ & + \beta_2 \ ln\_households_{it-2} + \ \beta_3 \ density_{it-2} + \ \beta_4 \ income_{it-2} + \ \gamma_1 \ unempl_{it-2} \\ & + \gamma_2 \ perc\_uni\_diploma_{it-2} + \ \gamma_3 \ employment\_groups_{it-2} + \ \mu \ year_t + \ \eta_i + \ \phi_t + \ \epsilon_{it}, \end{aligned} \tag{5}$$

where $ln\_new\_establishment_{it+1}$ represents the number of new companies (in log) that have been created in municipality i at time $t+1$. The presence of a very high-speed broadband network is likely to impact a firm's decision to enter a market differently depending on which sector this firm is going to operate. Therefore, new establishments are disaggregated into the three non-farm market sectors of the economy: the construction sector, the industrial sector and the tertiary sector. The tertiary sector is the one which is predicted to benefit the most from the presence of very high-speed broadband. It has been divided in three sub-sectors: the commerce, transport and services; the provision of services to companies and the provision of

[24] There are 21 regions and 93 departments.

[25] Few municipalities have 0 establishment creation, this number is set to 1. This can be done, because the number of 0 company creation is rather low: 1.4% for new establishments; 4.8% for new establishments from the construction sector; 0.7% for the commerce, service and transportation sub-sector; 1% for the provision of services to households sub-sector; 5.2% for the provision of services to companies sub-sector; 0% for the creation of new companies run by one individual. Only establishment creation in the industry sector display a higher number of 0, with 17% of the municipalities having 0 establishment creation from the industry sector. However, results are qualitatively similar in terms of signs and significance.

services to households.

$Establishment_{it-2}$ represents the number of establishments operating in municipality i at time $t-2$. As a matter of fact, the number of establishments in a locality is highly correlated with the number of establishments in the previous years. The market size is approximated by the number of households (in log) and the population density in municipality i at time $t-2$. The average fiscal income and the unemployment rate in municipality i at time $t-2$ are proxy for the quality of demand, in terms of purchasing power.

Education is measured by the percentage of inhabitants with a diploma from superior education in municipality i at time $t-2$. Population qualifications is approximated by the number of inhabitants of the different socio-professional groups, $employment\_groups_{it-2}$ in municipality i at time $t-2$. There are 6 socio-professional groups: Farmers (group 1), craft workers, retailers, and business owners (group 2), intermediate occupations (group 3), white collars (group 4), employees (group 5) and blue collars (group 6).

The second specification makes a specific focus on entrepreneurship by assessing the impact of very high-speed broadband networks on the creation of sole proprietorships, i.e. the creation of companies owned and run by one individual:

$$\begin{aligned} ln\_new\_proprietorship_{it+1} = \ & \alpha + \ \delta \ superfastbb_{it} + \ \beta_1 \ establishment_{it-2} \\ & + \beta_2 \ ln\_households_{it-2} + \ \beta_3 \ density_{it-2} + \ \beta_4 \ income_{it-2} \\ & + \gamma_1 \ unempl_{it-2} + \ \gamma_2 \ perc\_uni\_diploma_{it-2} + \ \gamma_3 \ perc\_no\_diploma_{it-2} \\ & + \gamma_4 \ employment\_groups_{it-2} + \ \mu \ year + \ \eta_i + \ \phi_t + \ \epsilon_{it}, \end{aligned} \tag{6}$$

where $ln\_new\_proprietorship_{it+1}$ represents the number of new sole proprietorships (in log)

that have been created in municipality i at time $t+1$. The percentage of inhabitants with no diploma in municipality i at time $t-2$ is added to the previous set of explanatory variables. As during a time of unemployment, some people which face difficulties to find a job, may decide to create their own business. This has been observed with the 2008 economic crisis, with an increase in the number of sole proprietorships (see descriptive statistics).

Nevertheless, all specifications are also estimated without the number of establishments operating in municipality i at time $t-2$ to ensure that this variable does not impact or hide the significance of others. Results are qualitatively similar in terms of sign and significance, they also display coefficients of similar magnitudes.[26] The same exercise has been made without the different socio-professional groups; the results are also qualitatively similar.

5 Estimation Results

Tables 6 to 9 show the estimation results of the impact of very high-speed broadband on the creation of establishments and of sole proprietorships. In the first specification (1) there is no geographic specific time trend, in (2) specific time trends at the regional level are added, in (3) specific time trends at the department level are added.

The results highlight that the availability of very high-speed broadband networks favors local economic development by increasing the number of new establishments created locally. Table 6 shows that the number of new establishments increases by an average of 2.8% with the presence of a very high-speed broadband network. This effect is reduce to 1.6% when adding region specific time trends and becomes insignificant with department specific time trends.

[26] Results are available upon request.

To better capture the effect of very high-speed broadband on the local economy, the establishments are disaggregated into the three main categories of the non-farm market sector: the industrial sector, the construction or building sector and the tertiary sector. As expected, municipalities benefit from the spill over of the local presence of very high-speed broadband networks, helping them to maintain and develop a healthy economic sector. However, the presence of very high-speed broadband networks does not have an impact on the creation of all types of establishments of the non-farm market sector. A positive and significant impact is only found for the creation of establishments from the commerce service and transportation sector, in which firms rely more on ICT to conduct their business. In this sub-sector, the number of new establishments increases by 6%. This effect is reduced to a bit less than 4% with the introduction of region or department specific time trends.

Not surprisingly, the estimation results don't show any significant effect on the creation of establishments of any of the other two tertiary sub-sectors, i.e. the provision of services to companies and to households. Besides, very high-speed broadband networks do not have any significant impact on establishment creation in the industry sector and in the construction sector.

The estimation results also highlight the existence of a positive impact of very high-speed broadband networks on the creation of sole proprietorships, with an increase in new companies created by one individual by roughly 1.8%. This effect is of somewhat similar amplitude with the introduction of region or department specific time trends (1.7% and 1.5% respectively).

Estimation results tend to confirm the findings of McCoy et al. (2018), which suggests that on average areas covered by broadband are more attractive for firms. Besides, the estimation results are also in line with the empirical literature, especially the study from Audretsch et

al. (2015) which highlights a positive effect of broadband infrastructure on entrepreneurship in technology oriented sectors and the study from Gruber (2014), which shows that economic benefits from the achievement of the 2020 Digital Agenda for Europe mostly spill over to users and to the national economy.

6 Robustness Checks

In order to test the robustness of the results, estimations are conducted using the nearest neighbor (difference-in-differences) matching estimator method. Table 10 shows covariate balance statistics and assesses the balance between the treatment and the control groups in the means and in the variances. Estimation results are provided in Tables 11 and 12. Figures 1 to 3 show the parallel trends assumption between the treated and the control group for establishment creation for different sectors of the economy. Table 13 provides an overview of the estimation results for all models.

6.1 Theoretical Assumptions and Settings

Matching techniques are non-parametric estimators used to estimate average treatment effect (ATE). ATE are commonly used to measure the average impact of a treatment or a program intervention, by measuring the difference in outcome between a treated group and a control group (Rosenbaum and Rubin (1983)).

$Y_{it+1}(1)$, $(Y_{it+1}(0))$ denotes an outcome which is realized at time $t+1$ if municipality i receives (doesn't receive) at time t a treatment $d_{it} = 1$ $(d_{it} = 0)$.

The outcome of interest could either be the number of new establishments created locally or

the number of new sole proprietorships. The treatment variable consists in a dummy variable indicating whether a treatment has been applied, i.e. whether a very high-speed broadband network is deployed in municipality i at time t. The control group consists in otherwise similar municipalities in terms of observable characteristics.

Then, the average treatment effect on the treated (ATT), which represents the average gain from the treatment for those who actually were treated, writes as follows

$$ATT = E(\Delta Y_{it+1}(1) \mid d_{it} = 1) - E(\Delta Y_{it+1}(0) \mid d_{it} = 1). \tag{7}$$

The first term represents the expected value of the outcome of interest, at time $t + 1$, in municipalities in which a treatment has been received at time t, which is observable. However, the second term in Eq.(6) is non-observable. It represents the expected value of the outcome of interest, at time $t + 1$, for the control group, had a treatment been received at time t. When evaluating the impact of a policy, or here of an investment decision, the researcher faces an identification issue. Besides, the treatment distribution may suffer from a selection bias. Considering the high costs of deployment, operators will select the municipalities in which to invest first depending on their return prospects. To alleviate these issues, matching estimators seek to reproduce the treatment group among the non-treated group using observable characteristics. Then, the key parameter is to identify the relevant set of matches.

The set of relevant matches is:

$$ln\_households_{it-2},\ density_{it-2},\ income_{it-2},\ unempl_{it-2},\ perc\_estab\_commserv_{it},\ year. \tag{8}$$

The key variables for the matching are the number of households (in log), the population density, the average fiscal income and the unemployment rate, all in municipality i at time $t-2$. In addition, to match municipalities with the same type of economy, the percentage of companies from the commerce and service sector in municipality i at time t is introduced.

Table 10 provides a table of descriptive statistics including the means, variances and skewness of the key variables used in the matching process. By comparing the distribution of the different variables between the treated and control group, one ensures that the two groups are similar in terms of observable characteristics. Besides, the balance between the treatment and the control groups is assessed in: the means by using the standardized difference, and in the variances by using the variance ratio. Table 10 shows that the control group created through the matching is similar to the treated group, in terms of households number, population density, income and unemployment rate. The percentage of inhabitants with no diploma is slightly higher in the control group, while the percentage of inhabitants with a diploma from the superior is slightly higher in the treated group.

As in the difference-in-differences method, one of the key assumption is that the treated and the control groups follow a parallel trend in the pre-treatment period. Absent treatment, both groups would have evolved the same way. Therefore, the difference in the outcome variable in the post-treatment period is assumed to be due to the treatment effect. Figures 1 to 3 show the parallel trends assumption for the number of new establishments, the number of new establishments from the commerce service and transport sector, as well as for the number of new sole proprietorships. We also observe from all Figures a small change in trends for the number of new sole proprietorships in the year following the treatment.

Considering that the average effects are estimated on the treated population and not on the whole population, it is expected to find higher effects than with the previous model.

6.2 Estimations Results

Table 11 confirms the results obtained with the panel data model. It shows that the number of new establishments increases by an average of 5% with the presence of a very high-speed broadband network. Unlike in the previous estimation, a positive average impact is found on the creation of establishments in the industry sector, which increases by 9%. However, the impact of very high-speed broadband networks on the number of new establishments from the construction sector is still not significant.

Similarly, municipalities in which a very high-speed broadband network has been deployed are found to be more attractive for establishments from the commerce service and transport sector. The creation of new establishments in this sub-sector increases by an average of 4.6%. Besides, unlike in the previous estimation, a positive effect of very high-speed broadband networks on the creation of establishments providing services to companies is found. Their number increases by an average of 5%.

Table 12 also confirms results from the panel data estimation as regard the creation of sole proprietorships. Municipalities in which a very high-speed broadband network has been deployed seem to create a more favorable environment for entrepreneurship, with an average increase in the number of new sole proprietorships of 3.6%.

Table 13 provides a summary of the effects of very high-speed broadband networks on local economic growth for each model and specification. As expected, coefficients are slightly higher

for the matching estimator model compared to the main model, as the average effect is estimated on the treated group. There are still two main differences between the models. Unlike the main panel data model, the ATT model shows a positive effect of the presence of a very high-speed broadband network on establishment creation in the industry sector and on new establishments providing services to companies. As mentioned above, the ATT model is estimated on the treated population and can therefore display higher coefficients and also highlights impacts which prevail in the treated population.

7 Conclusion

This paper analyzes whether the presence of very high-speed broadband networks has a causal impact on the creation of new businesses and sole proprietorships operating locally. Based on micro-level panel data covering almost 5,000 municipalities from 2010 to 2015, the estimation results confirm that the presence of next generations access networks enhances municipality attractiveness for the creation of new businesses.

As infrastructure investment produces spillovers, it affects all sectors of the national economy. However, the economic benefits vary significantly across sectors. As foreseen by policy makers and economic analysts, very high-speed broadband networks have on average a positive impact on the creation of establishments operating in the commerce, service and transport sector, where indirect jobs requiring ICT skills are mostly found. Moreover, municipalities in which a very high-speed broadband network has been deployed seem to provide a favorable environment for the creation of companies owned by one individual.

Thus, the paper highlights the benefits of very high-speed broadband networks on local eco-

nomic growth, providing further grounds for policy makers to stimulate investments from private operators. Local government may also consider subsidizing or deploying their own very high-speed broadband networks to bring their benefits in areas were private investment is unlikely to occur. By financially supporting the deployment of broadband in areas which are not attractive for private operators, local government may help to open up small or medium municipalities, contributing to their economic development and to the reduction of the digital divide.

A limitation of this paper is that the causal relation, intended to be estimated, between the local presence of very high-speed broadband networks and establishment creation may be subject to endogeneity. Though mitigated by the introduction of fixed effects, location specific time trends and lagged variables, the estimation results may suffer from an upward bias. In addition, the deployment of very high-speed network is fairly new. As a result, it is only possible, at this stage, to estimate short-term effects. Nevertheless, it fills a gap in the literature by providing empirical evidence on the impact of next generation broadband technologies on company creation and entrepreneurship at the local level.

In future research, when the broadband industry in France develops further and more detailed information becomes available, it may become possible to estimate longer-term effects of very high-speed broadband on local economic growth. Besides, it may also become possible to include municipalities located in rural areas.

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Appendix

Table 1: Data sources

Data	time-period	Source
fiber deployment by Orange	2010-2014	Orange's information system
fiber deployment by SFR	2010-2014	SFR's website
fiber deployment by Free	2010-2014	Free users' community + Free annual Reports
Cable upgrade to FttLA	2010-2014	Numericable's website
Copper upgrade to VDSL	2010-2014	Orange's information system
Population and population density	2006-2012	INSEE
Number of establishments	2009-2015	INSEE
Number of new establishments	2008-2015	INSEE
Number of new establishments per sector	2008-2015	INSEE
Number of new individual companies	2009-2015	INSEE
Unemployment rate (employment zone)	2010-2015	INSEE
Unemployment rate (municipality)	2006-2013	INSEE
Socio-professional groups	2006-2013	INSEE
Diploma	2006-2013	INSEE
Average fiscal income	2008-2015	DGFIP

Table 2: Summary Statistics of new establishment creation in municipalities in which there are no very high-speed broadband network and in municipalities in which such networks are present for 2010-2015

superfastbb		new estab	new ind	new construction
0	number	40136	30503	30503
	mean	53.74798	3.164476	7.954234
	sd	93.84598	5.056969	13.81333
	min	0	0	0
	max	2854	154	422
1	number	4556	4456	4456
	mean	291.8479	11.22195	35.08954
	sd	582.0718	22.13058	78.23895
	min	2	0	0
	max	6895	272	1382
Total	number	44692	34959	34959
	mean	78.02041	4.19151	11.413
	sd	218.2463	9.588983	32.06984
	min	0	0	0
	max	6895	272	1382

Table 3: Summary Statistics of new establishment creation in municipalities in which there are no very high-speed broadband network and in municipalities in which such networks are present for 2010-2015

superfastbb		comm serv transp	serv firm	serv hh	self-employment
0	number	30503	30503	30503	30507
	mean	17.03232	15.43491	12.37249	35.521
	sd	30.31258	28.87787	19.6356	58.23732
	min	0	0	0	0
	max	684	1140	650	1675
1	number	4456	4456	4456	4456
	mean	80.13106	97.59358	58.62118	170.6194
	sd	150.4043	214.3319	122.598	355.2885
	min	0	0	0	2
	max	1781	2629	1519	4609
Total	number	34959	34959	34959	34963
	mean	25.07512	25.90715	18.26751	52.73915
	sd	64.24479	85.63102	49.89729	145.1681
	min	0	0	0	0
	max	1781	2629	1519	4609

Table 4: Evolution of company creations in France between 2002 to 2015

	2002-2008	2008-2010	2010-2011	2011-2015
Industry	23%	124.5%	-15.7%	-12.3%
Construction	61.5%	65.6%	-11.5%	-21.8%
Commerce (retail)	50.1%	81.1%	-13.2%	-21.3%
Commerce (wholesale)	9.3%	10.4%	-13%	-2.3%
Accommodation restaurant	45.5%	33.5%	-5.8%	10.2%
Transportation	33.5%	27.2%	-1.9%	127.8%
Information and communication	59.1%	138.3%	-13%	-2.1%
Services to households	109.7%	212.5%	-22.8%	-28.9%
		2009-2010	2010-2011	2011-2015
Sole proprietorships		7.9%	-16.8%	-5.7%

Sources: INSEE

Table 5: Entry into fiber and upgraded cable in municipalities in France for years the 2010-2014

fiber					
	2010	2011	2012	2013	2014
Orange	117	196	299	456	589
SFR	83	150	214	347	425
Free	93	103	104	106	107
Numericable	202	202	329	699	1067

Out of 36,080 municipalities.

Table 6: Establishment creation in all sectors and in the industry sector in France for the years 2010-2015

	new establishment			new ind		
	(1)	(2)	(3)	(1)	(2)	(3)
very-high speed bb	0.0277***	0.0161**	0.0097	0.0011	-0.0115	-0.0065
	(0.007)	(0.007)	(0.007)	(0.018)	(0.018)	(0.019)
establishment	-0.0005***	-0.0006***	-0.0006***	-0.0002	-0.0005***	-0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
households	0.2285***	0.2120***	0.2054***	0.1945*	0.3035***	0.2761**
	(0.058)	(0.059)	(0.061)	(0.116)	(0.118)	(0.121)
density	0.1914***	0.1505***	0.1184***	0.3075**	0.2608**	0.2072
	(0.038)	(0.030)	(0.030)	(0.125)	(0.128)	(0.131)
income	0.0049***	0.0037**	0.0032*	0.0048	0.0046	0.0020
	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.005)
unemployment	-0.0048*	-0.0035	-0.0025	-0.0010	-0.0014	-0.0002
	(0.002)	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)
diploma superior	0.0014	0.0004	0.0001	-0.0009	-0.0009	-0.0015
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Constant	3.3730***	3.4773***	3.3352***	0.2270	0.2999	0.4268*
	(0.093)	(0.094)	(0.100)	(0.211)	(0.216)	(0.233)
Observations	24,674	24,674	24,674	24,674	24,674	24,674
Employment groups	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Geographic time trend	No	Yes	Yes	No	Yes	Yes
Prob > F	0.00	0.00	0.00	0.00	0.00	0.00
Adj R-squared	0.96	0.96	0.96	0.70	0.70	0.70
Municipality	4,935	4,935	4,935	4,935	4,935	4,935

Standard errors clustered at the municipal level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
with (1) no specific geographic time trend (2) regional specific time trend (3) departmental specific time trend

Table 7: Establishment creation in the construction sector and in the commerce, service and transport sub-sector in France for the years 2010-2015

	new construction			comm serv transp		
	(1)	(2)	(3)	(1)	(2)	(3)
very-high speed bb	0.0180	0.0112	0.0010	0.0611***	0.0386***	0.0351**
	(0.017)	(0.017)	(0.018)	(0.013)	(0.013)	(0.014)
establishment	-0.0003***	-0.0004***	-0.0004***	-0.0006***	-0.0007***	-0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
households	-0.0851	-0.0124	-0.0512	0.0566	0.0805	0.0685
	(0.114)	(0.119)	(0.124)	(0.099)	(0.103)	(0.106)
density	0.2831**	0.1734*	0.1753*	0.1254**	0.1092**	0.0537
	(0.113)	(0.092)	(0.099)	(0.049)	(0.046)	(0.044)
income	0.0126***	0.0122***	0.0107**	-0.0006	-0.0005	-0.0007
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
unemployment	0.0025	0.0016	0.0022	-0.0032	-0.0011	0.0008
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
diploma superior	0.0048	0.0045	0.0048	-0.0007	-0.0023	-0.0032
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	1.3267***	1.3516***	1.3976***	2.4758***	2.4742***	2.2261***
	(0.202)	(0.204)	(0.225)	(0.175)	(0.180)	(0.191)
Observations	24,674	24,674	24,674	24,674	24,674	24,674
Employment groups	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Geographic time trend	No	Yes	Yes	No	Yes	Yes
Prob > F	0.00	0.00	0.00	0.00	0.00	0.00
Adj R-squared	0.81	0.81	0.81	0.88	0.88	0.88
Municipality	4,935	4,935	4,935	4,935	4,935	4,935

Standard errors clustered at the municipal level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
with (1) no specific geographic time trend (2) regional specific time trend (3) departemental specific time trend

Table 8: Establishment creation in the services to the companies and services to households sub-sectors in France for the years 2010-2015

	service firms			service hh		
	(1)	(2)	(3)	(1)	(2)	(3)
very-high speed bb	0.0012	-0.0055	-0.0105	0.0142	0.0170	0.0103
	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.014)
establishment	-0.0005***	-0.0005***	-0.0006***	-0.0004***	-0.0006***	-0.0006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
households	0.5211***	0.4266***	0.4823***	0.2864***	0.2397**	0.2041*
	(0.096)	(0.099)	(0.100)	(0.097)	(0.101)	(0.104)
density	0.1324	0.0573	0.0051	0.2872***	0.2826***	0.2737***
	(0.090)	(0.070)	(0.067)	(0.070)	(0.073)	(0.080)
income	0.0089**	0.0058	0.0052	0.0105***	0.0095**	0.0089**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
unemployment	-0.0100**	-0.0083*	-0.0071	-0.0111**	-0.0101**	-0.0102**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
diploma superior	0.0054*	0.0043	0.0034	0.0007	0.0002	0.0009
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	1.6433***	1.8418***	1.7631***	1.5830***	1.7658***	1.5886***
	(0.180)	(0.176)	(0.180)	(0.181)	(0.185)	(0.200)
Observations	24,674	24,674	24,674	24,674	24,674	24,674
Employment groups	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Geographic time trend	No	Yes	Yes	No	Yes	Yes
Prob > F	0.00	0.00	0.00	0.00	0.00	0.00
Adj R-squared	0.81	0.81	0.81	0.88	0.88	0.88
Municipality	4,935	4,935	4,935	4,935	4,935	4,935

Standard errors clustered at the municipal level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
with (1) no specific geographic time trend (2) regional specific time trend (3) departemental specific time trend

Table 9: Creation of individually owned companies in France for the years 2010-2015

	Individually owned company		
	(1)	(2)	(3)
very-high speed bb	0.0183**	0.0167**	0.0143*
	(0.008)	(0.008)	(0.008)
establishment	-0.0004***	-0.0005***	-0.0006***
	(0.000)	(0.000)	(0.000)
households	0.2665***	0.1890***	0.1842***
	(0.061)	(0.064)	(0.066)
density	0.1633***	0.1342***	0.1047***
	(0.038)	(0.035)	(0.033)
income	0.0045**	0.0034	0.0029
	(0.002)	(0.002)	(0.002)
unemployment	0.0026	0.0034	0.0034
	(0.003)	(0.003)	(0.003)
diploma superior	0.0056**	0.0040*	0.0038
	(0.002)	(0.002)	(0.002)
no diploma	0.0064***	0.0055***	0.0053***
	(0.002)	(0.002)	(0.002)
Constant	2.4108***	2.6541***	2.5313***
	(0.169)	(0.170)	(0.175)
Observations	24,672	24,672	24,672
Employment groups	Yes	Yes	Yes
Year	Yes	Yes	Yes
Geographic time trend	No	Yes	Yes
Prob > F	0.00	0.00	0.00
Adj R-squared	0.93	0.93	0.93
Municipality	4,935	4,935	4,935

Standard errors clustered at the municipal level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
with (1) no specific geographic time trend (2) regional specific time trend (3) departemental specific time trend

Table 10: Covariate for Balance Test

	Treated			Control			Balance	
	Mean	Variance	Skewness	Mean	Variance	Skewness	Std-diff	Var-ratio
estab_commserv_perc	75.21778	104.3786	-0.4576889	71.88156	138.2795	-0.2382086	0.3028814	0.7548383
density	1.554482	6.703896	4.604425	0.2931954	0.1079544	3.56288	0.6834334	62.09933
households	1.201067	1.140388	0.767097	0.4358008	0.2875645	1.008727	0.9056709	3.965679
income	27.20733	67.94514	2.029876	23.89279	33.44573	2.024548	0.4655204	2.031504
unemployment	8.284171	9.454508	0.7606926	8.118084	8.388977	0.7826971	0.0556047	1.127016
no diploma	31.80636	64.66283	0.2513526	36.16033	75.80631	0.1488637	-0.51953	0.8530006
diploma superior	26.98883	102.6883	0.8918325	20.5735	56.69682	1.082169	0.7186378	1.811183

Table 11: Establishment creation in all sectors, in the industry and construction sectors in France for the years 2010-2015 using average treatment effect on the treated

	new establishments	new ind	new construction
superfastbb	0.0490**	0.0898**	0.0169
	(0.020)	(0.036)	(0.026)
Observations	24,674	24,674	24,674

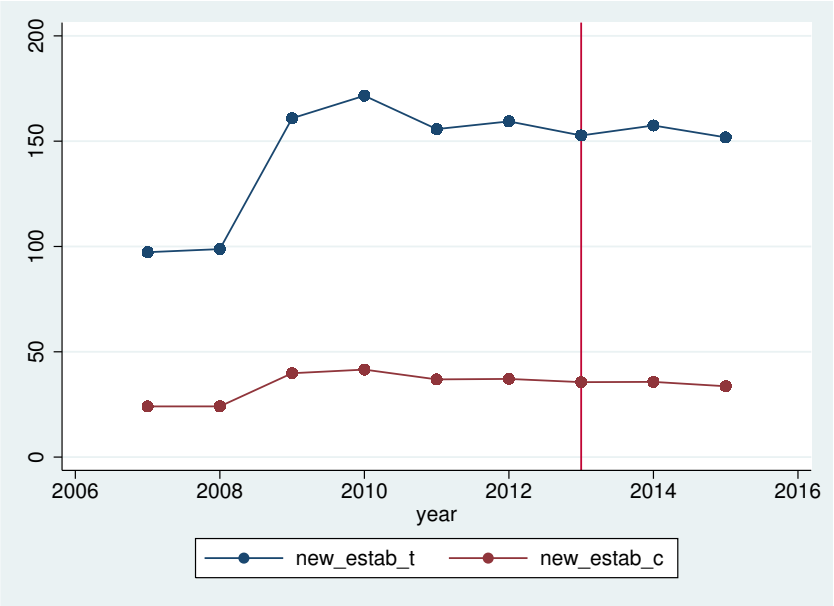
Robust standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 12: Establishment creation in the tertiary sector and new sole proprietorships using average treatment effect on the treated

	comm serv transp	service firms	service households	self-employment
superfastbb	0.0457*	0.0519**	0.0147	0.0358*
	(0.024)	(0.024)	(0.020)	(0.019)
Observations	24,674	24,674	24,674	24,672

Robust standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 1: Parallel lines assumption: number of new establishments



Figures 1 to 3 show that for all these variables, the parallel trend assumption is respected in the pre-treatment period. I also highlight a small change in the number of establishment creation after 2013, which increases slightly in the treated group, compared to the control group in which the number of establishment creation seems to be stable.

Figure 2 shows the same change in trends after 2013 for the number of new establishments from the commerce, service and transport sector created in treated municipalities.

Figure 2: Parallel lines assumption: number of new establishments from the commerce service and transport sector

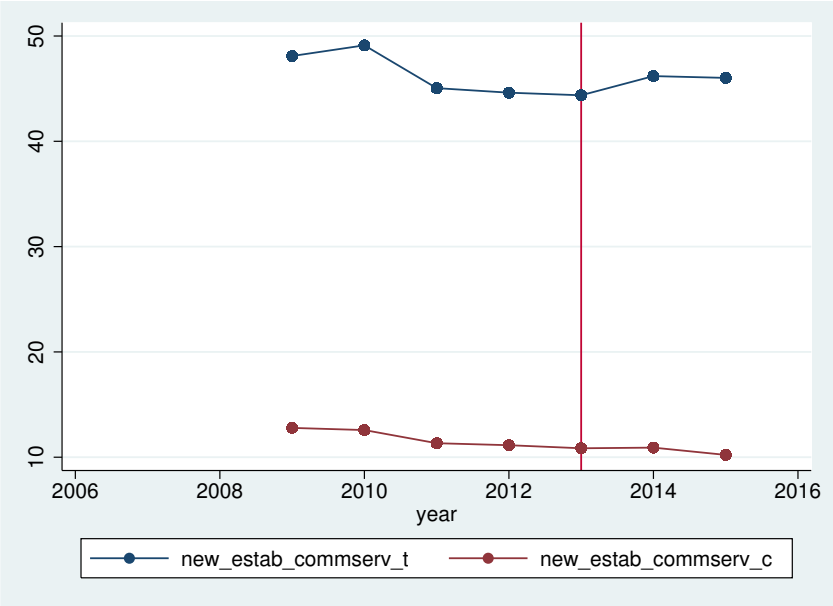


Figure 3: Parallel lines assumption: number of new sole proprietorships

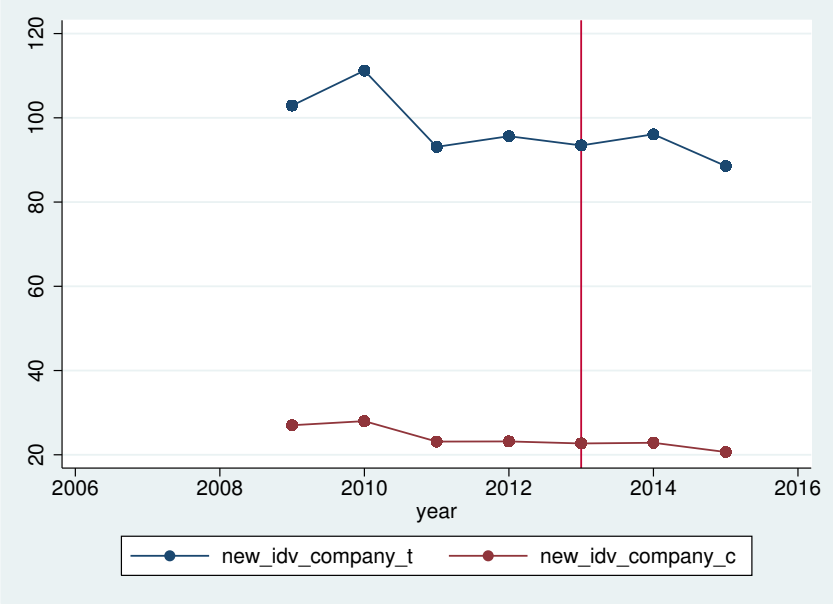


Table 13: Summary of effects

	Panel FE (1)	Panel FE (2)	Panel FE (3)	ATT
Geographic time trend	No	region	department	N/A
new estab	2.8%	1.6%	-	4.9%
new industry	-	-	-	9%
new construction	-	-	-	-
new comm serv transp	6.1%	3.9%	3.5%	4.6%
new service firms	-	-	-	5.2%
new service households	-	-	-	-
new individual_comp	1.8%	1.7%	1.4%	3.6%

-: results are not significant