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Broadband and Entrepreneurship

A cross-country study of 23 OECD countries between 2004 and 2009[1]

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Abstract:

BROADBAND INTERNET is becoming an increasingly essential part of our economy. Its widespread use is creating a connected information society that is fundamentally changing the business environment in an increasing number of sectors. While academia has devoted much attention to this topic and established the positive effects of this development on economic growth and employment, the work of determining how these effects are obtained has only just begun. In this paper, we investigate the impact of broadband penetration on the level of entrepreneurial activity in 23 OECD countries in the period 2004-2009. We employ robust econometric methods to analyze a panel data set on new business registrations and broadband subscribers. In our aspiration to isolate the causal relationship between these variables, we use an instrumental variable approach based on infrastructure interdependence and an empirically established technology diffusion model. The results verify the prevalence of a significant direct effect on new business creation, as we find that an increase in broadband subscriptions of 1 per 100 inhabitants causes an average increase of 3.8% in the number of new businesses registered. In the average OECD country studied, this corresponds to 1,625 new firms. We acknowledge the inherent difficulties in controlling for the wide range of determinants of entrepreneurship, but find the estimate to be robust to different specifications and different instrumental variables.

Key Words: Broadband, internet, infrastructure, diffusion, entrepreneurship, innovation

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1. Introduction

Over the last decade, internet has evolved to become a vital component in society, with broadband as the medium of supply. While businesses have always adapted to technological innovations, the speed and magnitude by which internet has transformed the business environment is astounding. Broadband has consequently been defined as a General Purpose Technology "that fundamentally change how and where economic activity is organised" (OECD, 2008, p. 5). Prior academic studies have played a vital role in helping policymakers to understand how this change materializes in the economy. This study attempts to provide further clarity on these effects by investigating whether broadband has a positive impact on entrepreneurship.

As scholars have exerted much effort into studying the effects of broadband penetration, the positive effects on aggregated measures such as economic growth, employment and productivity have been well established. These relationships are widely acknowledged by policymakers and there are many recent examples of policy measures aimed at stimulating broadband roll out. For instance, the U.S. Congress approved $7.2bn worth of funding for broadband planning and deployment initiatives, through the American Recovery and Reinvestment Act of 2009 (Kruger, 2009).

Empirical evidence on more granular aspects, such as *how* these positive effects are generated, has thus far been scarce. By further understanding how output is increased and where jobs are created, policymakers could gain a wider perspective of reasoning and become more able to determine whether the effects are sustainable. This type of knowledge would also be highly relevant in the current debate on how to (re)allocate the scarce spectrum frequencies available for 4G, the next generation of mobile broadband, as well as provide content in discussions about public spending on broadband infrastructure.

In this study on the effect of broadband on entrepreneurship, we use a theoretically established view of the entrepreneur as a utility maximizer to derive our hypothesis. The entrepreneur is assumed to make an occupational choice of either employment or entrepreneurship, based on the expected difference in utility from these two alternatives. We hypothesize that increased broadband penetration will cause the expected utility from entrepreneurship to increase relatively more, causing the number of new businesses to increase.

In order test this hypothesis, we use robust econometric methods to analyze a dataset of 23 OECD countries between 2004-2009,[2] compiled from a number of reliable statistical databases belonging to the OECD, World Bank and International Telecommunications Union (ITU). We begin using a regular ordinary least squares estimation and continue by adding country fixed effects and time-variant control variables, in our attempt to isolate the causal effect of broadband. While no prior study found on broadband and entrepreneurship have gone beyond this stage, we continue to identify and eliminate sources of estimation bias through the use of an instrumental variable, drawing from a method previously used by Czernich et al. (2011). The instrument builds on the level of cable TV and telephony infrastructure prior to broadband introduction, as well as an empirically established model of technology diffusion. Using non-linear least squares, predicted values of broadband penetration are obtained and subsequently used as an instrument.

Our results show that a one percentage point increase in broadband penetration, ceteris paribus, results in an additional 0.086 new business registered per 1000 inhabitants of working age. Such an increase in broadband penetration is in line with the average percentage point increase between 2008 and 2009 for the 23 OECD countries. For the average OECD country in our sample, this corresponds to 1,625 new firms. In Sweden, the estimated number of new firms is equivalent to 523, an increase of 2.2%. These estimates are found to be robust for different specifications and when using different instrumental variables.

The remainder of this paper will be organized as follows. Section 2 discusses relevant prior research in this field. Section 3 presents an occupational choice model and related theory used to establish our hypothesis. Section 4 provides a brief presentation of method and data. Section 5 contains a discussion on regular OLS, fixed effects, and control variables, and ends with a presentation of empirical results. Section 6 identifies remaining sources of estimation bias, outlines the instrumental variable approach and presents empirical results. Section 7 contains a robustness discussion and robustness tests. Section 8 concludes by presenting the insights from this study and discussing the implications of our results.

[2] Countries include: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom.

2. Prior Research

Empirical Studies on the Effects of Broadband

Since the pioneering study by Jipp (1963), who demonstrated that the telephone density in a country is positively correlated with GDP per capita, there has developed a consensus that telecommunications infrastructure has a positive impact on an economy (Hardy, 1980; Leff, 1984; Madden and Savage, 1998). Broadband specific studies have been conducted on cross-country (Koutroumpis, 2009; Czernich et al., 2011), national (Crandall and Jackson, 2001; Crandall et al., 2007; Connected Nation, 2008; Kolko, 2010) and regional levels (Ford and Koutsky, 2005; Shiedeler et al., 2007), generally finding that broadband penetration has a positive and significant impact on economic growth. Holt and Jamison (2009) offers several explanations for these type of findings, "broadband applications can potentially substitute for labor, make the use of labor more efficient, and change the way work is done and the products that are produced" (p. 577). However, as many of these studies have lacked a robust strategy to disentangle causality, estimates often suffer from issues such as reverse causality and spurious correlation (Koutroumpis, 2009).

To correct for these issues, some authors have used a range of econometric techniques. Czernich et al. (2011) used pre-existing cable TV and telephony infrastructure as instruments for broadband penetration rates, in order to study the causal effect of broadband penetration on economic growth for 25 OECD countries between 1996 and 2007. Using this technique, they found that an increase in broadband penetration by 10 percentage points raises per-capita economic growth by 0.9-1.5 percentage points. With similar scrutiny, Koutroumpis (2009) tried to control for the fact that wealthy economies demand more broadband by developing a micro-model of supply and demand that endogenizes investments in telecommunications. Using data for 22 OECD countries between 2002 and 2007, he too found a positive and significant effect.

Empirical studies have also covered the impact on employment levels (Crandall et al., 2003; Ford and Koutsky, 2005; Gillet et al., 2006). In general, these papers conclude that broadband has a positive effect, although they often include a caveat for difficulties in isolating causality (Katz, 2010). Some studies have also highlighted the fact that broadband usage leads to higher productivity levels, however potentially causing capital-labor substitution (Gillett et al., 2006; Garbacz and Thompson, 2008).

Few empirical papers have investigated the impact of broadband on entrepreneurship. Gillett et al. (2006) used data on broadband deployment for 477 US zip codes for 1998-2002 and found that broadband access reduces the share of small business establishments by 1.3-1.6%. Given the limited availability of data, the authors however acknowledged "methodological challenges inherent in disentangling causality" (p. 10). Heger et al. (2011) used county-level data for Germany and found that broadband infrastructure does not have an impact on the overall level of entrepreneurial activities after controlling for regional characteristics. They did, however, find that it impacts entrepreneurship positively in high-tech industries, in which efficient ways of knowledge transfer are important. We note that the authors did not correct for reverse causality, suspected to bias the result as high rates of broadband penetration may be caused by demand from entrepreneurs in the high-tech sector.

Furthermore, van Gaasbeck et al. (2007) studied broadband usage in California and found a small negative association with the number of business establishments. The authors were, however, cautious about this finding and noted mixed results once they performed robustness tests. To control for reverse causality, they introduced a one-year lag on broadband penetration. While this control is useful to some extent, our view is that it does not account for the possibility that broadband penetration rates are dependent on predicted future levels of business activity.

In addition to mentioned endogenity issues, all of these studies have used county or state level data, causing estimates to potentially suffer from migration issues (Holt and Jamison, 2009). Entrepreneurs that desire broadband for their ventures could migrate to areas with broadband access to start their firms. This would bias the estimated impact of broadband penetration.

Theories on Entrepreneurship

In 20th century economic literature, theories on entrepreneurship mainly stem from three scholars: Schumpeter, Kirzner, and Knight. In the Schumpeterian world, entrepreneurship and innovation are closely related. In Schumpeter's own words, the entrepreneur as an innovator is responsible for "the doing of new things or the doing of things that are already being done in a new way" (Schumpeter, 1947, p. 151). Through "creative destruction", Schumpeter argued that entrepreneurship is the driver for business cycles and growth, as new innovations introduced to the economy replace old products. Kirzner (1973, 1985) saw the entrepreneur as an opportunist, exploiting profitable, publicly available opportunities. Successful entrepreneurs would therefore be the most alert ones.

Building on the works of Cantillon (1755), who emphasized the role of an entrepreneur not as an innovator but as a risk-taking speculator or arbitrageur, Knight (1971) saw the entrepreneur as a provider of two functions: "(a) exercising responsible control and (b) securing the owners of productive services against uncertainty and fluctuations in their incomes" (p. 278). The first function, which can also be interpreted as providing entrepreneurial inputs, helps to explain why "different individuals make different occupational choices by emphasizing the role of entrepreneurial ability" (Freytag and Thurik, 2007, p. 119-120). The second function, relating to the entrepreneur as a risk-taker, emphasizes the importance of individuals' risk-appetite when choosing occupation. One of Knight's main contributions was therefore to highlight the individual choice of whether or not to become an entrepreneur, as well as the importance of the risk and return associated with each choice (Parker, 2004).

The works of Knight have contributed to a modern view on entrepreneurship, in which the utility maximization choice is emphasized (Parker, 2004). According to Grilo and Thurik (2006), "[t]his approach views agents as (expected)-utility maximisers taking an occupational choice decision — to become employees or entrepreneurs — on the grounds of the utility associated with the returns accruing from the two types of activity" (p. 96).

Determinants of Entrepreneurship

As much research have built on occupational choice models, the earnings differential between self-employment and employment has had an elevated role. Several empirical studies, for example by Rees and Shah (1986), Dolton and Makepeace (1990), Bernhardt (1994), and Taylor (1996) have demonstrated that relatively higher earnings in the self-employed sector significantly increase the probability of individuals choosing to engage in entrepreneurial activities. Studies by Gill (1988) as well as Earle and Sakova (2000) have found opposite results. Parker (2004) argued that the mixed results could be a result of poor quality of data or varying definitions. Market imperfections in developing countries could as well be an explanation, as they would distort the occupational choice model (Earle and Sakova, 2000). The ambiguity could also potentially be explained by non-monetary factors. Prior studies have highlighted these factors by, for example, finding that individuals who value autonomy and "being one's own boss" could choose to be self-employed despite earning less (Hamilton, 2000).

Studies have also provided insight into how different variables can impact entrepreneurial earnings. Djankov et al. (2010) studied the impact of the corporate tax rate on new business registrations and found that it has a significant adverse effect on a cross-country level. Similar results were found by Klapper et al. (2006). The impact of taxation on occupational choice might, however, be more complex as all taxes on actual distributed profits should be accounted for. Prior studies by, for example, Fjaerli and Lund (2001) have showed that the choice of payout, in the form of wages or dividends, from corporations to owners, varies strongly with tax rates.

In accordance with the risk and return framework, scholars have also highlighted the role of risk in determining entrepreneurship levels. For example, Kihlstrom and Laffont (1979) developed a model in which they showed that risk-averse individuals to a higher extent choose wage employment, whereas less risk-averse individuals choose entrepreneurship. Models providing similar insights have been developed by Kanbur (1979) as well as Blanchflower and Oswald (1998), and empirical results confirming these insights have been established by van Praag and Cramer (2001).

It can further be argued that entrepreneurship levels vary with the business cycle. In this regard, Blanchflower (2000) found a negative relationship between unemployment and self-employment in most OECD countries. Bernanke and Gertler (1989) showed that upturns in the business cycle increase the net wealth of entrepreneurs, causing the costs of borrowing for investments to fall as agency costs for financiers decrease. High levels of real investment by entrepreneurs would therefore be prevalent in good economic times. Other scholars have studied the interdependence between entrepreneurship, risk and business cycles. Rampini (2004), for example, developed a model in which individuals could choose between a risk-free project and a risky project with higher expected value, interpreted as employment or entrepreneurship, respectively. As individuals are wealthier in good economic times, and thus able to take on more risk, more of them would choose the risky project. Cagetti and De Nardi (2006) found similar results showing that borrowing constraints, which are likely to be more prevalent in recessions, delay entrepreneurial activities.

Moreover, Reynolds et al. (2005) investigated the impact of per capita income on the level of nascent entrepreneurship. Interestingly, they found a U-shaped relationship, suggesting that nascent entrepreneurship is most prevalent in very poor and very wealthy economies. This could be explained by the findings of Autio et al. (2008), who showed that more than 50% of the entrepreneurs in less-developed countries, to some extent, choose to be self-employed out of necessity. This level is found to be lower in developed countries, where individuals to a greater extent choose to become entrepreneurs as a result of "improvement-driven opportunity recognition" (p. 19).

As previously mentioned, individuals have different entrepreneurial abilities and thus face different expected returns. In this regard, many studies have been devoted to determining the individual-level characteristics that promotes entrepreneurship. Extensive research has, for example, been done on the impact of education, although results are fragmented (Borjas, 1986; Fuji and Hawley, 1991; Georgellis and Wall, 2000). On the one hand, it is argued that education leads to selection into professions in which entrepreneurship is more common, such as managerial occupations (Evans and Leighton, 1989). On the other, the skills valued in entrepreneurial activities are different from those developed in formal education (Casson, 2003). However, results from empirical studies generally indicate that education levels have a positive net impact on entrepreneurship (Blanchflower, 2000; Parker, 2004).

Concluding Remarks

In the few papers studying the relationship between broadband and entrepreneurship, too little have, in our opinion, been done to ensure that reverse causality and spurious correlation are fully controlled for. Moreover, these studies have used regional level data and been unable to control for entrepreneurial migration. Empirical studies in related fields, such as those measuring the impact of broadband on economic growth, have employed more robust econometric methods to isolate the causal effect of broadband. Combining these robust econometric methods with relevant theories on entrepreneurship and cross-country level data,[3] we intend to contribute to the current state of knowledge by establishing the *causal* impact of broadband on entrepreneurship.

[3] We acknowledge that migration between OECD countries, in particular those which are members in the European Union, is relatively unrestricted. However, there certainly exists cultural and language barriers to a greater extent than for migration within countries.

3. Theory

As academic research on the determinants of entrepreneurship draws from a range of disciplines such as economics, psychology, and sociology some "eclectic" frameworks have been developed (Audretsch et al., 2002). In order to provide clarity to our hypothesis, we will however use an elementary risk and return framework based on our interpretation of Grilo and Thurik (2006).[4] To formalize our interpretation of this view, consider:

$$UD_i = U_{ei}[A_{ei} * \frac{E(E_e)}{r_e}; NMP_{ei}] - U_{wi}[A_{wi} * \frac{E(E_w)}{r_w}; NMP_{wi}] \tag{1}$$

Where, for every individual i, A_e denotes the entrepreneurial abilities, $E(E_e)$ denotes the general level of expected earnings as an entrepreneur, and r_e denotes the general risk associated with entrepreneurship. These factors, together with the non-monetary preferences for entrepreneurship, NMP_e, are inputs into the utility function, U_e. Similar to this, A_w denotes the abilities as an employee, $E(E_w)$ denotes the general level of expected earnings as an employee, and r_w denotes the general risk associated with employment. These factors, together with the non-monetary preferences for employment, NMP_w, are inputs into the individual's utility function, U_w.

The utility differential, UD, between entrepreneurship and employment determines the occupational choice of individual i. Assuming that the individual acts to maximize her utility, she will choose to engage in entrepreneurial activities if $UD > 0$, and she will choose employment if $UD < 0$.

To present our hypothesis, we will discuss how the components in Equation 1 are impacted by increased broadband penetration. While prior studies, as previously mentioned, have highlighted the importance of non-monetary preferences in occupational choice, our belief is that these will be largely unaffected by broadband. The non-monetary preferences are assumed to be relatively stable throughout the period of measurement. Similarly, the personal abilities for engaging in entrepreneurship or employment are not believed to be significantly affected by increased broadband penetration. Although virtually no empirical studies have been found to confirm this assumption, related empirical papers have, for instance, found that internet usage has no impact on the level of social capital (Bauernschuster et al., 2011). For these reasons, our hypothesis is based on the assumption that broadband mainly impacts $E(E_e)$, r_e, $E(E_w)$ and r_w.

[4] For more comprehensive models, see Kanbur (1979), van Praag and Cramer (2001), and Parker (2004).

It should be noted that we will discuss many internet functions as being enabled by broadband only. This is seen as a fair assumption given that the maximum speed obtained through dial-up modems, the main alternative technology, is 56kbit/s (Australian Communications and Media Authority, 2011). Studies have shown that many activities, such as e-shopping, are technically too complex for these dial-up modems (Kiesler et al., 1996). Furthermore, as dial-up technologies connect via the dialed telephone connection and do not have a dedicated line (Australian Communications and Media Authority, 2011), usage could sometimes be constrained.

Impact on Expected Earnings as an Entrepreneur

Broadband is believed to increase the revenue potential for entrepreneurs, as well as reduce the costs of obtaining external resources. As potential entrepreneurial earnings increases, entrepreneurship becomes more attractive. The level of entrepreneurship should therefore rise. Three main reasons for increased potential earnings are presented below.

Broadband and Market Access

The increased diffusion of broadband and internet usage will enable entrepreneurs to "efficiently expose their companies, market and sell their products and services to a wider audience than they would have been able to afford to reach using the traditional methods" (Lawrence and Tar, 2011, p. 102). For example, broadband enables activities such as e-commerce, through which retailers can reach customers in a much wider geographic area than through physical stores (Atasoy, 2011). The market potential therefore increases significantly for entrepreneurs with access to broadband. Numerous studies have verified the impact of market potential on entrepreneurship. Berry and Reiss (2007) claimed that thresholds exist to the regional population size for which firms establish themselves as going concerns. Also, they argued for a positive relationship between population size and firm entry rate. Sato et al. (2012) verified the prevalence of this relationship as they found that an increase in population density by 10% raises the number of individuals intending to become entrepreneurs by approximately 1%.

Broadband and Transaction Costs

Increased internet usage allows for the establishment of an "effective inter-business collaboration" (Hsieh and Lin, 1998). As small firms often suffer from limitations in various types of resources (Regan and Wymer, 2005), broadband can reduce the transaction costs involved in obtaining these resources externally. According to Williamson (1985), transaction costs stem from asset specificity, information asymmetry, and opportunism. Based on this widely accepted theory, other scholars have argued that the increased prevalence of broadband and internet could reduce these factors, hence lower the transaction costs.

Afuah (2003) argued that asset specificity, defined as the "degree to which an asset can be redeployed to alternate uses and by alternate users without sacrifice of productive value" (Williamson, 1991, p. 281), is affected in three ways by increased internet usage. First, internet could facilitate low-cost information exchange about the asset and its value to other potential owners. Second, it reduces the site-specificity of assets as firms can exchange large quantities of information without actual physical interactions, reducing the dependency of geographic proximity to counterparts. Third, internet reduces the specificity of some information technology related assets by replacing them with its more standardized technology.[5]

Increased broadband and internet access also reduces information asymmetries (Wallace, 2004) by facilitating access to market prices through, for example, search engines and price-comparison websites (Brynjolfsson and Smith, 2001). Costs of monitoring and enforcement can also be reduced, as information on and reputation of the potential counterpart becomes more accessible (Brews and Tucci, 2004).

In line with the theories of Coase (1937), these developments should lower the optimal size of a firm. As transactions can be more efficiently handled through market exchange, the incentive for firms to internalize transactions diminishes. Lower transaction costs could thus indirectly increase the market potential for entrepreneurs, as potential customers become more inclined to purchase goods and services externally, as well as directly lower the costs for entrepreneurs to obtain resources externally.

Broadband and Entrepreneurial Opportunities

The potential earnings as an entrepreneur could also be positively impacted by new opportunities that arise due to widespread broadband access. Baumol (1986) expressed a view of entrepreneurship as individuals responding to opportunities for new products that arise due to technological progress. Eckhardt and Shane (2003) viewed changes in supply and demand as one way to categorize how these opportunities occur. On the supply side, Schumpeter (1934) identified five sources of opportunities including changes in the ways of organizing, new products or services, and new production processes. Exogenous shifts in demand factors such as perception and taste could similarly act as sources of opportunities (Kirzner, 1997). Scholars have further argued that incumbent corporations and organizations might not automatically respond to these opportunities, for example due to uncertainties about the value of new knowledge,

[5] Afuah (2003) exemplifies this with internet replacing proprietary communication networks such as Electronic Data Interchange (EDI), in which only network members could exchange information. For example, if a supplier wanted to cooperate and communicate with a new retailer, the supplier had to invest in new EDI equipment in order to access the network specific to the retailer. With the introduction of internet, the supplier could use the same equipment for all relationships.

information asymmetries and discrepancies between the new idea and core competencies (Acs and Varga, 2005; Audretsch and Keilbach, 2006; Acs et al., 2009). This would consequently leave room for entrepreneurial exploits.

In accordance with Carree et al. (2010) who claimed that "[t]echnological change may be the most significant determinant of expanded entrepreneurial opportunities in the late twentieth and early twenty-first century" (p. 212), our belief is that increased diffusion of broadband will allow for new entrepreneurial opportunities to arise. These could either be supply-oriented, for example through new ways of using the internet for organizational purposes, or demand-oriented, as consumers demand more IT-solutions.

Increased broadband penetration can also be expected to facilitate the *discovery* of new opportunities. Heger et al. (2011) argued that broadband access reduces proximity not only to customers, but also to "knowledge incubators", such as universities, other institutions, and, in particular, local business communities. According to Harhoff (1999), these networks facilitate entrepreneurial activities through "knowledge spillovers", especially in technology-intensive industries. This line of reasoning is supported by scholars such as Christensen and Peterson (1990), who argued that encounters between an individual and his network are important sources of new ideas.

Impact on Entrepreneurial Risks

To clarify the impact of broadband penetration on entrepreneurial risks, r_e, we will discuss how broadband affects new firm survival. Based on the many empirical studies conducted in this field (see Evans and Siegfried, 1994 and Parker, 2004 for summaries), two variables, market positioning and financing, are believed to be of particular importance.

As entry into an industry often entails investments (Porter, 1979), entrepreneurs are likely to lack the capital for these relative to larger firms. As support for this hypothesis, White (1982) found that small businesses are more present in industries with low capital to labor ratios. As entrepreneurs therefore tend to be more dependent on financing, this factor might pose a significant obstacle for survival. Bates (1997) found that American males who became self-employed between 1976 and 1982 and received above-average rates of financing were less likely to exit than their counterparts. Similar results have been found by Taylor (1999). As internet have made business activities more digitalized and less capital intensive (Porter, 2001; Parker, 2004), the need for financing investments has reduced and the risk of entrepreneurship has consequently decreased.

Furthermore, scholars have argued that firms having a dynamic or diversified product range as a result of, for example, re-positioning in the event of market changes that creates new niches (Holmes and Schumitz, 1990), increases the chance of entrepreneurial survival. Brüderl et al. (1992) found supporting results showing that survival rates were higher for firms with national rather than local market coverage. As broadband increases "firms' ability to move more quickly from idea to product" (OECD, 2008, p. 11) as well as to reach a wider market, entrepreneurial survival rates should increase.

Given that broadband has a positive impact on new firm survival rates, the risk associated with entrepreneurial activities is expected to have decreased, making entrepreneurship a more attractive alternative relative employment.

Impact on Expected Employment Earnings and Risks

There have historically been doubts as to whether information and communications technologies (ICT) impact productivity. Scholars have discussed the "productivity paradox", classically described by Robert Solow as, "[y]ou can see the computer age everywhere but in the productivity statistics" (Solow, 1987, p. 36). In recent years, increasing evidence have been found on the positive effects of ICT on productivity (Bosworth and Triplett, 2003; Carare et al., 2009). One could therefore expect some of the increased productivity to be captured by higher wages, increasing expected employment earnings. Scholars such as Gillet et al. (2006) and Kolko (2010) have tried to prove this hypothesis empirically but found no significant evidence of it to be true. According to Kolko (2010), this could be due to flexible labor markets in the sense that immigration of workers keeps wages from rising.

Broadband could also be argued to impact some determinants of employment risk, for example by substituting some labor functions (Garbacz and Thompson, 2008) and by increasing labor market efficiencies through increased use of e-recruiting. However, due to the lack of research in this field (Holt and Jamison, 2009), it becomes difficult to assess the net impact.

Despite the results from prior studies, one might suspect that increased broadband penetration increases the risk-weighted wages as a consequence of productivity increases. In particular, the argument by Kolko is not fully convincing in a cross-country setting where labor migration between countries is more restricted.

Potential Lagged Effect of Broadband

One might suspect there to be a time-lag before a given increase in the number of broadband subscriptions is reflected in higher levels of entrepreneurship. It could be argued that individuals must pass through a process of "organizational emergence", which consists of activities such as preparing a plan or buying or renting facilities, before they start their business (Carter, 1996). Few prior empirical studies on the economic effects of broadband have however used lagged variables for other reasons than to correct for reverse causality. Kolko (2012) investigated the possibility of an impact from broadband expansion 1992-1999 on employment growth 1999-2006 and found no significant results, concluding that there are no long lags in the relationship. Czernich et al. (2011) also use time-lags of their independent variable, but conclude that most of the effect of broadband on economic growth occurs contemporaneously.

Summary and Hypothesis Formulation

As can be concluded from the discussion above, increased broadband penetration is believed to be reflected in significantly higher entrepreneurial earnings, as well as lower entrepreneurial risks. While broadband could also potentially raise the risk-weighted employment earnings through increases in productivity, these increases are expected to be significantly lower. Although the magnitudes of our arguments have not been quantified, this is to be expected given the many more channels through which broadband penetration increases the utility of entrepreneurship.

Thus, our hypothesis is that increased broadband penetration has a significant and positive impact on the utility differential, UD. This would make entrepreneurship a more attractive alternative for many individuals, and should therefore result in a higher number of new business registrations.

4. Method and Data Presentation

Given the empirical nature of the research question, an econometric approach will be employed in this study. Since the aim is to obtain the causal effect of broadband on entrepreneurship, a range of econometric techniques will be introduced to disentangle causality. First, a regular ordinary least squares estimation will be run. Second, country fixed effects will be added to capture country-specific time-invariant factors affecting entrepreneurship. Control variables will also be introduced in an attempt to control for time-variant factors. Third, drawing from a prior empirical study by Czernich et al. (2011), an instrumental variable approach, based on pre-existing cable TV and telephony infrastructure as well as a non-linear technology diffusion model, will be employed to correct for any potential bias. These methods will be further discussed and evaluated in coming sections. Potential remaining endogenity issues will then be identified, and the model will be tested for robustness.

Panel data for 2004-2009 on 24[6] OECD countries have been collected from the statistical databases of OECD, World Bank and the ITU.[7] Definitions of the variables and their corresponding sources are presented in Table 1. Table 2 and 3 contains statistical descriptions of the variables.

There are two major reasons for studying OECD countries. First, due to the relative novelty of broadband as well as the expensive networks required to supply it, mainly developed economies have been able to expand its broadband infrastructure to such an extent that relevant variation exists in the data. Second, given the previously mentioned differences in motivations for entrepreneurial activity between developed and developing countries, our interest is mainly to capture "opportunity-based entrepreneurship". This is the kind of entrepreneurship that is expected to affect economic growth, and hence be of greatest interest to policymakers.

Entrepreneurship data is obtained from the World Bank (The World Bank, n.d.) and defined as new business registrations per 1000 inhabitants of working age (15-64 years). The World Bank, in turn, has collected this data from national business registries. New business registrations are defined as the number of new limited liability corporations registered in the calendar year.

Broadband penetration data is obtained from the OECD (OECD, 2011b) and is defined as the number of broadband internet subscribers per 100 inhabitants. OECD defines broadband as a

[6] 23 countries were used in the regressions as Korea is subsequently removed as an outlier.
[7] Due to data limitations, Chile, Estonia, Iceland, Israel, Luxembourg, Mexico, New Zealand, Slovenia, Turkey and the United States are not included in the sample despite being OECD members.

line that offers more than or equal to 256Kbit/s in download speed.[8] This definition is shared by the ITU (ITU, 2010), although other bodies such as the U.S. Federal Communications Commission (FCC) have historically used 200Kbit/s as its lower limit (FCC, 2010). It should be noted that this data does not capture mobile broadband subscribers that have increased significantly over the previous decade. In the U.S., for example, the number of mobile subscribers grew from 3 million in December 2005 to 51 million in December 2007 (Wireline Competition Bureau, 2009).

Moreover, as many prior studies (for example Gillett et al., 2006; Kolko, 2010) use availability-oriented measures as independent variable,[9] it should be noted that this data measures penetration using actual subscriptions as a proxy. The reason for choosing data on "subscriptions", over for example "broadband lines", is that it lies much closer to actual usage of broadband, a prerequisite for economic consequences to occur.

[8] Technologies include xDSL, cable, satellite, fibre-to-the-home, Ethernet LANs, and fixed wireless broadband.
[9] These studies use FCC Form 477 data on zip-code level which captures the number of broadband providers with at least one provider in each zip code.

Table 1: Variable Definitions

Variable	Variable Name	Definition	Source
NBD	New business density	New business registrations per 1000 inhabitants of working age (15-64 years)	World Bank, WDI
BBPEN	Broadband penetration rate	Number of broadband internet subscriptions (≥ 256 Kbit/s) per 100 inhabitants	OECD Communications Outlook
GDPG	Real GDP growth	Real gross domestic product growth rate	OECD Stat
WAGE	Average wage	Average annual wage (thousands), 2009 USD PPPs, 2009 constant prices	OECD Stat
EDUC	Education	Students enrolled in tertiary education per 100 inhabitants	OECD Stat
TAX	Total tax on distributed profits	Total tax (corporate and personal tax) on 100 units of distributed corporate profits	OECD Tax Database
CTV96	Cable TV subscribers	Cable TV subscriptions per 100 inhabitants	ITU World Telecommunications
TEL96	Fixed telephone lines	Fixed telephone lines per 100 inhabitants	ITU World Telecommunications

Table 2: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
NBD	130	3.9	2.33	0.5	11.0
BBPEN	138	19.1	9.19	0.5	37.4
GDPG	138	1.8	3.30	-8.4	10.5
WAGE	138	34.1	9.63	14.3	49.6
EDUC	137	4.0	0.87	2.7	6.0
TAX	138	43.9	9.07	19.0	60.1
CTV96	23	13.6	11.55	0.0	37.3
TEL96	23	47.1	13.45	17.1	68.2

Table 3: Descriptive Statistics by Country

	AUS	AUT	BEL	CAN	CHE	CZE	DEU	DNK	ESP	FIN	FRA	GBR	GRC	HUN	IRL	ITA	JPN	NLD	NOR	POL	PRT	SVK	SWE	Total
NBD	6.33	0.64	4.15	8.00	3.38	2.53	1.18	6.29	4.57	3.20	3.14	9.25	0.94	4.46	5.97	1.89	1.43	2.95	4.84	0.49	4.01	3.64	4.04	3.86
	(0.30)	(0.04)	(0.37)	(1.05)	(1.33)	(0.53)	(0.04)	(1.39)	(0.97)	(0.62)	(0.32)	(1.08)	(0.22)	(1.48)	(0.90)	(0.08)	(0.19)	(0.43)	(0.90)	(0.02)	(0.38)	(0.63)	(0.58)	(2.33)
BBPEN	18.4	17.4	23.1	24.8	28.2	11.8	20.2	30.9	15.6	25.5	21.3	21.9	7.76	11.5	13.6	15.1	21.8	30.4	27.1	7.19	13.4	6.54	26.9	19.1
	(6.71)	(4.45)	(5.37)	(4.86)	(6.69)	(6.44)	(8.57)	(7.47)	(5.11)	(5.96)	(7.62)	(7.42)	(6.71)	(6.01)	(7.47)	(4.62)	(2.66)	(7.00)	(7.25)	(4.17)	(3.56)	(4.48)	(5.40)	(9.19)
GDPG	2.86	1.66	1.45	1.51	2.11	3.78	0.80	0.52	1.92	1.45	1.05	0.94	1.96	1.14	1.73	-0.02	0.27	1.64	1.67	4.78	0.54	5.23	1.56	1.76
	(0.88)	(2.82)	(2.27)	(2.28)	(2.05)	(4.39)	(3.16)	(3.42)	(2.99)	(5.11)	(2.09)	(3.06)	(3.21)	(4.31)	(5.36)	(2.93)	(3.51)	(2.67)	(2.07)	(1.90)	(1.87)	(5.35)	(3.70)	(3.30)
WAGE	42.8	39.9	42.0	39.3	47.8	18.7	37.4	41.3	30.9	33.7	36.3	43.4	27.5	18.7	44.5	31.8	33.0	43.3	41.6	17.2	21.5	16.1	35.0	34.1
	(1.02)	(0.90)	(0.37)	(1.89)	(1.14)	(1.13)	(0.09)	(1.10)	(1.00)	(1.14)	(0.59)	(0.67)	(0.70)	(0.44)	(2.13)	(0.13)	(0.28)	(1.20)	(2.20)	(0.53)	(0.71)	(1.20)	(1.30)	(9.63)
EDUC	5.14	3.20	3.76	3.66	2.81	3.49	2.81	4.20	4.05	5.78	3.53	3.88	5.68	4.21	4.35	3.40	3.13	3.56	4.58	5.58	3.56	3.79	4.61	4.04
	(0.18)	(0.29)	(0.09)	(0.71)	(0.14)	(0.32)	(0.09)	(0.10)	(0.16)	(0.12)	(0.05)	(0.07)	(0.24)	(0.15)	(0.24)	(0.04)	(0.06)	(0.14)	(0.07)	(0.12)	(0.11)	(0.51)	(0.14)	(0.87)
TAX	47.2	44.9	43.9	50.9	49.0	35.3	51.5	58.8	46.6	38.1	56.1	47.0	29.7	45.5	48.8	39.8	45.6	46.1	41.4	34.4	41.6	19.0	49.4	43.9
	(1.02)	(2.76)	(0.00)	(3.39)	(7.77)	(2.55)	(2.27)	(0.91)	(3.73)	(4.60)	(0.59)	(0.77)	(4.14)	(2.94)	(0.48)	(2.49)	(0.00)	(3.34)	(10.41)	(0.00)	(0.44)	(0.00)	(0.49)	(9.07)
CTV96	1.17	10.4	36.0	26.6	34.2	6.04	20.4	23.6	1.11	16.4	3.65	3.56	0.00	13.9	14.8	0.03	10.0	37.3	15.2	7.21	1.70	8.37	21.5	13.6
TEL96	50.1	49.0	45.5	60.7	64.6	27.3	53.8	61.8	39.0	55.5	56.7	52.7	49.8	25.7	38.3	44.4	50.9	54.3	56.7	17.1	38.0	23.2	68.2	47.1

Note. Mean values. Standard deviations in parentheses.

5. The Relationship between Broadband and Entrepreneurship

Results are presented in Table 4. Model 1 shows the relationship between broadband penetration and new business density obtained using a regular ordinary least squares (OLS) estimation for the set of 23 countries. As can be inferred from Table 4, there exists a positive and significant correlation between the two variables. As Model 1 does not account for persistent country-specific differences, such as the level of other infrastructure and the quality of the institutional framework, it is likely to suffer from spurious correlation, since countries are compared without accounting for their inherent differences.

In Model 2, country fixed effects are added to control for these persistent differences. Revisiting Equation 1, country fixed effects also control for non-monetary occupational preferences and relative occupational abilities, assuming that they remain stable between 2004 and 2009. As can be seen in Table 4, introducing country fixed effects causes the coefficient of broadband penetration to decrease significantly, indicating that the time-invariant fraction of the error term causes the coefficient estimated by regular OLS to be positively biased.

Model 2 does not account for time-variant omitted variables such as the business cycle. Our estimate is therefore still likely to be biased. Controlling for these effects cannot be done on a general basis but omitted variables will have to be individually identified and made exogenous. To identify variables to include, we base our reasoning on prior research on the determinants of entrepreneurship as well as the model specified in Equation 1. Thus, we include controls for real GDP growth, average wages, the share of population enrolled in tertiary education and the tax rate on total distributed profits. This specification is shown in Model 3.

These added control variables are deemed to have fulfilled the criteria for being omitted. While varying relatively much over time, they also partially determine the components in our model specified in Equation 1, thus affecting entrepreneurship levels. They are also suspected to be correlated with the level of broadband penetration for various reasons.

Real GDP growth, interpreted as the business cycle, could potentially correlate with the level of broadband penetration through the investment levels of telecom firms. In good economic times, firms are more optimistic, have access to more capital and invest more, thus increasing penetration rates. Average wages could also correlate with broadband penetration as higher wages might result in higher demand for broadband. Moreover, education levels are suspected to correlate with broadband penetration as education increases the "technological literacy" among individuals, thus increasing the demand for broadband, as these skills are required for many technological products. The tax rate on total distributed profits is also expected to correlate with broadband penetration. In countries with high levels of taxation, government spending is likely to be relatively high. As some of this is spent on infrastructure, such as broadband, penetration rates are likely to be high in these countries.

Having added country fixed effects and controlled for time-variant omitted variables, the estimate of the impact of broadband penetration is less biased than prior ones. However, adding the above mentioned controls causes the significance level of the estimate to decrease from 1% to 5%, as shown in the results of Model 3. Model 4 instead includes a lag on broadband penetration, and as can be seen, lagged broadband penetration has a significant and positive impact. While multicollinearity between present and lagged penetration rates prevents us from determining whether the effect occurs contemporaneously or with a time-lag, we can see that coefficients are similar and that our estimates are therefore not reliant on the independent variable being correctly specified in time. We interpret this as a sign of robustness.

Even though the model specified in Equation 1 is useful for identifying potential omissions, employing it for this purpose implies one significant danger. The identified and included control variables impact entrepreneurship levels causally. If one of these variables is also causally impacted by increased broadband penetration, then our specification might have over-controlled for variables as these should be captured by the estimated effect of broadband. Given the productivity increases caused by broadband, one could argue that including average wages suffers from this fallacy. We have, however, included it as a control variable since omitting it would likely lead to a greater bias, as we reason that it is more likely to be correlated with broadband in other ways than through productivity.

Table 4

Ordinary least squares: Controls and Fixed Effects

	Model 1	Model 2	Model 3	Model 4
Dependent variable	New business density	New business density	New business density	New business density
Broadband penetration rate	0.079***	0.047***	0.067**	
	(0.019)	(0.015)	(0.029)	
Lagged broadband penetration rate				0.060***
				(0.023)
Real GDP growth			0.072	0.086*
			(0.047)	(0.046)
Average wage			-0.003	0.002
			(0.202)	(0.194)
Education			0.088	0.100
			(0.490)	(0.509)
Total tax on distributed profits			0.013	0.009
			(0.022)	(0.020)
Country dummies	No	Yes	Yes	Yes
Constant	2.355***			
	(0.403)			
Observations	130	130	129	129
Countries	23	23	23	23
R^2 (within, for fixed effects models)	0.10	0.13	0.20	0.20

Note. Ordinary least squares estimation for 2004-2009. New business density measured as number of business registrations per 1000 inhabitants of working age (15-64 years). Broadband penetration rate measured as subscriptions per 100 inhabitants. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

6. The Causal Effect of Broadband on Entrepreneurship

The Need for Further Econometric Methods

Even though Model 3 in Table 4 contains controls for both time-invariant and relevant time-variant variables, we still suspect that broadband penetration remains endogenous and that its estimated effect on entrepreneurship therefore suffers from a bias. There are two main reasons for this.

First, due to the wide range of variables potentially correlated with entrepreneurship and broadband penetration as well as the difficulty in finding data for some of these, the estimation may still suffer from omitted variable bias. One of the most significant omitted variables is believed to be government policy. Given that policies affecting both entrepreneurship levels and broadband penetration could be discretionary, finding a suitable proxy for it becomes difficult. Other potential omitted variables are increased usage of different communication technologies, such as mobile broadband, mobile telephones and computers. Provided that these technologies have a similar effect on entrepreneurship as fixed broadband has, the omission of controls for these technologies potentially make our estimates biased. Moreover, given the wide range of determinants of entrepreneurship, it is likely that some critical control variables have been overlooked and consequently omitted.

Second, the estimation model has thus far not corrected for reverse causality. One direct and one indirect source of this have been identified. Assuming that most of the new businesses require broadband access, an increase in the number of new firms will directly increase the demand for broadband and potentially affect penetration rates. Also, as a significant share of the new businesses are likely to be IT-related, innovations and new product offerings created by these firms will indirectly increase the value that consumers put on broadband access. This shift in valuations may cause some consumers, who previously valued broadband lower than its price, to demand broadband and cause penetration rates to increase.

To solve these issues and obtain an unbiased and consistent estimate of the isolated causal effect of broadband penetration on entrepreneurship, an instrumental variable approach is employed.

The Technology Diffusion Model

The instrumental variable (IV) approach employed in this paper fundamentally follows a procedure developed by Czernich et al. (2011), who studied the effect of broadband penetration on economic growth. The approach is based on the interdependence between telephony, cable TV, and broadband infrastructure. Most broadband technologies (e.g., ADSL, VDSL, Cable) are dependent on the copper wire of the telephone lines and the coaxial cable of the cable TV network, for transmission of data from telephone exchange to household and from street cabinet to household, respectively (Aber, 1998; Lane, 1998). In deployment of fibre-to-the-home (FTTH), another common broadband technology, operators use the existing ducts of prior networks. A new cable can be pulled or blown into the existing duct, while operators otherwise have to dig trenches to deploy new ducts (CSMG, 2010). A country with an extensive existing telephony and cable TV infrastructure should thus be expected to reach high levels of broadband penetration. This interdependence is exploited to construct a relevant IV for broadband penetration.

Data from the ITU on telephone lines and cable TV subscribers, as per 1996, is used to predict the maximum achievable rate of broadband penetration. This was the year before broadband deployment had begun in any of the OECD countries in this study.[10] In line with the reasoning of Czernich et al. (2011), the maximum achievable rate of broadband penetration within a country, denoted by δ_i, can thus be predicted by the following model:

$$\delta_i = \alpha_0 + \alpha_1 CTV96_i + \alpha_2 TEL96_i \qquad (2)$$

Extensive research on technology diffusion pioneered by Griliches (1957) and Mansfield (1961), and brought forward by for example Geroski (2000) and Comin et al. (2008), have found that the diffusion rate over time, for a large number of technologies, follow an S-shaped curve.[11] Two established explanations for this phenomenon have been discussed by Geroski (2000), and will be presented in order to underpin our hypothesis that broadband penetration follows a similar pattern.

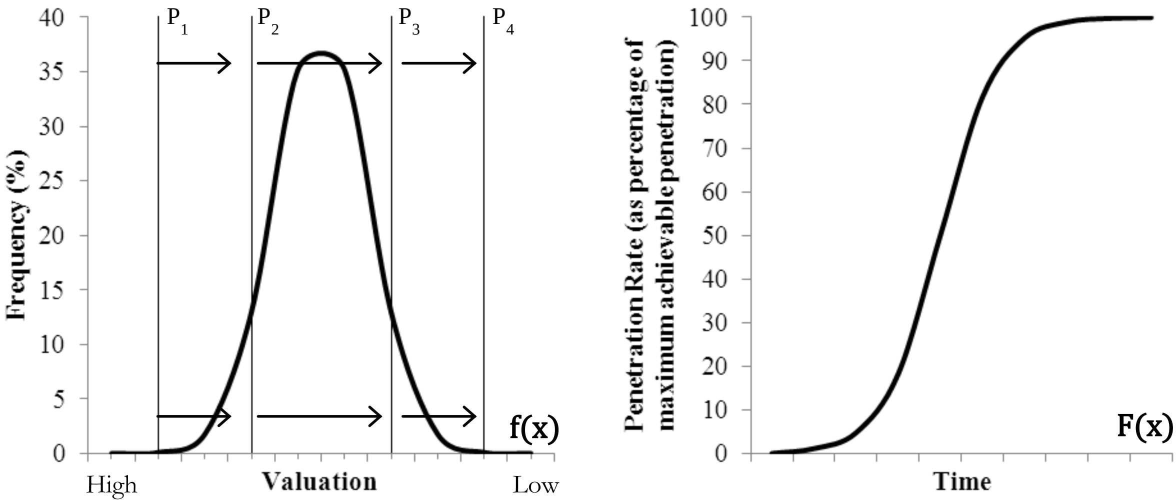
One of them is the probit model, in which three assumptions are made: 1) The values that individuals put on technology access follow a normal distribution 2) The price of technology access decreases over time 3) An individual adopts the technology when his or her valuation is greater than the price. This set of assumptions generates a situation where, for every discrete decrease in price, a larger fraction of the population finds the price of technology access below their valuation. This makes adoption of the technology an opportunity for a positive consumer surplus trade, which consumers are assumed to take. Given the bell shape of the normal distribution, diffusion starts out slowly but increases exponentially until the diffusion speed

[10] In our dataset, the first country to deploy broadband was Canada that started deployment in 1997 and had reached 0.1 subscribers per 100 inhabitants by the end of the year (OECD, 2011b).

[11] When only the extensive margin is considered (the number of users), technology diffusion tends to be S-shaped. Comin et al. (2008) however found that once the intensive margin is included in the measure (frequency of use), the S-shaped curve provides a poor estimation of the actual diffusion process. As we only consider the extensive margin of broadband penetration, the S-shape should be a good estimation.

reaches its peak as price moves past the mean valuation. The diffusion speed then diminishes towards the end of the period. This will create an S-shaped diffusion curve, as shown in Figure 1. The S-shaped curve is essentially a cumulative function of the normally distributed valuations.

Figure 1: The Probit Model



Note. P_t denotes discrete decreases in price

The alternative, and arguably more popular, explanation is the epidemic model of information diffusion. In this model, it is assumed that potential adopters will adopt a new technology once they learn about it. One can think of the technology as superior to any existing alternative technology. As current users are the ones teaching potential adopters about the new technology, the diffusion speed is slow at first as the number of users is small. As more and more individuals adopt the technology, the diffusion speed increases exponentially. Diffusion inevitably approaches its saturation point, at which the speed of diffusion decreases and goes towards zero. This too will generate an S-shaped curve. It should be noted that one explanation does not necessarily rule out the other, as the combination of the probit model and the epidemic model "simply reinforces the S-shape of the curve" (Hall, 2005, p. 467).

Provided that broadband penetration follows this pattern of technology diffusion, it can be described by the following logistic model, first applied by Griliches (1957):

$$BBPEN_{it} = \frac{\delta_i}{1 + \exp\left(-\alpha_3(t - \alpha_4)\right)} + \epsilon_{it} \qquad (3)$$

In this model, $BBPEN_{it}$ denotes the broadband penetration rate at time *t* for country *i*. It is given by the maximum achievable rate of penetration, δ_i, the diffusion speed, α_3, the inflexion point of the S-curve, α_4, and the error term, ϵ_{it}. By inserting Equation 2 into Equation 3 we can form an estimation model for broadband diffusion curves:

$$BBPEN_{it} = \frac{\alpha_0 + \alpha_1 CTV96_i + \alpha_2 TEL96_i}{1 + \exp\left(-\alpha_3 (t - \alpha_4)\right)} + \epsilon_{it} \tag{4}$$

This model serves as a prediction model for broadband penetration. By using non-linear least squares, we can fit the model to actual broadband penetration rates and generate fitted values for α_0, α_1, α_2, α_3, and α_4. With these fitted values at hand, predictions of broadband penetration rates can be made.

These counterfactual values are thus determined solely by a set of predetermined factors and an empirically established functional form assumption. The diffusion model allows two time-invariant predetermined values, cable TV subscribers and telephone lines, to generate time-variant predicted values of broadband penetration.

$$\widehat{BBPEN}_{it} = \frac{\widehat{\alpha_0} + \widehat{\alpha_1} CTV96_i + \widehat{\alpha_2} TEL96_i}{1 + \exp\left(-\widehat{\alpha_3} (t - \widehat{\alpha_4})\right)} \tag{5}$$

Prediction Results from the Technology Diffusion Model

When fitting the logistic diffusion curve in Equation 4 to the actual broadband penetration rates of the 23 OECD countries, we obtain very accurate predictions. As can be seen in Table 5, cable TV subscribers and fixed telephone lines both have a significant impact on the maximum achievable penetration rate δ_i. The F-test of both coefficients jointly being zero results in an F-statistic of 95.75, with which the null hypothesis can be rejected at any reasonable level of significance. The significance is substantiated in Figure 2, which shows that predictions of maximum achievable penetration rate results in close approximations of actual values.

As shown in Table 5, the inflexion point of the diffusion curve is estimated to be in year 2004, which corresponds to the beginning of the period studied in this paper. The S-shape of the actual broadband diffusion curve is evident in Figure 2, and it is clear that a linear functional form would fit the diffusion curves significantly worse than the non-linear logistic model employed. Furthermore, we see no general trend of either over or under-prediction across countries. Greece is an example of over-prediction, for which the reason is most likely the Greek government's slow implementation of the EU framework on broadband competition, as it took until 2006 for Greece to allow multiple telecom operators to use the existing fixed telephony infrastructure for transmission of broadband internet (Point Topic, 2011). Korea is an example of a country where the predicted values are significantly lower than actual values. This is because the government has invested heavily in the deployment of fibre-to-the-home (FTTH), and thus raised the diffusion speed abnormally high (Business Software Alliance, 2012).

These are both examples of countries for which government involvement is potentially making actual broadband penetration an endogenous variable. As shown in Figure 2, our predictions resolves this endogeneity by using only predetermined factors in combination with the diffusion model. While this control for endogeneity issues is the reason for employing the diffusion model, the exceptionally bad fit for Korea makes it an outlier. We have therefore excluded Korea throughout our estimations.

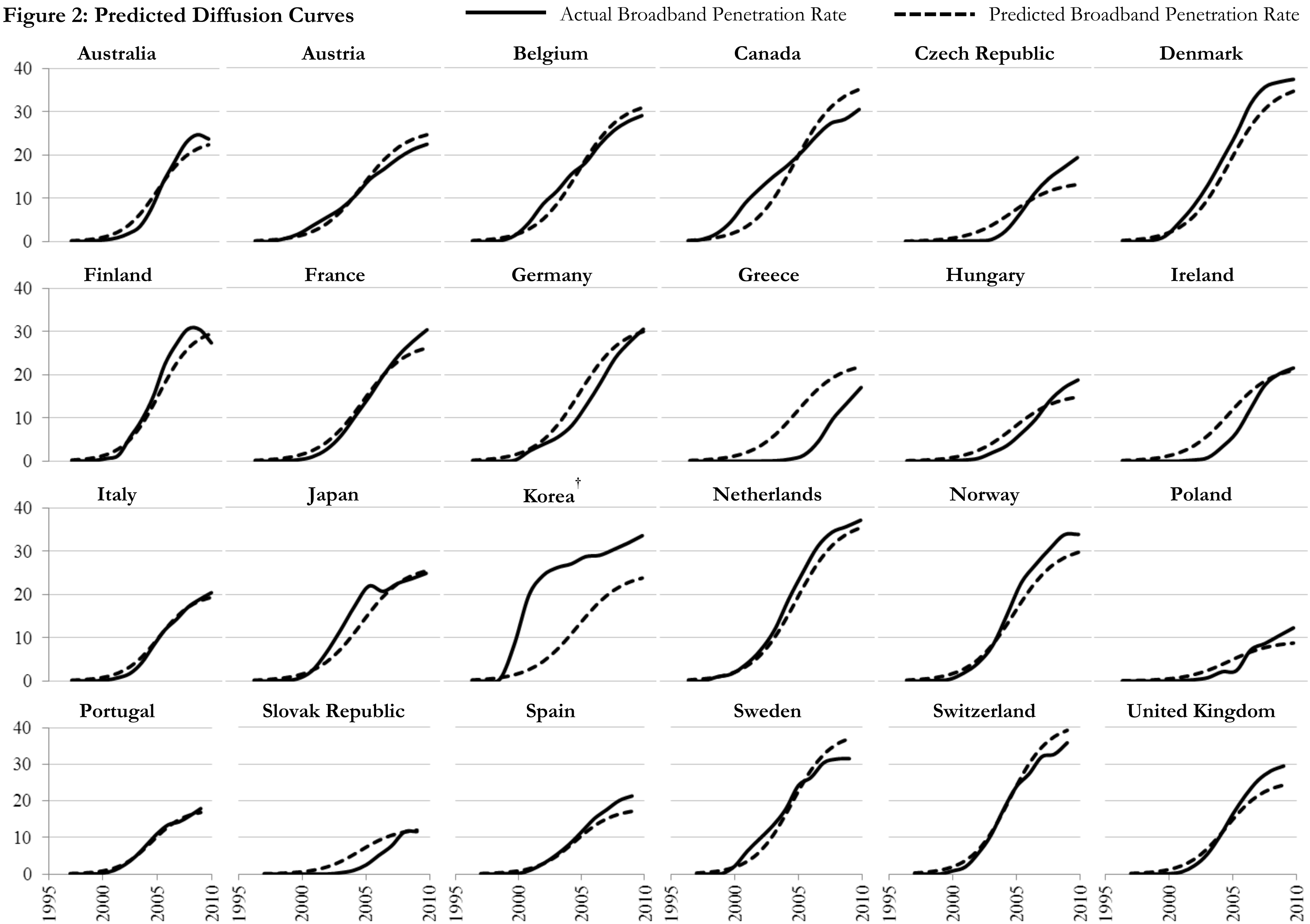
Table 5

The Diffusion Curve

	Model 1
Dependent variable	Broadband penetration rate
Cable TV subscribers (α_1)	0.322*** (0.089)
Fixed telephone lines (α_2)	0.491*** (0.052)
Diffusion speed (α_3)	0.663*** (0.041)
Inflexion point (α_4)	2004.501*** (0.202)
Constant (α_0)	-1.512 (1.870)
F-test ($\alpha_1 = \alpha_2 = 0$)	95.75
Observations	299
Countries	23
R^2	0.97

Note. Non-linear least squares estimation from 1997-2009. Broadband penetration rate measured as subscriptions per 100 inhabitants. Cable TV subscribers measured as subscriptions per 100 inhabitants. Fixed telephone lines measured as lines per 100 inhabitants. Diffusion speed and inflexion point are equal across countries while cable TV subscribers and fixed telephone lines are country specific and measured 1996, before broadband introduction. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

Figure 2: Predicted Diffusion Curves



†Korea removed as an outlier

Predicted Values as Instrumental Variable

In the paper by Czernich et al. (2011), whose IV approach has been followed thus far, the diffusion model serves as the first stage in a two-stage least squares (2SLS) estimation. According to Angrist and Kreuger (2001), the method of "using a nonlinear first stage to generate fitted values that are plugged directly into the second-stage equation does not generate consistent estimates unless the nonlinear model happens to be *exactly* right" (p. 80). Czernich et al. (2011) acknowledge the risk associated with their approach, but argues that "the vast empirical literature on technology diffusion finding an S-shaped diffusion process gives [them] confidence in this specific non-linear model" (p. 517).

Instead of taking the risk of misspecification associated with the approach, we will circumvent it by using predicted values from the non-linear model as an *instrument* for actual broadband penetration. While the non-linear model has an impressive ability to predict actual broadband penetration rates, final estimates do not necessarily need to be reliant on the non-linear model being *exactly* right. As proposed by Angrist and Kreuger (2001), we will instead employ a linear first stage model, in which instrumented broadband penetration will be obtained by regressing actual broadband penetration on predicted broadband penetration together with the control variables to be used in the second stage regression. The first stage regression model is thus given by:

$$BBPEN_{it} = \beta_0 + \beta_1 \widehat{BBPEN}_{it} + \beta_2 GDPG_{it} + \beta_3 WAGE_{it} + \beta_4 EDUC_{it} + \beta_5 TAX_{it} + v_{it} \qquad (6)$$

In a traditional 2SLS estimation, the instrumented values generated in the first stage, denoted by $\widehat{BBPEN}'$, are then used in the second stage regression in order to isolate the causal effect of broadband penetration on new business density. The second stage is thus given by:

$$NBD_{it} = \beta_0 + \beta_1 \widehat{BBPEN}'_{it} + \beta_2 GDPG_{it} + \beta_3 WAGE_{it} + \beta_4 EDUC_{it} + \beta_5 TAX_{it} + u_{it} \qquad (7)$$

Instrumental Variable Results

First stage regression results are reported in Models 1-3 of Table 6. As one could expect, given the close prediction of the diffusion model, the IV show strong significance in all of the first stage specifications. As can be inferred from the R-squared, the explanatory variables in the first stage explain around 90% of the variation in actual broadband penetration, which highlights the relevancy of our instrument.

Second stage regression results are reported in Models 1-3 of Table 7. The effect of broadband penetration on entrepreneurship is strongly significant in all specifications. In Model 2, the main model of interest, the coefficient of broadband penetration is slightly higher than in the fixed effects estimation in Model 3 in Table 4, indicating that the instrument corrects for a downward bias. This is unexpected as the endogeneity issues previously identified were mainly expected to cause an upward bias. However, the difference is reasonably small, and we previously acknowledged that some determinants of entrepreneurship could have been overlooked. In Model 4 we include lagged instrumented broadband penetration as independent variables. As in the fixed effects estimations in Table 4, the coefficient of lagged broadband penetration is statistically significant and similar in magnitude to present penetration. As discussed in the previous section, this is a sign of robustness but do not help us to determine whether the predominant effect is contemporaneous or lagged.

In general, the reasoning behind our occupational choice model used in the hypothesis is well reflected in the regression estimates. The coefficients of all control variables have expected signs, except for the coefficient of taxes on distributed profits. The reason might be that this variable is not completely exogenous but correlated with an otherwise positive climate for businesses. Governments can be expected to be reluctant to increase corporate taxes when corporates are distressed, but may be inclined to do so when corporates are performing well. Another potential reason is that tax rates show little variation over time, and its effect in our model may thus be estimated with low precision. The latter is supported by the fact that the estimate is strongly insignificant; for this reason, it deserves little attention.

The estimates of the effect of broadband penetration on new business density are controlled for time-invariant and time-variant factors affecting the occupational choice model, as well as for omitted variables and reverse causality by the use of an IV. This estimation has thus gone far in the attempt to disentangle the causal relationship between broadband and entrepreneurship.

Table 6

First Stage: Predicted Penetration as Instrumental Variable

	Model 1	Model 2	Model 3
Dependent variable	Broadband penetration rate	Broadband penetration rate	Broadband penetration rate
Predicted broadband penetration rate ($\widehat{BBPEN}_t$)	0.979***	0.864***	
	(0.068)	(0.089)	
Lagged predicted broadband penetration rate ($\widehat{BBPEN}_{t-1}$)			0.886***
			(0.073)
Real GDP growth		-0.087	-0.206**
		(0.125)	(0.097)
Average wage		0.621	0.431
		(0.538)	(0.530)
Education		0.389	0.017
		(1.211)	(0.974)
Total tax on distributed profits		0.001	0.107
		(0.067)	(0.068)
Country dummies	Yes	Yes	Yes
Observations	130	129	129
Countries	23	23	23
R^2 (within)	0.87	0.88	0.92

Note. Ordinary least squares estimation for 2004-2009. New business density measured as number of business registrations per 1000 inhabitants of working age (15-64 years). Predicted broadband penetration rate measured as subscriptions per 100 inhabitants. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

Table 7

Second Stage: Instrumented Broadband Penetration

	Model 1	Model 2	Model 3
Dependent variable	New business density	New business density	New business density
Instrumented broadband penetration rate ($\widehat{BBPEN'}_t$)	0.053*** (0.013)	0.086*** (0.028)	
Lagged instrumented broadband penetration rate ($\widehat{BBPEN'}_{t-1}$)			0.069*** (0.023)
Real GDP growth		0.074 (0.047)	0.089* (0.048)
Average wage		-0.080 (0.192)	-0.039 (0.186)
Education		0.099 (0.487)	0.108 (0.510)
Total tax on distributed profits		0.019 (0.023)	0.011 (0.021)
Country dummies	Yes	Yes	Yes
Observations	130	129	129
Countries	23	23	23
R^2 (within)	0.13	0.19	0.20

Note. Ordinary least squares estimation for 2004-2009. New business density measured as number of business registrations per 1000 inhabitants of working age (15-64 years). Instrumented broadband penetration rate measured as subscriptions per 100 inhabitants. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

7. Robustness Discussion

In this section, we will discuss how our IV corrects for identified endogeneity issues. We will put instrument exogeneity under scrutiny, by trying to identify sources of potential endogeneity and run robustness tests to see whether our estimation holds when we attempt to correct for these.

As Czernich et al. (2011) also point out, we acknowledge that the predetermined nature of the instrumental variable does not necessarily make it exogenous. In order to hold a constructive discussion around instrument exogeneity, we must first identify variables that can potentially be in the error term. As discussed in previous sections, the error term can only include variables that are time-variant, as all time-invariant variables are controlled for by country fixed effects. For cable TV subscribers and telephone lines in 1996 to be endogenous, they must therefore partially explain the variation over time in omitted variables.

For the sake of clarity, the motivation for employing an IV approach was twofold. Its first objective was to eliminate bias caused by omitted variables such as government involvement and the development of other communication technologies. Its second objective was to correct for reverse causality.

The most evident advantage of using predetermined values to construct an IV is that the issue of reverse causality is effectively eliminated. While the direct and indirect effect of entrepreneurs on broadband demand may have affected actual broadband penetration rates, increased demand in 2004-2009 is unlikely to have affected the level of cable TV and telephony infrastructure in 1996. The only possible way for which instrumented values could be affected by reverse causality is if cable TV and telephony infrastructure investments were made in anticipation of a future increase in entrepreneurial activity, and therefore made partly for the reason of facilitating widespread broadband diffusion that these entrepreneurs would come to demand. The likelihood of this scenario is to be considered as very low, especially considering that telephone companies have been building these lines for over a hundred years (Lane, 1998). Fixed telephone lines were built to carry analog voice signals at a maximum speed of around 56kbit/s. The idea of letting these lines carry digital internet signals, which can be carried at broadband speeds, had not been developed when the principal part of the telephone lines were built. The same argument applies to the idea of using spare bandwidth in coaxial TV cables for transmission of internet data. To conclude this discussion, we find it highly unlikely that instrumented broadband penetration would suffer from reverse causality. Concerns regarding reverse causality are therefore alleviated by using instrumented broadband penetration.

The bias caused by omitted variables was previously deemed to be significant. In particular, bias was believed to be caused by omitted government involvement stimulating both broadband and entrepreneurship. By revisiting Figure 2 we can however note that our concerns may not have been warranted. The fit of the predicted diffusion curves should be considerably worse if government involvement played a significant role. The only other explanations for the good fit would be either that all governments intervened equally much at the same points in time, or that our IV is not completely exogenous.

One could further argue that a government investing in telecom infrastructure prior to 1996 is more prone to invest in telecom infrastructure in 2004-2009. Although this is acknowledged to be a potential issue, our instrumented values can be expected to be significantly less affected than the actual values. The predetermined nature of the IV helps to control for this omitted variable in the sense that continuous elections and changes in public opinion may only make government involvement prior to 1996 weakly correlated with government involvement in 2004-2009. Country fixed effects also contribute by controlling for a country-specific level of government involvement, so that only a deviation from this level would affect the error term.

We also raised the diffusion of other communications technologies, in particular mobile broadband, mobile telephones and computers, as potential omitted variables. These too could impact entrepreneurship, while being positively correlated with broadband diffusion. Czernich et al. (2011) have similar concerns as these technologies are also believed to stimulate economic growth. They perform a robustness test, in which cable TV subscribers and fixed telephone lines are used as predictors for the maximum achievable rate of mobile telephony and computer penetration. These predictors are found to be statistically insignificant. As a similar interdependence cannot be found in the robustness test, the IV should correct for any potential bias caused by omission of these technologies.

Adding to this robustness test, we run the complete three-stage approach with different specifications. We use one predictor at a time and run one model with only cable TV subscribers and one with only fixed telephone lines. The reasoning behind these additional tests is that if only one of the variables is endogenous, finding a significant effect using the other predictor strengthens our conclusion of an actual effect of broadband penetration on entrepreneurship.

We reason that a large telephony infrastructure could be associated with strong telecom companies. The prevalence of such companies might increase the speed of subsequent diffusion of mobile broadband and mobile telephony, causing fixed telephone lines to be an endogenous predictor. To test this, we estimate a model with only cable TV subscribers as predictor. This estimation should control for the potential bias, as cable network operators technically cannot offer any mobile services. The cable TV subscriber model is also run for the years 2004-2006 only. This is to add an additional robustness check, as mobile broadband diffusion had not yet reached high levels during that time period.[12] The potential bias mobile broadband cause is therefore expected to be minor in that time period. A model with telephone lines as only predictor is also run to compare estimates.

Results are reported in Tables 8-10. Estimates of the impact of broadband penetration for all three specifications are significant and coefficients in the second stage differ only slightly from the prior estimates. The coefficient in Model 1 in Table 10 is however somewhat higher than the estimate in Model 2, which estimates the effect for 2004-2006 only. This could be a result of a positive bias created by mobile broadband omission, but could also simply mean that the effect of broadband increases over time, as for example broadband speed gets faster. While the estimate in Model 2 below is likely to be less precise due to the lower number of observations, it is still significant at the 5% level. Model 3, with telephone lines as a predictor, results in a similar but slightly lower coefficient than the one in Model 1. Coefficients are still larger than for the fixed effects models in Table 4 for all three specifications. These results provide additional proof that broadband penetration has a strong causal effect on new business density, in the range of 0.074-0.098.

Czernich et al. (2011) run further tests controlling for telephone lines being separate growth determinants, something that would make their instruments endogenous. While their result of this effect being insignificant is not transferable to our study, as we investigate the effect on entrepreneurship rather than growth, the explanation for this finding may apply. Fixed telephone lines' possible direct effect on entrepreneurship could be expected to have subsided, as substitutes of mobile and IP telephony have overtaken the use of fixed telephony in our period of study. Data from the OECD clearly shows that fixed telephone revenues represent a diminishing share of total telecom revenues between 1998 and 2009 (OECD, 2011a).

[12] According to OECD (2011a), the average number of 3G mobile subscribers, per 100 inhabitants, for our set of 23 countries had reached 10.3 in 2006. This can be considered as relatively low compared to the average of 43.2 in 2009.

Table 8

The Diffusion Curve: Different IVs

	Model 1	Model 2
Dependent variable	Broadband penetration rate	Broadband penetration rate
Cable TV subscribers (α_1)	0.574***	
	(0.102)	
Fixed telephone lines (α_2)		0.611***
		(0.045)
Diffusion speed (α_3)	0.656***	0.667***
	(0.039)	(0.041)
Inflexion point (α_4)	2004.599***	2004.532***
	(0.217)	(0.208)
Constant (α_0)	18.569***	-2.697
	(2.063)	(2.136)
Observations	299	299
Countries	23	23
R^2	0.92	0.95

Note. Non-linear least squares estimation from 1997-2009. Broadband penetration rate measured as subscriptions per 100 inhabitants. Cable TV subscribers measured as subscriptions per 100 inhabitants. Fixed telephone lines measured as lines per 100 inhabitants. Diffusion speed and inflexion point are equal across countries while cable TV subscribers and fixed telephone lines are country specific and measured 1996, before broadband introduction. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

Table 9

First Stage: Different IVs and Time Periods

	Model 1	Model 2	Model 3
Dependent variable	Broadband penetration rate	Broadband penetration rate	Broadband penetration rate
Predicted broadband penetration rate (Cable TV subscribers)	0.909***	0.878***	
	(0.100)	(0.104)	
Predicted broadband penetration rate (Fixed telephone lines)			0.866***
			(0.089)
Real GDP growth	-0.023	0.110	-0.075
	(0.104)	(0.280)	(0.126)
Average wage	0.519	0.705	0.644
	(0.517)	(0.667)	(0.525)
Education	-0.765	0.872	0.731
	(0.859)	(2.187)	(1.251)
Total tax on distributed profits	0.022	0.102	-0.010
	(0.061)	(0.069)	(0.056)
Country dummies	Yes	Yes	Yes
Observations	129	67	129
Countries	23	23	23
R^2 (within)	0.90	0.89	0.88

Note. Ordinary least squares estimation for 2004-2009. New business density measured as number of business registrations per 1000 inhabitants of working age (15-64 years). Predicted broadband penetration rate measured as subscriptions per 100 inhabitants. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

Table 10

Second Stage: Different IVs and Time Periods

	Model 1	Model 2	Model 3
Dependent variable	New business density	New business density	New business density
Instrumented broadband penetration rate (Cable TV subscribers)	0.098*** (0.029)	0.074** (0.031)	
Instrumented broadband penetration rate (Fixed telephone lines)			0.075*** (0.027)
Real GDP growth	0.074 (0.047)	0.090 (0.078)	0.073 (0.048)
Average wage	-0.126 (0.198)	0.136 (0.224)	-0.034 (0.188)
Education	0.106 (0.483)	-0.850* (0.498)	0.092 (0.490)
Total tax on distributed profits	0.022 (0.023)	0.023 (0.024)	0.015 (0.023)
Country dummies	Yes	Yes	Yes
Observations	129	67	129
Countries	23	23	23
R^2 (within)	0.18	0.38	0.20

Note. Ordinary least squares estimation for 2004-2009 in model 1 and 3 and for 2004-2006 in model 2. New business density measured as number of business registrations per 1000 inhabitants of working age (15-64 years). Instrumented broadband penetration rate measured as subscriptions per 100 inhabitants. Robust clustered standard errors in parentheses. Significance level of * p<10%; ** p<5%; *** p<1%.

8. Conclusion

Interpretation of Results

As presented in Table 7, the main finding in this study is that the causal impact of broadband penetration on the number of new business registrations, a proxy for entrepreneurship, is positive and significant. A more concrete economic interpretation of our main finding is:

All else equal, an increase in broadband penetration by 1 percentage point results in 0.086 new businesses registered per 1000 inhabitants of working age.

The average increase in broadband penetration over 2004-2009 for the OECD countries shown in Table 11 was 3 percentage points per year. As the inflexion point of the broadband diffusion curve was estimated to be in 2004, the diffusion speed has most likely decreased after 2009. In a conservative case, we calculate the impact if broadband penetration grows by 1 percentage point. The results provided in Table 11 illustrate this scenario. As shown, when an additional 1 per 100 inhabitants obtains a broadband subscription, the mean impact on the displayed OECD countries is an increase by 3.8% in new business registrations. For the average OECD country in the sample, this translates into 1,625 new firms. Although some countries, such as Denmark and Netherlands, seem to approach a plateau-phase in broadband diffusion, others, such as Greece, Hungary, and Poland, still have much growth potential, underlining the practical relevancy of our findings.

It should be acknowledged that discussing the number of broadband subscriptions in terms of population size gives a somewhat skewed view. Since broadband subscriptions are mostly shared, often between household members, an increase by one percentage point in broadband penetration typically implies that more than one percentage point of the population obtains broadband access.

Table 11

The impact on OECD countries in 2009

	Increase in new business registrations	New business registrations 2009	Percentage change in new business registrations	New business density 2009	Broadband penetration rate 2009	Avg. annual percentage point increase in broadband penetration 2004-2009
Australia	1,277	n.a.	n.a.	n.a.	23.7	3.2
Austria	486	3,228	15.0%	0.6	22.5	2.4
Belgium	613	29,548	2.1%	4.1	29.0	2.7
Canada	2,015	174,000	1.2%	7.4	30.5	2.6
Czech Republic	639	21,717	2.9%	2.9	19.4	3.4
Denmark	312	16,519	1.9%	4.6	37.4	3.7
Finland	305	11,820	2.6%	3.3	27.3	2.5
France	3,495	128,906	2.7%	3.2	30.4	4.0
Germany	4,653	n.a.	n.a.	n.a.	30.5	4.4
Greece	651	n.a.	n.a.	n.a.	17.0	3.3
Hungary	592	42,951	1.4%	6.2	18.8	3.0
Ireland	260	13,188	2.0%	4.4	21.5	3.6
Italy	3,389	68,508	4.9%	1.7	20.4	2.5
Japan	7,008	n.a.	n.a.	n.a.	24.8	1.5
Netherlands	955	35,100	2.7%	3.2	37.1	3.6
Norway	275	n.a.	n.a.	n.a.	33.8	3.7
Poland	2,339	14,434	16.2%	0.5	12.3	2.0
Portugal	613	27,759	2.2%	3.9	17.9	2.0
Slovak Republic	337	15,825	2.1%	4.0	11.6	2.1
Spain	2,703	79,757	3.4%	2.5	21.3	2.6
Sweden	523	24,228	2.2%	4.0	31.5	2.8
Switzerland	453	25,250	1.8%	4.8	35.8	3.6
United Kingdom	3,484	330,100	1.1%	8.1	29.5	3.8
Mean	1,625	59,047	3.8%	3.9	25.4	3.0
Median	639	26,505	2.2%	3.9	24.8	3.0

Note. Impact of an increase in broadband penetration by 1 percentage point. Chile, Estonia, Iceland, Israel, Korea, Luxembourg, Mexico, New Zealand, Slovenia, Turkey and the United States have been omitted as data for these countries were not available.

Implications of Results

The potential welfare gains of increased entrepreneurial activity are expected to be substantial. Scholars such as van Praag and Versloot (2007) conclude that entrepreneurs "have a disproportionately high contribution to the creation of jobs" (p. 356) and that employment in entrepreneurial firms tend to be associated with higher levels of job satisfaction. Acs (2006) further argues that opportunity-based entrepreneurship, as opposed to self-employment in agriculture or small-scale industries, raises the level of economic development. Other scholars, such as Schumpeter (1947), have long viewed entrepreneurship as the driving force of innovation. As most policymakers acknowledge these benefits, many OECD countries have introduced measures to stimulate entrepreneurship. Examples include "tax breaks for the self-employed, labor market deregulation, deregulation of entry, and privatization of many hitherto (semi-) public sectors" (Carree et al., 2010, p. 207).

The result of this study, confirming the positive effect of broadband on entrepreneurship, can be interpreted as additional proof of positive externalities of broadband internet. Investment in broadband infrastructure should therefore be considered as "productive" spending, which Angelopoulos et al., (2007) refer to as the "engine of long-term growth" (p. 886). As opposed to "unproductive" spending, it has dual effects by its initial contribution to employment and activity in the telecom sector and its subsequent contribution to employment and economic growth through the new businesses created. Governments should therefore have a strong incentive to increase broadband infrastructure investment. This can mainly be done in two ways.

First, governments can work with legislation to create a business environment that maximizes the incentives for telecom operators to invest in broadband infrastructure. In the OECD report "Broadband and the Economy" (2008), "legal frameworks, security and privacy concerns, cross-border transactions and co-operation, and the protection of intellectual property" (p. 49) are highlighted as policy areas affected by the evolution towards an always connected "broadband society". It should be of major interest for policymakers to adapt legislation in these areas to prevent it from constraining broadband development. An example of adaptation in this direction is the Obama administration's stimulus package of 2009 that allowed hospitals to use electronic medical journals (Agarwal et al., 2009).

Second, governments can commit public funding for broadband infrastructure investment. This is particularly crucial in the telecommunications sector as high levels of capital expenditure are required to build new networks (PricewaterhouseCoopers, 2012). As can be seen in the broadband diffusion curves in Figure 2, Korea, in which the government has actively supported broadband expansion, has reached high levels of penetration much faster.

While the extent of private and public investment is crucial, policymakers should also take into account the potential welfare gains from broadband access when deciding on how to allocate scarce radio spectrum frequencies, a heavily debated subject today. Spectrum frequencies used for transmission of mobile broadband signals are prerequisites for further mobile broadband roll out, and decision-makers can facilitate an effective expansion by allocating the necessary range of frequencies to broadband operators.

Furthermore, the most common way of allocating spectrum among broadband operators is currently through auctions, in which licenses are sold to the highest bidder (Gruber, 2007). Given the prevalence of positive externalities from widespread broadband penetration, it might however be plausible for governments to require auction contesters to commit to extend the broadband network even to rural areas where such an investment would otherwise be unprofitable.

In relation to prior research in this field, it should further be noted that the results of this study differ somewhat. While likely to suffer from estimation biases, prior papers have, as previously mentioned, not found similar convincing results of the positive impact of broadband on entrepreneurship. There are, in our view, two main reasons for this. First, as previously mentioned, we use broadband subscriptions as explanatory variable while the papers by, for example, Gillett et al. (2006) have used availability-oriented measures. In our view, broadband subscriptions renders a more robust estimation as it is much closer to actual broadband usage. Second, we have used more robust econometric methods than previous papers in this field. It is therefore possible that our econometric methods corrects for a bias, unaccounted for in prior studies.

In terms of method, our study fundamentally draws from the instrumental variable approach developed by Czernich et al. (2011). However, instead of using the prediction model as a first stage regression, we use the predicted values as an instrument in a three-stage approach. This allows us to circumvent potential risks of misspecification. Our method therefore offers a robust alternative for future scholars using this approach to study the effects of broadband.

In the selection of the sample used for this study, we have tried to focus on the impact of broadband on opportunity-based entrepreneurship, rather than necessity-based. Given the previously mentioned U-shaped relationship between entrepreneurship and economic development, selecting OECD countries should, to some extent, avoid necessity-based entrepreneurship. An indication that we succeed to predominantly capture opportunity-based entrepreneurship is the positive coefficient of real GDP growth, which indicates that entrepreneurship tends to be positively affected by a prospering economic climate. Based on this, our results offer one explanation to the previously established view that broadband has a positive effect on real GDP growth.

Validity of Results

While our study measures the impact of broadband on new business registrations, it does not account for how broadband affects new firms beyond birth. This is a relevant issue as prior studies by for example Evans and Leighton (1989) have indicated that approximately a third of the entrants to self-employment leave within three years. On the other hand, studies by for example Cooper (1986) as well as Cowling and Westhead (1995) have found that small high-tech companies, which are likely to be common among the firms formed as a result of higher broadband penetration, tend to exhibit relatively higher survival rates.

Second, all new business registrations do not stem from individuals seeking to start their own firm. Rather, the newly registered limited liability firm could be a subsidiary of another firm. Using the Orbis database (Bureau van Dijk, n.d.), we find that approximately 8.2% of limited liability firms incorporated in the OECD countries during 2004-2009 were reported to have an institutional ultimate owner.[13] While this might cause some disturbances to our results, it is relatively negligible.

Third, the data represents the number of limited liability firms registered. While this has been found to be the most common way of doing business in most economies (The World Bank, 2010), entrepreneurs can choose other legal forms such as sole proprietorships and partnerships. As these could be relatively common among entrepreneurs, this is acknowledged to be a weakness in the study. However, we have few reasons to believe that entrepreneurs would act differently in their choice of legal form as a result of increased broadband penetration. Scholars such as Stiglitz and Weiss (1981) have also argued that entrepreneurial activities associated with limited liability firms exhibit more growth potential, although entailing more risk. This hypothesis has been confirmed by Harhoff et al. (1998). Thus, from a policy perspective, these types of firms are more interesting to capture.

[13] 402,859 out of 4,911,770 firms were found to have an institutional ultimate owner. Ultimate ownership defined as ownership of at least 50.01% from the path of the subject company to the ultimate owner.

Suggestions for Future Research

Although we set out to provide granularity to the current state of knowledge on the economic effects of broadband, more remain to be done in this field. Future studies should attempt to determine how broadband impacts entrepreneurship in different industries. As the reasoning behind our hypothesis should be applicable to most sectors, it would be particularly interesting to see whether the impact of broadband remains significant once the level of entrepreneurship in the IT-sector is controlled for. This would have significant implications for policymakers as to whether they want to stimulate new business creation in emerging industries or in mature ones.

Moreover, future studies should investigate the impact of broadband on entrepreneurship in developing countries as this is where broadband penetration rates can increase the most. While data availability and limited diffusion rates are likely to have been the main obstacles thus far, these should be mitigated with time. Although admittedly challenging, scholars in this field should also try to separate opportunity and necessity-based entrepreneurship in order to increase the relevancy of their studies.

As empirical papers have thus far treated broadband usage as binary, we also welcome studies taking a more dynamic and futuristic view on broadband usage. In particular, scholars should investigate the impact on entrepreneurship by other dimensions such as broadband speed. In line with technological progress, broadband access will become the norm and few gains will be obtained from further understanding the benefits of availability. As products and applications accessed over the internet continuously develop to more complex forms, speed will become more and more important for users.

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