Does Internet Speed Matters?

Impacts of Internet Speed on E-Applications Adoption By Firms in Luxembourg

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Abstract

The aim of this paper is to examine the impacts of the type of Broadband connexion and the speed of Internet on the e-activities (e-commerce, e-administration, e-tendering, e-invoice…) of the Luxembourgish firms. Our paper shows how the speed of Internet connexion impacts the intensity of Internet use (measured by the number of e-activities adopted). Using an ordered logit model we show that the more is the speed of Internet the more is the probability for the firm to adopt a higher number of e-activities. Our work uses the 2013 survey on Information and Communication Technologies (ICT) usage and e-commerce in enterprises in the case of Luxembourg (STATEC, 2013). The dataset covers firms with at least 10 employees in manufacturing and services (except for financial activities). This provides us a representative sample of the population of 1869 firms. Five results at least were found. Firstly, e-commerce is found to be linked to the speed of Internet. Firms are more likely to undertake e-commerce when the speed of the connexion is higher than 30 Mbits. Second, firms with broadband and mobile connection are much more prone to adopt e-activities than those who did not, everything else constant. Thirdly, Being in a very intense competitive market increases by 2% point the probability to adopt three or more e-practices. Fourthly, considering the characteristics of the enterprise show that large firm and part of KIS are more prone to adopt more e-activities as suggested previously in the univariate analysis. Fifthly, the rank effect is not found in our study. Big and small firms have similar chance to use e-applications especially when the Internet speed is high and when the broadband connection is adopted together with mobile connection.

JEL Classification: L21, O31, 033

Key words: E-commerce, Broadband, Internet use, Ordered logit model,

1. Introduction

The Internet is becoming the lifeblood of business. It enables a variety of e-activities for the firms such as e-commerce, e-training, e-procurement, e-learning, e-tendering, e-….It enables also online research, customer interactions via social media forums, wikis, and enable workers to use virtual platforms in order to better coordinate their works. Despite the fact that most of businesses are using Internet, it is quite common to see businesses with an insufficient Internet connection. Not many know what connection level is appropriate for their needs. How much bandwidth do they need depends on what they are doing, and how many people are doing it.

Broadband infrastructure is supposed to improve Internet access in matter of quality and the speed of the connexion which in turn improves firm's productivity (Grimes et al. 2012), enhances efficiencies (Greenstein and Prince 2007), reduces costs, permits to produce more goods and services, and fosters innovation. Broadband is supposed to be the last General Purposes Technology (GPTs)[1] (Bertschek et al. 2013). Broadband provision is considered nowadays as a potential source of economic growth and constitutes an important topic in economic development policies (OECD, 2008).

Since its start in Canada in 1997, the deployment of Broadband was supported by several waves of technological innovations. For example, Copper-Wire based ADSL took place instead of Dial-up. Fibre optic cable took place instead of ADSL[2]. In matter of Mobile we have nowadays the 3G, the 4G, the 4G+ and many other technologies allowing mobile broadband access. These technological innovation have allowed to increase the speed of Internet and the quality of the connexion. Since there firms and Businessmans are calling for upgrading continuosly the speed of the Internet connectivity worldwide. This requirement of most up-to-date technology is supposed to increase the performances of the firms and to allow them to enlarge their markets.

Given these properties, Broadband provision and its economic impacts were at the heart of an extensive economic debate last decade. A plethoric literature examined how Broadband is impacting the economic growth (Qiang and Rossotto, 2009; Czernich et al. 2011; Atif et al, 2012), employment (Grandall et al. 2007, Lehr et al. 2006), innovation and efficiencies worldwide. Several authors have examined also its micro-economic impacts and how the use of high speed Internet is permitting to boost the productivity (Grimes et al. 2012), to cut costs (Allen Consulting Group, 2002), to re-design the internal economic activities, to improve the innovativeness capacity of the firm (Bertschek et al. 2013).

Most of the literature considers under the « umbrella » of Broadband a variety of types of connexions and speeds of Internet. According to the OECD, Broadband is a connexion of more than 256Kbps. Currently, firms can subscribe depending on the available technologies

[1] The reader can examine Bresnahan and Trajtenberg (1995) or Helpman and Trajtenberg (1998) for a better understanding of GPTs.

[2] ADSL (Asymmetric Digital Subscriber Line) normally provides data transmission speeds of at least 256 Kbps, consistent with the EOCD (2002) definition of Broadband.

to a connexion with a speed between 256 Kbps and more than 100 Mbps. This wide variety of speed has several implications on the economic activities of the firm which is not taken into account by the emergent literature. Moreover, there is little research focused on how the shift from one type of connexion to another can allow better firm's performances and enhances its productivity (except the work of Grimes et al. 2012).

For example, Cloud computing allows nowadays firms to buy elastic resources of computing (both hadware, software and servers) without initial expenditure and for an appropriate period of time (Martson et al. 2010). ICT investment becomes delivered on-demand and as a service payed as a metered system. Cloud computing is found to be cost cutting (Wilson, 2011, Jackson, 2011) and improving the firms innovativeness (Sultan, 2014). Moreover some authors state that is a game changer in all industry and services for the next decade (Etro, 2009 and Xu, 2012). However the literature found that one of the limitation of the adoption by firms of Cloud computing is the connexion speed. The quality of the services of Cloud computing depends strongly on the Internet speed connexion.

Starting from these considerations, the aim of this paper is to fill this gap and to contribute to the debate about economic impacts of Broadband by examining how the speed of Internet connexion impacts the e-activities undertaken by the firms. The speed of the connexion has an implication on the intensity of usage of ICT measured here by the number of e-activities of the firm. Our work is based on the 2013 survey on Information and Communication Technologies (ICT) usage and e-commerce in entreprises in the case of Luxembourg (STATEC, 2013). The dataset covers firms with at least 10 employees in manufacturing and services (except for financial activities). This provides us a representative sample of the population of 1869 firms.

Luxembourg is a small country with a competitive economy very keen to adopt the latest generations of ICT nevertheless there are discrepancies between sector and size of the firm. At the same time, as figure 1 shows, Luxembourg has one of the lowest Broadband median and average advertised download speeds among OECD countries in 2012. The investigation of the link between the demand for Internet speed and e-activities seems more appropriate in Luxembourg than in countries like Denmark where more or less all the firms have already access to high speed Internet.

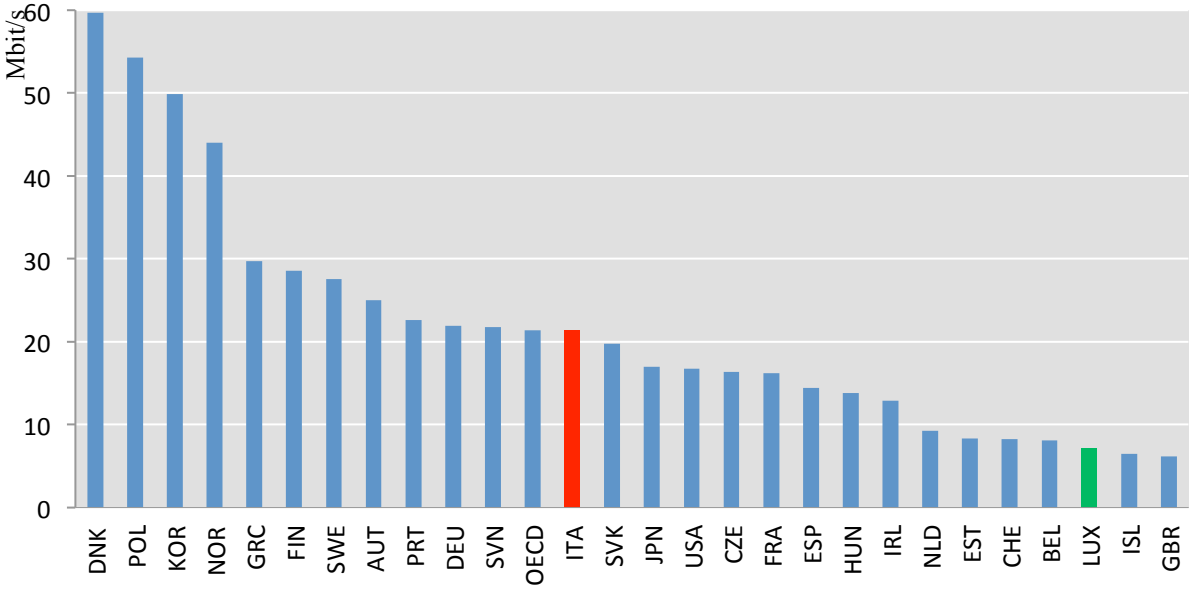


Figure1. Internet connection speed (September 2012): Source: OECD (2013).

Our paper contains two novelties:

Firstly, existent literature has focused on the effects of the adoption of broadband without making the distinction among the large variety of Internet speeds. Under Broadband connexion we have several technologies with several speeds varying between 1 and 100 Mbits per second. The speed of Internet is an important determinant of Internet usages. We have focused on the speed of Internet as an explanatory variable of e-applications usage.

Secondly, most of previous literature have considered only fixed broadband connexion. As the deployment of mobile phone has extensively increased worldwide the demand for mobile broadband has been very fast even in developed countries. Since that there is a need to take into account the mobile broadband. Our data allow us to overcome this limitation and to consider the mobile broadband given its impacts on firms' performances. In some how, our paper takes into account the mobility dividend (Kathuria et al. 2009).

The remaining of the paper is structured like the following. Section two surveys the existant literature. Section three presents the data, the sample and its characteristics. Section four presents descriptive statistics and the univariate analysis. Section five presents the econometric model. Section six discusses the results and section seven concludes.

2. Literature survey

Economic literature has mainly focused on the impacts of broadband on economic performances at the macroeconomic and microeconomic levels.

A first set of literature examined at the macroeconomic level the impacts of Broadband infrastructure deployment[4]. According to the endogenous growth theory, broadband can accelerate economic growth by facilitating the development of innovation process and by fostering information considered as a vital input. Broadband is also considered as a General Purposes Technology (with computers and Internet). It is changing the economic activities

[4] For a survey the reader can see Holt and Jamison, 2009

and increasing the efficiency in all sectors. Qiang and Rossotto (2009) use the Barro cross-sectional growth model to analyse the impact that Broadband has had on long-term economic growth rates over the period 1980 to 2006. They found a robust and important growth divide from Broadband access in developed countries. A 10% increase broadband penetration yield 1.21 per cent increase in economic growth in developed countries and 1.38 per cent in developing countries. Czernich et al. (2011) using an instrumental variable model have estimated the effect of Broadband infrastructure on economic growth in a panel of OECD countries in 1996-2007. They found that 10% increase in broadband penetration raised annual per capita growth by 0.9-1.5 percentage points. Atif et al. (2012) use a basic macroeconomic model using a static fixed effects estimators and a dynamic model (Basic Linear Dynamic Model) for a panel of 31 OECD counties over a period from 1998 to 2010. Their results suggest that broadband penetration has had a positive impact on economic growth. An increase of 10 per cent of broadband penetration will increase economic growth per employee by approximately 0.035 percentage points.

Instead of measuring the impact on growth some scholars have tried to estimate the effect on employment. Grandall et al (2007) estimate the effects of broadband adoption on employment and output at the state level for 48 States in the U.S during the period 2003-2005. They found that for every increase in broadband adoption by 1%, employment increase by 0.2-0.3 per cent per year for the private non-farm sector. Lehr et al. (2006) found similar results and support the hypothesis that Broadband penetration enhances economic activity with significant effects on job growth and business growth. Moreover they found that Broadband penetration has a positive effect on wages. Forman and al (2002) found that the diffusion of Internet affect regional wage inequality. Advanced Internet technology is associated to a substantial wage growth.

This strand of literature confirms the positive impact of Broadband on economic growth and employment. Since then a real need to examine how Broadband improves the microeconomic performances of the firm.

A second set of literature has focused on the effects of Broadband adoption by firms on their performances. Most of these contributions aimed to show how Broadband enhances firms performances using several indicators like cost-saving, productivity and output. A study conducted by Allen Consulting Group (2002) in Australia indicates that businesses have experienced a cost-saving around 6.3 per cent due to adoption of Broadband (compared to 1.5 per cent for the use of dial-up Internet). One can expect that given the fact that the speed of Internet is constantly increasing, cost-saving may increase. Grimes et al. (2012) using micro a panel of 6060 New Zealand firms show that the shift from a standard connexion to broadband boosts firm productivity by 7-10% in New Zealand in 2006. This effect is found whatever the location of the firm is and whatever the knowledge intensity of the sector. Polder et al. (2010) take a firm-level perspective to analyze the role of ICT and R&D for innovation success and productivity of Dutch firms. They find that the use of broadband Internet is particularly important for services firms where broadband is positively related to product and process innovation as well as to organizational innovation. By contrast, in the manufacturing sector, broadband is significant only for product and organizational innovation. For process innovation it is rather e-commerce that plays a significant role. Bertschek et al. (2013) found that broadband Internet enabled firms to reorganize and reshape their business processes and

to improve their products or services. This innovation activity induced by broadband usage may have been translated into productivity gains in later periods.

While this literature has contributed to the validation of the positive impacts of ICT on performances at the macro and micro levels it have several limitations. Firstly, little attention was given to the speed of Internet. Most of the papers do not make the differences between the several speeds within the broadband category. Secondly, Internet develops very fast, at first the importance thing was to have connection, then to have broadband, now to have very fast broadband. In this sense, ICT surveys collected info first on infrastructure, then broadband, and now in some cases we get the information on speed.

Another strand of literature has discussed extensively the use of e-applications especially in the Luxembourgish context without considering the variety of speeds as main explanatory variable. Chaibi et al (2015) found causal links between e-skills, usage of Information and Communication Technologies (ICT) and firm's performance using a sample of Luxembourgian manufacturing and services firms. They found a positive effect of e-applications usage (ICT usage) on the probability of the implementation of successful new projects, and an asymmetric effect of usage of e-commerce and e-administration. However, their paper has not discussed the sensitivity of the findings to the speed of Internet. Ben Youssef and Pelletier-Ben Aoun (2015) found that the usage of e-applications has different effects between short term and long-term performances. The use of the latest generation of ICT increases firm's revenues (short term returns) especially when ICT uses' serves to customize the services and products and if the firms have the dedicated IT staff. Secondly, using the last generation of ICT permits long run returns (if they are used intensively for several purposes (setting a catalogue online, setting e-commerce solutions and customizing the website).

Our paper seeks to extend the latest literature by challenging this question of how the speed of Internet connexion can impact the variety of usage by firms. Previous literature have showed that this variety of usage impacts short-term and long-term performances of the firm and its ability to innovate.

3. Data, sample and characteristics

The data set used in this study is the 2013 Survey on Information and Communication Technologies (ICT) Usage and e-Commerce in Enterprises in the case of Luxembourg (STATEC, 2013). It contains information about ICT adoption and use. While this information has been collected since 2003, this wave is the most recent available that contains information about the type of connection adopted and their connection speed. This dataset covers firms with at least 10 employees in manufacturing and services, except for financial activities. This provides us a representative sample of the population covered of 1869 firms (3651 firms if weighted by its firm size and economic activity).

We will reduce our sample to the firms that have at least adopted Broadband connection. As shown below in figure 1, in doing so we will ease the interpretation of our result and exclude the very few enterprises that have not adopted this technology (less than 1% of the population). Only companies that have a connection Dial-up / ISDN or mobile are excluded from our analysis is less than the total population.

4. Descriptive statistics

Our sample shows that 97% of the firms have already the Broadband connexion. Instead of comparing this proportion of firms (that have adopted Broadband) to the rest of the population (3%), we have focused on the firms that have adopted at least broadband among the firms that have 10 workers and more. Indeed, as shown in figure 1, 36% of companies have only a broadband connection, while 64% prefer to combine it with a mobile connection or ISDN. Altogether, 2 firms out of 10 in our population (18%) will even pair it with both ISDN and mobile connection.

It could be argued that focusing on broadband connection is synonym on studying fast connection, in absolute terms it is true but there are large differences in terms of connection speed (see figure 2). Indeed, almost half of the firm has a speed less than 10Mbit/s and only 28% of the firm has in 2013 a speed equal or greater than 30 Mbit/s.

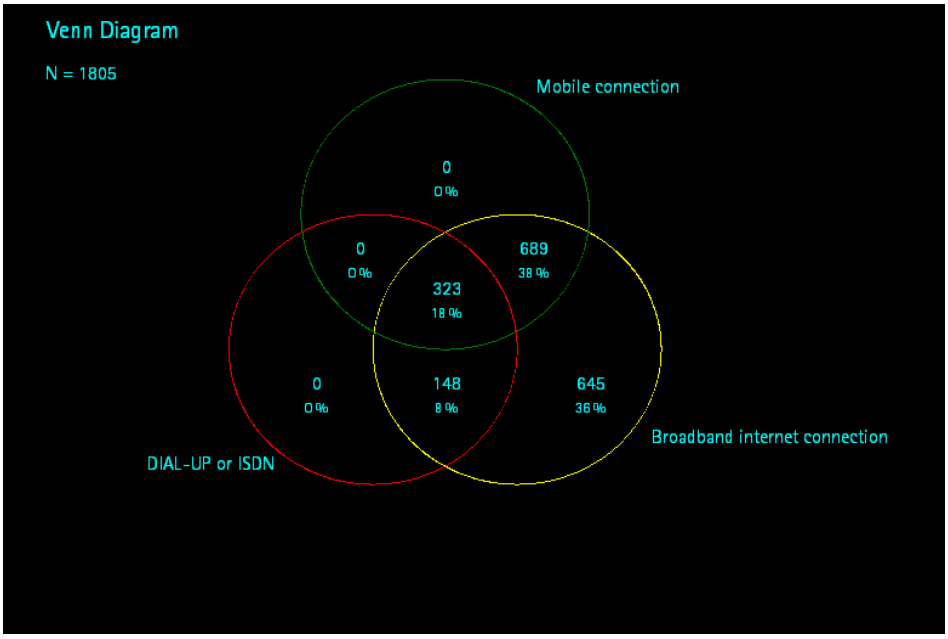


Figure 1. Type of connection

The figure shows that the speed of Internet adoption varies between all the firms and there is no one way of adoption.The needs for high speed may differ depending on their practices and their needs for specific usages.

As we see from figure 2, 52.1% of the firms that has adopted Brodband only and have a connexion between 2 and 10 Mbits per second, while this proportion is only 40.2 per cent for those who have adopted Broadband and Dial-up/ISDN connexion type. One can observe also that among firms that have adopted Broadband and Dial-up/ ISDN connexion we have the largest proportion of firms having low speed connexion (less than 2 Mbits per second). We can also observe that among the firms that have adopted Broadband and mobile connexion we found 19.8% having a connexion between 30 Mbits per second and 100M bits per second; moreover 13% of these firms have a speed of more than 100 Mbits.

Descriptive statistics by size and main economic activity confirm existing literature where large firms adopt more often faster connection and combine their broadband connection with mobile connection. Thus, Knowledge Intensive Services are more prone to adopt very fast Internet; their share is double compare to their counterparts (18% versus an average 9%). Moreover, they combine more often broadband and mobile connection than in construction and in less intensive services.

Regarding e-Activities, the survey provides information on the following four practices:

- E-Commerce: Selling or buying via Internet
- E-invoice: Electronic invoicing (e-invoicing, e-invoice)
- E-administration (Treat an administrative procedure electronically without additional hard copy, such as: e-VAT)
- E-Tendering: Providing goods or services as part of an electronic tendering procedure.

For each of these practices descriptive statistics were performed to see whether the existing link between these practices and the connection speed of the company.

The univariate analysis showed that there is an apparent and statistically significant link between some e-practices and the connection speed of the firm. There is a positive relationship between connection speed and E-Commerce, 66% of companies having a minimum speed of 30Mbt/s adopt E-Commerce, while only 4 out of 10 companies when they have a speed less than 2Mb/s. In terms of e-Invoicing and e-Tendering there is a phenomenon of U-shaped curve.

Finally, when looking at administrative procedures there is significant difference depending on the connection speed. We can formulate the assumption that this practice should meet more stringent legislation that should not penalize companies with poor internet connection. A simple cross tabulation shows that companies that adopt the most Internet activities mentioned above are those that are most often connected to a speed greater than the average and vice versa.

5. Econometric Model

5.1. Dependent variables

Five dependent variables are defined in order to study the relationship between Internet connection speed and e-practices.

The four first dependent variables refer to whether the firm decided to engage in each of this practice. E-Commerce: Selling or buying via Internet; E-invoice: Electronic invoicing (e-invoicing, e-invoice); E-administration (Treat an administrative procedure electronically without additional hard copy, such as: e-VAT); E-Tendering: Providing goods or services as part of an electronic tendering procedure. They are dummy variables taking the value 1 when the firm has declared adopted the practice and 0 otherwise.

The last dependent variable represent a score of the intensity of e-practices, it takes values between 0 and 4. As shown in the figure 5, firm that adopt all four e-practices are rare and so

we decide that the maximum category will represent 3 and more e-practices. A company practicing none of the activity listed above will have a value of 0, while companies with all these practices will a score of 4. There is no weighting of the activities; otherwise some will aim to reduce costs while others will increase the turnover.

5.2. Explanatory variables

Following the large literature about determinants of innovation and the diffusion of ICT we explore four types of categories of variables. The two first categories are generally supposed in the literature: (a) Size of the firm, (b) intensity of competition and the market position in order to test the competition effects. The third category focuses on the speed of Internet. We divided them in five types of categories: less than 2Mbits, between 2 and 10 Mbits, between 10 and 30 Mbits, Between 30 and 100 Mbits and more than 100 Mbits. The fourth category discusses the type of connection. We have divided them into four categories: broadband only, Broadband and Dial-up/ISDN, Broadband & Mobile connection, Broadband & Mobile & Dial-up/ISDN.

5.3. Model Specification

This aim of this paper is twofold. On a first step we want to focus on the relationship between the four e-practices and the speed of Internet connection, and on a second step we discuss the link between speed of Internet connection and intensity of e-practices. In order to answer to the first question we will use a logit specification, while we will implement an ordered logit to test the second assumption.

5.3.1. Probit specification

To estimate the probability of adoption for each e-practice we use the well-known Probit estimation. For each practice we observe a binary outcome whether the firms has adopted or not.

$$Y=1 \text{ if } Y^* = X + \beta\, \varepsilon>0 \text{ with } \varepsilon \sim N(0,1)$$

$$Y=0 \text{ Otherwise}$$

Y is an indicator for the latent variable, in our case: firm adopts Internet if their utility is greater than non-adopting. The probability is equivalent to:

$$\text{Prob}\,(Y=1 \mid X) = \Phi\,(X'\,\beta)$$

5.3.2 Ordered probit specification

To estimate the probability of the intensity of e-practices, which is here an ordered qualitative, we estimate the following Ordered Probit model (Greene, 1997):

$$Y^* = X + \beta\, \varepsilon$$

And $\varepsilon \sim N(0,\sigma\varepsilon)$. The latent variable Y* indicates the level of e-practices. The correspondent observed variable is the score in 5 categories from 0 to 4. The vector X contains all the previously described variables which possibly explain e-practices adoption.

β is the parameter vector. The probabilities are then:

Prob (Y = 0) = Φ (- X β)

Prob (Y = 1) = Φ (mu1- X β) - Φ (- X β)

Prob (Y = 2) = Φ (mu2- X β) - Φ (mu1- X β)

Prob (Y = 3) = 1- Φ (mu2- X β)

6. Econometric Results

6.1. Internet Speed and adoption of e-activities

The estimates for whether firms have adopted e-commerce, e-invoicing, e-administration and e-tendering are shown in Table 2. Results in columns (1)-(4) indicate the existence of big differences in the determinants of adopting specific e-practices.

6.1.1. Competition effect works

Looking at the impact of the market on e-practices we have distinguished between market position and market competition. Indeed, the market position does not influence the propensity to adopt e-activities, except in the case of e-commerce practice. Being leader on the marker increase the probability of doing e-commerce by 9% point compared to follower, other things being equal. This finding confirms previous findings related to the adoption of innovation. Firms in leader position try to keep their advantage by adopting new technological innovations. The second aspect of the competition concentrates on its intensity. Our results show that firms facing stronger competition are more willing to practice e-commerce or e-tendering. In economic sectors where the competition is fierce, firms try to make differentiate their practices and products. E-commerce is a mean to differentiate their practices and enlarge the scope of their market. At the same time adopting e-tendering is supposed to decrease the costs of inputs (less or no paper, increase speed of process and benefiting from more competitive prices) and make higher profit. It is not surprising that competition does not impact on e-administration activities, since in Luxembourg more and more administrative procedures have to be completed online.

6.1.2. The speed and type of connection matter

Considering the speed of Internet connection, our results show that speed does not matter for e-applications related with government (e-Administration or e-Tendering). It is compliant with policy makers wishes stating that this practices must accessible to any firm. At the same time, this may also rely on the fact that e-applications developed by the government are simplistic and not elaborated (e.g. filling in a web form), which may explains why the speed of connection is not needed. However, when it comes to e-commerce and e-invoicing the speed of connection matters. Indeed, when the speed of the connection is at least 10Mbits, the faster the connection is the more the firm adopts e-commerce practice. For e-invoicing the highest speed (100Mbt/s and more) is the only that discriminates. Having this type of speed increased by 7% points the propensity to practice invoicing electronically. E-tendering is in some way seen as an elaborated practice that is specific for “innovators” firms.

Our results suggest as well that the combination of the type of connection and more particularly the use of mobile connection increases the probability of all e-practices even e-tendering. Indeed, Table 2 shows that the adoption of Broadband and mobile connection are more likely to engage their selves in e-commerce, e-invoicing and e-administration than firm with only broadband connection. There is no statistical difference between firm with broadband only and firms equipped with broadband and Dial-up ISDN connection in terms of e-practices. Our result has a direct economic policy consideration since it gives a channel through which policy makers can act in order to foster e-commerce in Luxembourg. Promoting and fostering higher speed of connection and mobile connection can increase e-commerce adoption.

6.1.3. Control variables

Another finding is that firms that are part of a group have only an impact on the propensity to adopt e-administration. When the firm is networked (part of a group) in order to avoid duplication of efforts and resources, e-administration activities become activities with significant cost impacts. This may explain why multi-plants firms adopt them.

6.2. Intensity of Internet connection and e-activities

The second part of our analysis stresses the relationship between speed of connection and intensity of e-activities. It turns out that there is a positive relationship between them.

6.2.1. The rank effect is not found in our study

Our study reveals a rank effect. The size of the firm is an important determinant of the depth of adoption of e-applications. Our results show that there is a difference between small and big firms in matter of intensity of use of e-applications. This result validates the existing literature. In fact, most of the economic literature has shown that the rank effect works. Big firms are more likely to adopt new ICT innovation. Our results show that they are also able to adopt the fastest Internet speed connection in order to deepen their use.

6.2.2. Market structure

As shown in previous paragraph, being a leader has an impact on the number of Internet practices. Leaders are more reluctant to not have Internet activities or only one kind. But the strength of the competition on the market influences the intensity only in the case of very intense competition. When it is the case those leading firms are more reluctant to adopt only on Internet practice and more prone to engage in the maximum of Internet practices. The idea behind, may be that in a very competitive pressure, firm are trying to find much more way to reduce costs and so favour electronic practices. Being in a very intense competitive market increases by 2% point the probability to adopt three or more e-practices and decrease, it is small in absolute term but important considering the small share of enterprises that have adopted at least three type of e-activities. Being a leader on the market has a relatively equivalent impact.

6.2.3. The speed of Internet is important for the depth of usage

There is no statistical difference between the intensity of e-practices and firms who adopted Internet speed less than 30 Mbits. However our results show a clear relationship between the intensity of e-applications and Internet speed higher than 30 Mbits compared to firms with less than 2Mbt/s. The fastest the speed is the larger the number of e-practices is. Our results confirm that the speed of Internet is a major determinant of intensity of usage of e-applications. As e-solutions are more and more available to firms, the adoption of high-level speed of Internet increases the probability of their use. Moreover, we can observe the negative sign of the marginal effects for the category no Internet activity or only one and the positive sign for the two other categories. Indeed, having a connection between 30 & 100 Mbit/s increases by 6% point the probability of having 2 different types of Internet activities (among those defined previously) compared to the slowest connection. Figure 6 below emphasizes this result.

Another important result from this part of the analysis is the importance of mobile connection with e-activities. Figure 7 shows that firm with broadband and mobile connection are much more prone to adopt larger number of Internet activities than those who did not, ceteris paribus.

Lastly, considering the characteristics of the enterprise we confirm the main assumption that firm involved in a group, with higher number of employees and those involved in KIS are more prone to adopt more e-activities as suggested previously in the univariate analysis and in the literature.

Our econometric results confirm the intuition that the speed of Internet has an important impact on the scope and the intensity of use of e-applications by firms. More importantly, while thousands of applications are available nowadays for firms and the link seems to work at a large scale, we have demonstrated the existing of this link only by focusing in four types of e-applications.

Table 2. Determinants of e-practices adoption: Probit estimates.

VARIABLES	e-commerce	e-Invoicing	e-administration	e-Tendering
	-0.013	0.019	0.086***	0.028
Group	-0.03	-0.01	-0.03	-0.02
Market position (*ref: follower*)				
Challenger	0.018	-0.002	0.043	-0.029
	-0.04	-0.02	-0.04	-0.03
Leader	0.092**	0.02	0.06	-0.031
	-0.04	-0.03	-0.04	-0.03
Competition (*ref: limited*)				
Intense	0.083*	-0.002	-0.033	0.041*
	-0.04	-0.03	-0.05	-0.02
Very intense	0.076*	-0.003	-0.02	0.076***
	-0.05	-0.03	-0.05	-0.02
Internet speed (ref: <2 Mbit/s)				
Between 2 & 10 Mbit/s	0.071	-0.008	0.053	-0.064
	-0.06	-0.03	-0.06	-0.05
Between 10 & 30 Mbit/s	0.136**	-0.009	0.002	-0.014
	-0.06	-0.03	-0.07	-0.05
Between 30 & 100 Mbit/s	0.162**	-0.01	0.056	-0.01
	-0.07	-0.03	-0.07	-0.05
100 Mbit/s and more	0.220***	0.074*	0.077	-0.007
	-0.07	-0.04	-0.07	-0.05
Type of Connection (*ref: Broadband only*)				
Broadband & Dial-up/ISDN	0.013	0.007	-0.031	0.033
	-0.05	-0.02	-0.05	-0.03
Broadband & Mobile connection	0.193***	0.036**	0.086***	0.032*
	-0.03	-0.01	-0.03	-0.02
Broadband & Mobile & Dial-up/ISDN	0.162***	0.079***	0.096**	0.037
	-0.04	-0.02	-0.04	-0.02
Employment *(ref : less than 50 emp.)*				
50-250 emp.	0.002	0.043***	0.219***	0.048**
	-0.03	-0.02	-0.03	-0.02
250 emp. and more	-0.045	0.190***	0.254***	0.078*
	-0.06	-0.05	-0.06	-0.04
Economic activity *(ref : Manufacturing)*				
Construction	-0.087*	-0.051**	-0.035	0.043*
	-0.05	-0.02	-0.05	-0.02
Knowledge Intensive Services	0.085*	-0.015	0.015	0.104***
	-0.05	-0.02	-0.05	-0.03
Less Knowledge Intensive Services	-0.004	-0.016	-0.014	0.054**
	-0.04	-0.02	-0.05	-0.02
Observations			**3148**	

Notes: Probit estimations: coefficients are estimated marginal effects (∂F/∂xk), i.e. the marginal effect on Pr(y=1) given a unit increase in the value of the relevant (continuous) regressor (xk), holding all other regressors at their respective sample means. The discrete change in the probability is reported for binary regressors .

Standard errors, adjusted for potential regional clustering, in parentheses.
* p<0.10 ** p<0.05 *** p<0.01.

Table 3. Determinants of intensity of e-practices adoption: Ordered Probit estimates

VARIABLES	None	One	Two	Three and more
Group	-0.041 **	-0.013 **	0.032 **	0.022 **
	(0.016)	(0.005)	(0.013)	(0.009)
Market position (ref: follower)				
Challenger	-0.012	-0.003	0.009	0.005
	(0.023)	(0.005)	(0.018)	(0.011)
Leader	-0.051 **	-0.018 **	0.041 **	0.028 **
	(0.025)	(0.009)	(0.020)	(0.013)
Competition (ref: limited)				
Intense	-0.031	-0.007	0.024	0.015
	(0.029)	(0.005)	(0.022)	(0.013)
Very intense	-0.045	-0.011 **	0.034	0.022 *
	(0.029)	(0.006)	(0.022)	(0.013)
Internet speed (ref: <2 Mbit/s)				
Between 2 & 10 Mbit/s	-0.025	-0.004	0.018	0.01
	(0.042)	(0.005)	(0.031)	(0.016)
Between 10 & 30 Mbit/s	-0.043	-0.008	0.033	0.018
	(0.043)	(0.006)	(0.032)	(0.017)
Between 30 & 100 Mbit/s	-0.073 *	-0.02 **	0.058 *	0.036 **
	(0.043)	(0.009)	(0.032)	(0.018)
100 Mbit/s and more	-0.118 ***	-0.051 ***	0.096 ***	0.073 ***
	(0.043)	(0.016)	(0.033)	(0.023)
Type of Connection (ref: Broadband only)				
Broadband & Dial-up/ISDN	-0.003	0.001	0.002	0.001
	(0.037)	(0.001)	(0.026)	(0.011)
Broadband & Mobile connection	-0.121 ***	-0.036 ***	0.098 ***	0.058 ***
	(0.019)	(0.007)	(0.016)	(0.009)
Broadband & Mobile & Dial-up/ISDN	-0.128 ***	-0.041 ***	0.105 ***	0.064 ***
	(0.022)	(0.012)	(0.019)	(0.014)
Employment (ref : less than 50 emp.)				
50-250 emp.	-0.094 ***	-0.048 ***	0.08 ***	0.062 ***
	(0.014)	(0.01)	(0.013)	(0.011)
250 emp. and more	-0.131 ***	-0.09 ***	0.114 ***	0.108 ***
	(0.021)	(0.028)	(0.019)	(0.03)
Economic activity (ref : Manufacturing)				
Construction	0.053 *	0.01	-0.04 *	-0.023
	(0.029)	(0.008)	(0.023)	(0.014)
Knowledge Intensive Services	-0.055 **	-0.027 **	0.046 **	0.036 **
	(0.026)	(0.012)	(0.022)	(0.016)
Less Knowledge Intensive Services	-0.002	-0.001	0.002	0.001
	(0.026)	(0.008)	(0.021)	(0.014)
Observations		**3148**		

Notes: Probit estimations: coefficients are estimated marginal effects (∂F/∂xk), i.e. the marginal effect on Pr(y=1) given a unit increase in the value of the relevant (continuous) regressor (xk), holding all other regressors at their respective sample means. The discrete change in the probability is reported for binary regressors .

Standard errors in parentheses.

* p<0.10 ** p<0.05 *** p<0.01.

7. Concluding remarks

The aim of this paper was to examine the impact of the type of Broadband connection and the speed of the Internet connection on the e-activities (restricted here to four main activities: e-commerce, e-administration, e-Tendering, e-invoice) of the Luxembourgish firms. Our paper has found clear link how the speed of Internet connection and the type of use of e-application and the intensity of Internet use (measured by the number of e-activities adopted). Using an ordered logit model we show that the fastest is the speed of Internet the higher is the probability for the firm to adopt a higher number of e-activities.

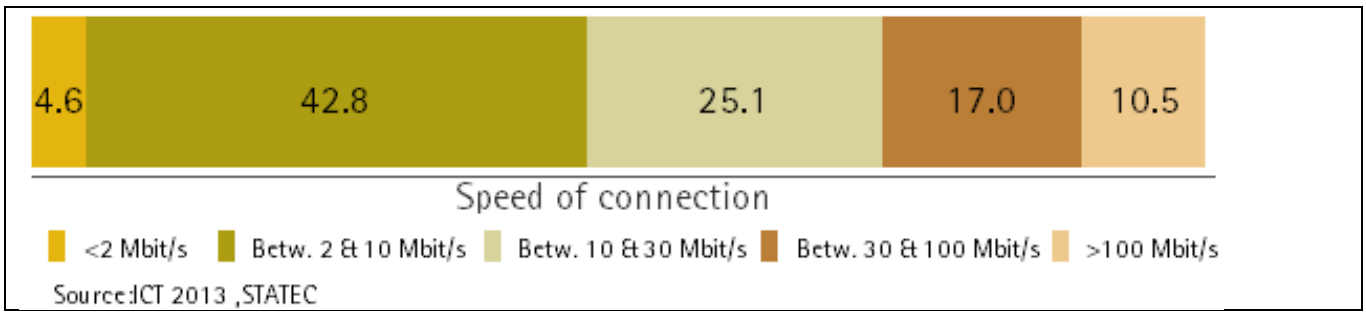
Moreover, we found that adoption of e-commerce is linked to the speed of Internet. Firms are more likely to undertake e-commerce when the speed of the connexion is higher than 30 Mbits. Our findings suggest that in order to foster e-commerce in Luxembourg (and probably in European Countries), public policies aiming at increasing the speed of Internet connection are appropriate. Moreover, as the speed increases more elaborated use are found. In our case we found that e-tendering is used especially by firms that have a connection or more than 100Mbits.

Mobile connection is an important lever for increasing the use of e-applications. Our results show that firms with broadband and mobile connection are much more prone to adopt e-activities than those who did not, everything else constant. Mobility is increasing the needs for coordination between employees via new e-applications. As they are using these applications, their e-skills are increased and they are more likely to use other e-applications especially in matter of e-administration. Applications that have a direct impact on revenue and costs are more likely to be adopted than e-administration activities (considered as less cost-cutting) except for firms being part of a group.

Moreover, classical arguments in matter of competition effects are found. The more the intensity of the competition, the more the firms adopts new applications (especially e-commerce). At the same time, leaders try to maintain their market position by using more technological innovation than followers. Lastly, considering the characteristics of the enterprise our results show that large firm and part of Knowledge Intensive Services (KIS) are more prone to adopt more e-activities

ANNEX1: figures

Figure 2. Share of firm by speed of connection



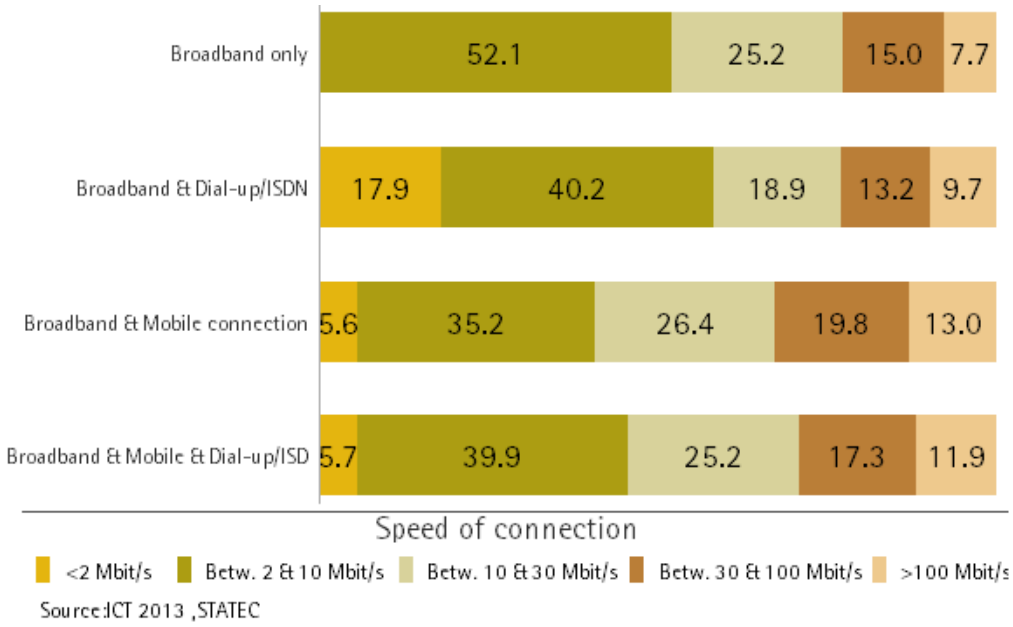
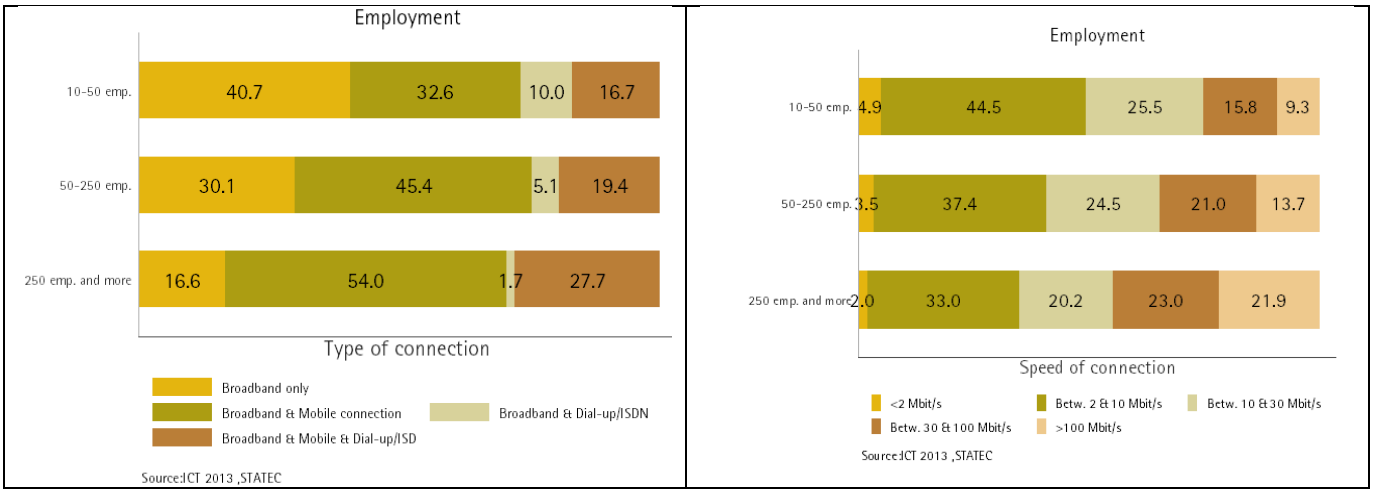


Figure 3. Type of connection by speed of connection

Figure 4. Type of connexion, speed of Internet by size and economic activity of the firm



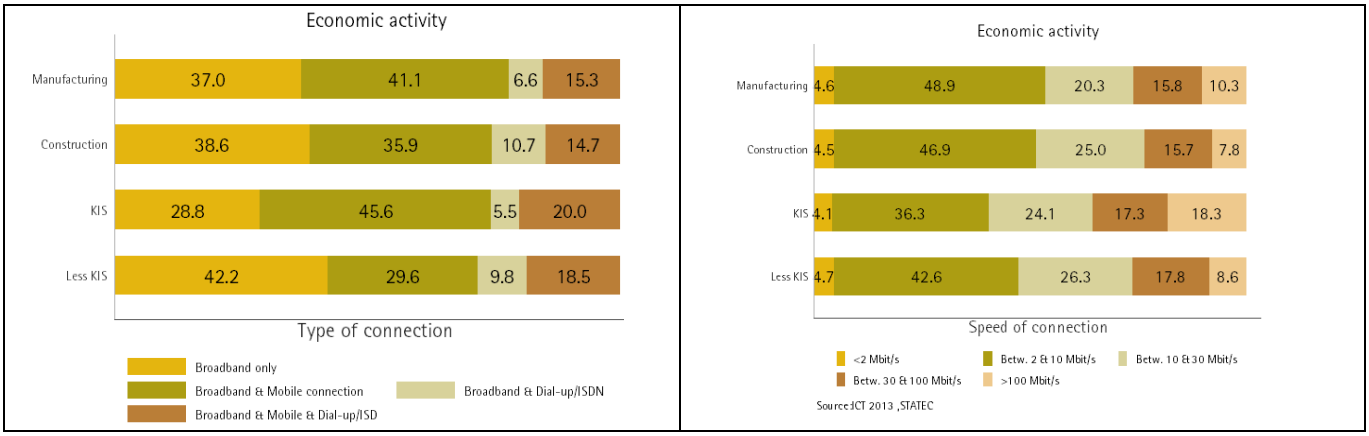


Figure 5. Connection speed and e-activities

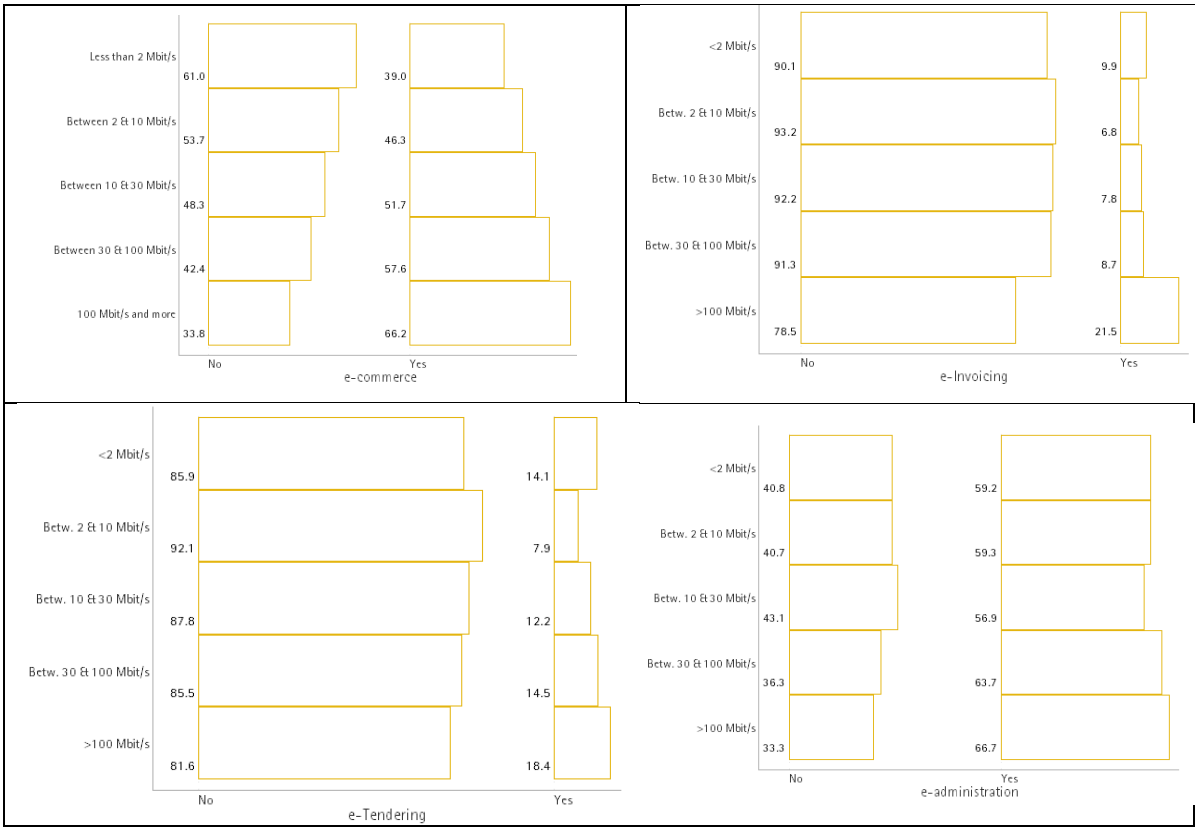


Figure 6. Connection speed and intensity of e-activities

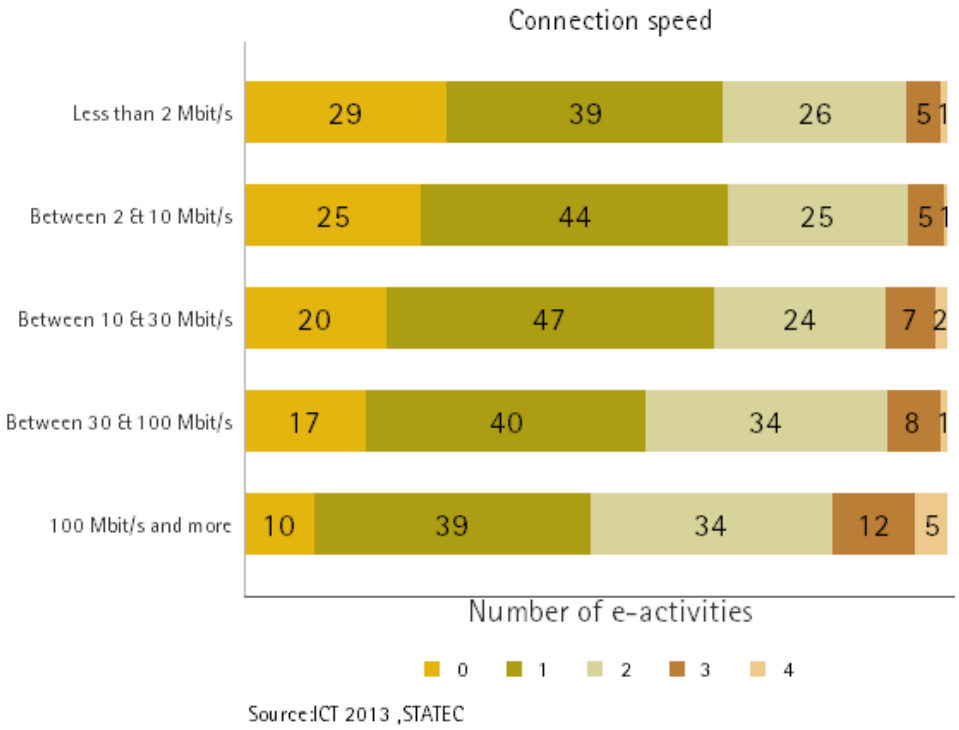


Figure 7. Predicted probabilities by type of connection

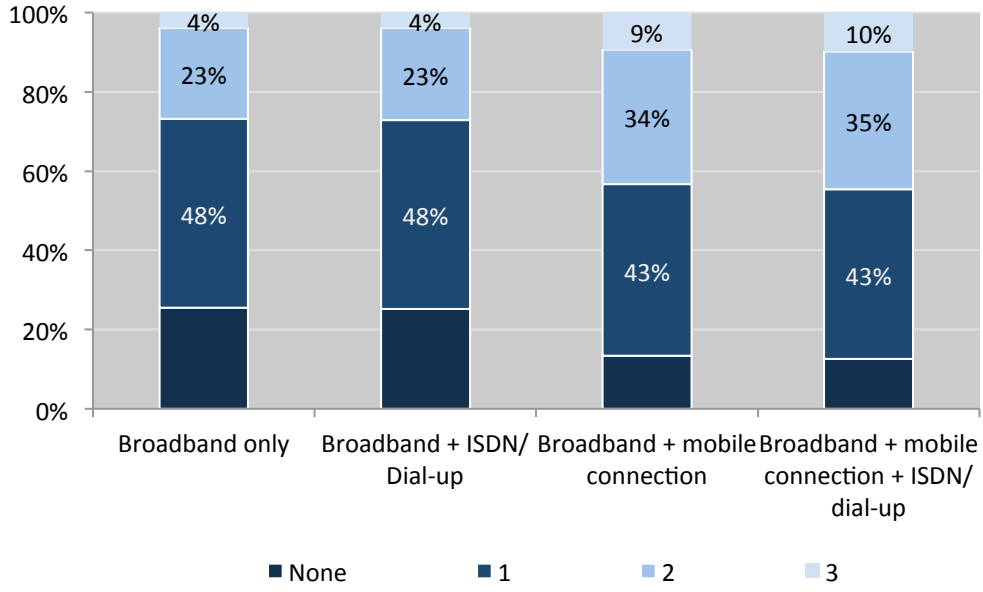
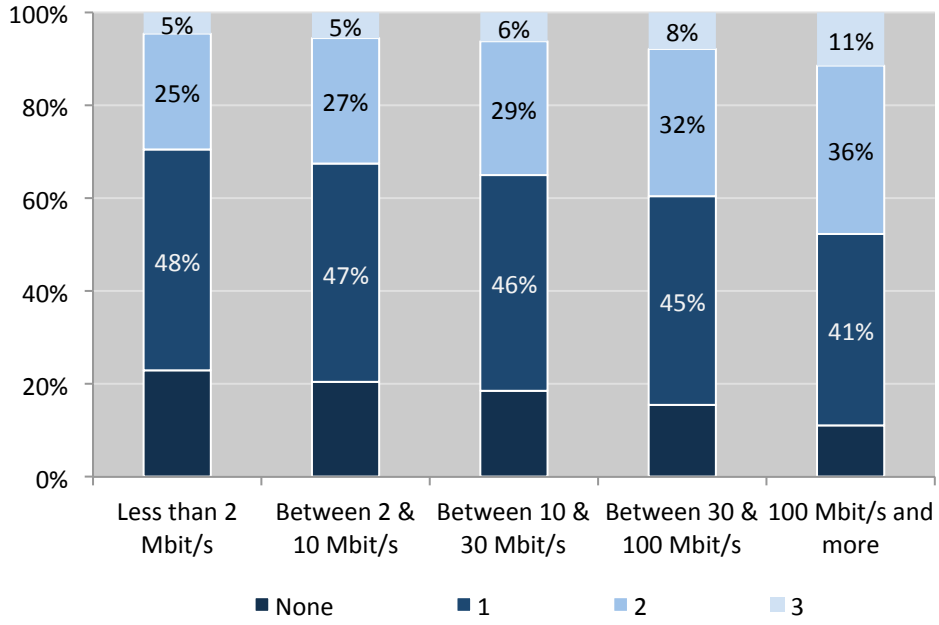


Figure 8. Predicted probabilities by speed of connection.



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