Broadband speed and firm entry in digitally intensive sectors: The case of Croatia

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BROADBAND SPEED AND FIRM ENTRY IN DIGITALLY INTENSIVE SECTORS: THE CASE OF CROATIA

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We explore how improvements in digital infrastructure contribute to digital transformation of the Croatian economy. More specifically, we investigate under what conditions improvements in broadband speed are conductive for firm entry in digitally intensive sectors at the local level (cities and municipalities; LGUs) during the period 2014–2017. The results of the benchmark random effects panel data model suggest a 10 percent increase in broadband speed increases the number of new digitally intensive firms by 0.68. Two-way interactions between explanatory variables suggest improvements in broadband infrastructure yield the greatest number of new firm entries in densely populated LGUs, and in LGUs with a higher quality of human capital and greater public investment in physical infrastructure. Using the spatial Durbin panel method, we find improvements in broadband infrastructure exhibit positive firm entry effects both within and between cities and municipalities.

Key words: firm entry, digitally intensive sectors, broadband speed, digital transformation, Croatia, spatial spillovers

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1. Introduction

One of most profound features of modern economies is the penetration of digital technologies into nearly every aspect of socio-economic living. The benefits of digital transformation encompass easier search for information, greater consumer choice, ease of access to organizational resources, cost savings due to automation and penetration of artificial intelligence in production process, and the ability to reach customers at greater economic distances, thereby improving organizational performance. This motivates many advancing economies to seek out ways to steer their economic structure towards digitally intensive activities and to facilitate entry of firms into digitally intensive sectors. The success of such incentives depends on actions in the field of key enabling technologies, among which the most relevant is broadband infrastructure.

Empirical studies investigated the contribution of broadband to digital transformation of the economy and organizational behaviour in advanced countries. However, far less is known about its effects in advancing economies. The reason for this is lack of relevant firm and industry level data that would enable assessment of the microeconomic dynamics of digital transformation.

This paper explores for the first time how improvements in broadband infrastructure facilitate digital transformation of local governmental units in Croatia (LGUs). Specifically, we investigate whether faster broadband increases firm entry in digitally intensive sectors and whether these effects are spatially bounded. We want to determine the conditions under which improvements in digital infrastructure can foster entrepreneurship in digitally intensive sectors within and between LGUs. We use LGU level data for the period 2014–2017, and apply random effects and spatial Durbin panel data models. Panel data on broadband speeds at LGU level are, in general, rare and beyond the reach of researchers. Our study is in unique position to obtain access to the most recent available dataset covering all Croatian LGUs and timespan of several years. This allows us to advance existing literature by tracing the relationship between broadband speeds and firm entry in spatio-temporal framework.

In terms of broadband speeds Croatia falls in the group of digitally lagging European economies. European Commission's Digital Scoreboard (2020) data shows that share of fixed broadband subscriptions with speeds above 30 Mbit/s has been much lower than EU average and growing at slower rate throughout analysed period. These trends are still present in 2020 and particularly evident in case of broadband speeds equal to or higher than 100 Mbit/s. Worldwide broadband speed rankings (Cable.co.uk, 2021) further confirm these trends. On global scale Croatia ranked 40 in 2017 but fell on 52nd position in 2020. Understanding whether broadband speeds influence firm entry in digitally intensive sectors of such environment may serve as input to both academics and policy makers.

To the best of our knowledge, this is the first study to explore the relationship between the state of digital infrastructure and market outcomes in digitally intensive segments of the economy, and the first to explore the influence of broadband Internet on firm entry in advancing country such as Croatia.

The paper is organised as follows. The second section reviews the literature. The third section describes the dataset and the methodology. Section four discusses the main findings. Section five summarises the main findings and offers policy recommendations.

2. Conceptual framework

The relationship between broadband speeds and firm entry belongs to relatively unaddressed areas of market dynamics literature. From rare studies undertaken on advanced economies we know that better broadband quality (including speed) facilitates firm entry (Lehr et al., 2006; McCoy et al., 2018) and that it can offset disadvantages of rural regions (Mack, 2014; Kim and Orazem, 2017). However, its effects vary across sectors (Hasbi, 2019). Evidence was found of particularly beneficial effects on knowledge and digitally intensive sectors (Mack et al., 2011).

The effect of better broadband access on firm entry takes place through several channels. Improvements in broadband lower transaction costs and facilitate coordination between firms, customers and suppliers (Borenstein & Saloner. 2001; Sinai and Waldfogel, 2004; Lamie et al., 2014). Further beneficial effects are instigated through remote working opportunities and easier job matching that reduce firm dependence on local labour markets (Autor, 2001). Finally, better broadband increases market transparency and thus reduces barriers to firm entry (Czernich et al., 2011). These beneficial effects of broadband speed facilitate firm entry but they also may increase attractiveness of some locations over others leading to spatial divergence of firm entry rates (Grubesic & O´Kelly, 2002; Grubesic & Murray, 2002; Grubesic & Murray, 2004; Kolko, 2012).

Despite its beneficial effects for firm entry, the role of broadband speeds did not receive much attention outside of advanced economies. This is surprising as digital transformation presents window of technological opportunity for catching-up of advancing economies and first step in such direction are key enabling technologies such as broadband. It follows from there that investigation of broadband speed effects on firm entry in such economies may present first evidence-based step towards formulation of digital transformation policies in advancing economies. Our study aims to fill this literature gap.

3. Dataset and methodology

The objective of the analysis is to assess the impact of improvements in broadband speed on firm entry in digitally intensive sectors. Although digital transformation has impacts across a variety of sectors, these effects are not evenly distributed across all industries. Considering this, a taxonomy of sectoral digital intensity was recently proposed by Calvino et al. (2018) and adopted by OECD. The taxonomy considers the contribution to sectoral digital transformation from firms' investment in digital assets and the digital transformation of organizational business models, particularly their customer and supplier relations management, production organization, and skill mismatch management in the digital economy. Such a taxonomy acts as a proxy for the extent of the digital transformation in sectors.

The taxonomy takes into account measures such as shares of investment in ICT equipment and software, purchases of ICT intermediate goods, stocks of robots per employee, share of ICT specialists in employment, and propensity towards engagement in e-commerce. The choice of the underlying indicators is reliant on the availability of data used in the derivation of the index. Some measures relevant for edge technologies in digital transformation, such as additive manufacturing or big data and machine learning, are not used due to a lack of relevant and comparable data. Based on available indicators, industries are grouped as high, medium-high, medium-low or low-digitally intensive sectors. Table 1 provides an overview of the taxonomy of digitally intensive sectors.

Table 1: Taxonomy of sectors by digital intensity

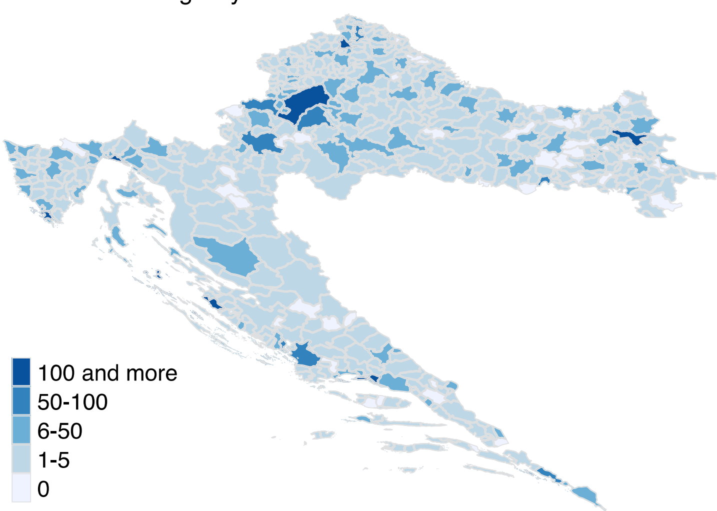
Sector	Intensity	Sector	Intensity
Agriculture, forestry and fishing	Low	Wholesale and retail trade, repair	Medium high
Mining and quarrying	Low	Transportation and storage	Low
Food products, beverages and tobacco	Low	Accommodation and food service activities	Low
Textiles, wearing apparel, leather	Medium low	Publishing, audiovisual and broadcasting	Medium high
Wood and paper products, and printing	Medium high	Telecommunications	High
Coke and refined petroleum products	Medium low	IT and other information services	High
Chemicals and chemical products	Medium low	Finance and insurance	High
Pharmaceutical products	Medium low	Real estate	Low
Rubber and plastics products	Medium low	Legal and accounting activities, etc.	High
Basic metals and fabricated metal products	Medium low	Scientific research and development	High
Computer, electronic, optical products	Medium high	Advertising and other business services	High
Electrical equipment	Medium high	Administrative and support service	High
Machinery and equipment n.e.c.	Medium high	Public administration and defence	Medium high
Transport equipment	High	Education	Medium low
Furniture; other manufacturing; repairs	Medium high	Human health activities	Medium low
Electricity, gas, steam and air cond.	Low	Residential care and social work activities	Medium low
Water supply; sewerage, waste	Low	Arts, entertainment and recreation	Medium high
Construction	Low	Other service activities	High

Source: Calvino et al. (2018)

Following the above classification, we focus on medium-high and high digitally intensive sectors which we label as digitally intensive. The analysis utilises several data sources to explore how improvements in broadband speed facilitate the birth of new firms in these sectors. A detailed description of data sources is provided in the Appendix. Most data is available for all 557 Croatian LGUs. However, data on average broadband speeds were obtained only for 480 LGUs. To this end, our analysis covers 86% of all LGUs distributed across the country. Figure 1a provides a visual presentation of our sample through the average number of firm entries in digitally intensive sectors at the LGU level.

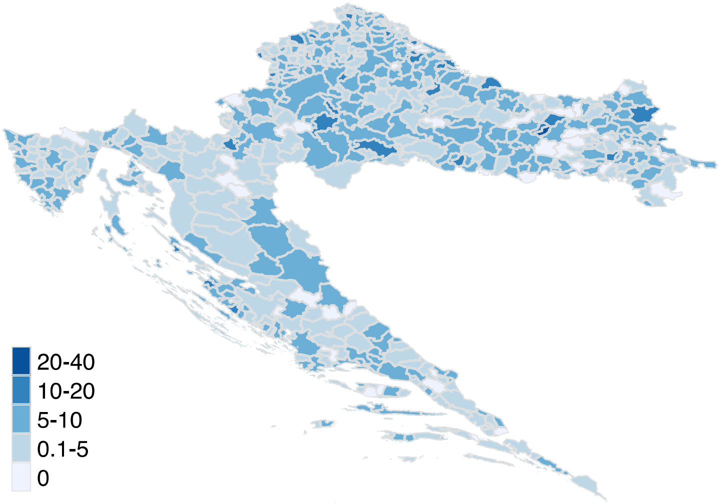
From Figure 1, it is evident that digitally intensive firms are concentrated in several regions in Croatia, which is most pronounced in the capital city of Zagreb. In most cities and municipalities for which data were available, the number of newly established firms in digitally intensive sectors during the study period ranges from 0 to 5. In most areas, the share of digitally intensive entries in the total number of firms in digitally intensive sectors (Figure 1b) is fairly low, ranging between 0 and 5 percent. However, digitally intensive entrants constitute the bulk of entries when examined across the entire population of entrants in each year. Figure 1c indicates that in most cities and municipalities, these firms constitute more than 25% of new firm establishments.

Figure 1a) Number of firm entries in digitally intensive sectors 2014-2017



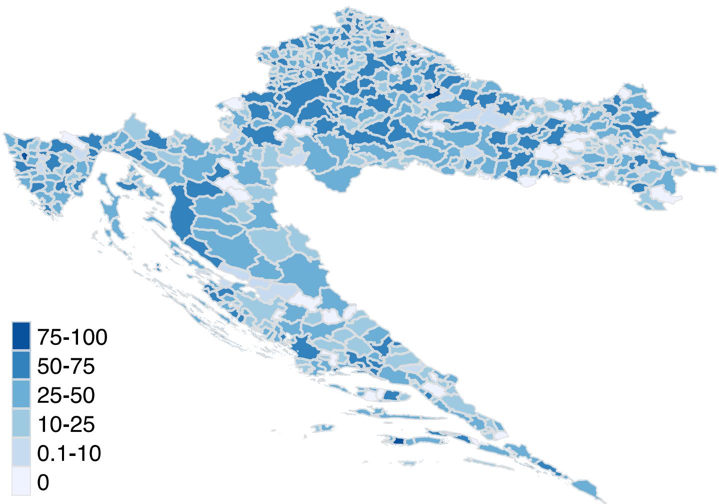
Source: Authors calculations based on FINA database

Figure 1b) Share of firm entries in number of firms in digitally intensive sectors 2014-2017 (in %)



Source: Authors calculations based on FINA database

Figure 1c) Share of firm entries in digitally intensive sectors in total number of firm entries 2014-2017 (in %)



Source: Authors calculations based on FINA database

To explore the relationship between broadband speed and firm entry in digitally intensive sectors, we develop an empirical model based on the theoretical predictions of determinants of firm entry and the available data. The key independent variable is average broadband speed in a given LGU, as measured in Mbit/s. The Croatian fixed broadband market is dominated by two large operators (Hrvatski Telekom, i.e. Croatian Telecom, and A1), where Croatian Telecom is considered the market leader, holding 51 percent of the market (Institute of Economics, Zagreb. 2020). Both companies are foreign-owned. The majority owner of Croatian Telecom is Deutsche Telekom, while A1 is part of the Telekom Austria Group. The fixed telecommunication market in Croatia is in gradual decline, with the last quarter of 2017 recording a 12.04 percent annual drop in revenues, accompanied by annual decline in the number of new landline hook-ups of 2.14 percent.

We control for the distance of the local unit from the county administrative centre (measured in kilometres). Administrative centres provide a variety of amenities for new businesses such as professional expertise, greater workforce pool, and higher demand, and as such are more attractive to potential entrepreneurs. We also control for average population density in LGUs as a proxy for local demand that may facilitate firm entry. Several variables control for public incentives of the local administration. Public expenditure in material assets was included as a proxy for investments in infrastructure. Moreover, the model includes the share of public production subsidies in total revenues of the business sector in a given LGU. We expect that better access to infrastructure and financial incentives support firm entry. We also control for a locational wage premium through the ratio between the local average wage and average wage at the national level. The model also includes categorical variables for development levels of each LGU.

Finally, we include year and county categorical variables among control variables. All non-categorical variables and variables not taking zero values enter the model in natural logarithm form. Table 2 provides the list of variables and their definitions, while a detailed explanation of data sources and descriptive statistics for the main variables are provided in the Appendix.

Table 2: Description of variables

Variable	Definition	Source
Entry	Number of firm births in digitally intensive sectors in city/municipality *i* in period *t*.	FINA
Speed	Broadband speed in city/municipality *i* in period *t* in Mbit/s – natural logarithm	Croatian Telecom
Distance	Distance from the county administrative centre in kilometres – natural logarithm	Google maps
Density	Population density in city/municipality *i* in period *t* (number/km^2) – natural logarithm	Central Bureau of Statistics

Expenditure	Average amount of public expenditure on material assets in the three years prior to period *t* (in HRK 1000s) - natural logarithm	Ministry of Economy
Subsidies	Share of production subsidies in total revenues of the business sector in city/municipality *i* in period *t*	FINA
Wage	Ratio between the average wage in city/municipality *i* in period *t* and the average wage at the national level in period *t* (in %) – natural logarithm	FINA
IR1-IR8	Categorical variables for categories of development level index	Ministry of Regional Development and EU Funds
County 1-21	Categorical variables for Croatian counties	FINA
Year1-Year4	Categorical variables for years	FINA

Our empirical analysis combines several techniques. Baseline analysis relies on the use of a random effects panel estimator. The choice of estimation technique is driven with several features of our model. The relatively short time span prevents the use of dynamic panel estimators. Our model contains several time invariant variables, such as measures of distance, population density and categorical variables for development index, year and county, as dummy variables that would be differenced away with fixed effects estimators.

Random effects models rest on several assumptions such as strict exogeneity, homoscedasticity and existence of significant differences in variance across units (i.e. panel effects). The strict exogeneity assumption means that in random effects estimation independent variables and unobserved individual effects are uncorrelated. For such assumption to hold researcher should include all relevant variables in the model. However, it is often the case that all variables cannot be accounted for. This poses a risk of omitted variable bias. In our analysis we included all possible variables to which we had access. However, our estimates should be interpreted taking into consideration the above requirement of random effects estimation. To control for further requirements of random effects estimation such as homoscedasticity we incorporated robust standard errors. Finally, Breusch-Pagan LM test was performed to assess whether variation in variance across entities is equal to zero, i.e. whether random effects estimation should be preferred over pooled OLS one.

In the second part of the analysis, we are also interested in mediating the effects of several of our controlling variables, which is why the subsequent parts of analysis assess the role of different interaction effects. This allows us to assess how outcome of our interest (firm entry) varies as partial change in one independent variable takes place in relation to the change of another independent variable. Additional value of this part of analysis is that it enables assessment of whether the interactions between different variables are large enough to matter.

Urban and regional economics recognised long ago that linkages between business entities in different locations have a non-negligible role in stimulating local economic activity of other geographic areas (Marshall, 1920; Jacobs, 1969). To explore whether investments in broadband infrastructure create any effects on other spatial units, we employ the spatial Durbin panel model (Lesage and Pace, 2009; Elhorts, 2014). The choice of such model is motivated by the ability of that model to take into account the variety of spatial linkages through the dependent and independent variables. In turn, these are aggregated and averaged in the form of direct, indirect and total spatial effects (LeSage and Pace, 2009; Elhorst, 2014; Belotti et al., 2017; Stojcic and Orlic, 2020). Direct effects refer to those effects of independent variables within the LGU, while indirect effects encompass the effects from the original spatial unit to other spatial units, accounting for the feedback loops between them.

An important issue in the specification of spatial models is also the selection of the spatial weight matrix, as an NxN matrix that defines the correlation between units in space. To explore the reach of spatial effects, we employ three types of matrices, i.e. two contiguity matrices limiting the range of spatial correlation, one to first order only and the other to first and second order neighbouring LGUs, and an inverse distance matrix allowing for spatial correlation across the entire sample. The next two sections discuss the findings from our analysis.

4. Discussion of findings

a. Baseline specification

The premise is the assessment of the baseline specification presented in Table 3. As our dependent variable enters the model in its original form, while other variables enter the model in the form of a natural logarithm, our model takes on the form of a semi-log estimation. Care must be taken with interpretation since in semi-log models, a 1% increase in the logarithmic independent variable corresponds to a 1/100 coefficient of magnitude change in the units of the dependent variable.

As Table 3 shows, model diagnostics provide support to our model. Wald test value is highly significant suggesting that all coefficients in the model are jointly different from zero. Breusch-Pagan Lagrange multiplier test suggests that variances across entities are not zero and that panel effect is present. In other words, there are significant differences across LGUs and random effects model should be preferred over pooled OLS regression.

Several of the variables included in our model are highly significant. Starting with broadband speed, our principal variable of interest, it is evident that a 1% increase in broadband speed increases number of firms in digitally intensive sectors by a factor of 0.068. This should be considered in the context of current changes in the broadband speed during the analysed period. From 2014–2017, broadband speed in Croatian LGUs increased by an average of 10%. Relating to the above, this means that, on average, 0.68 new digitally intensive firms were established in each LGU as a result of broadband speed increase. As Croatia has 557 LGUs, this suggests that broadband improvements over the observed period contributed to the birth of 379 new firms nation-wide. To assess the magnitude of this finding one has to look into total number of entries in digitally intensive sectors over analysed period. In total, 22.094 new firms were established in digitally intensive sectors over analysed period. When placed in such perspective it follows that creation of only small fraction of them can be attributed to the improvements in broadband speeds.

An increase in the distance from administrative centre reduces the number of new firms in digitally intensive sectors by 0.07, suggesting that amenities of agglomerations also matter for firms in digitally intensive sectors.

Table 3: Results from baseline specification

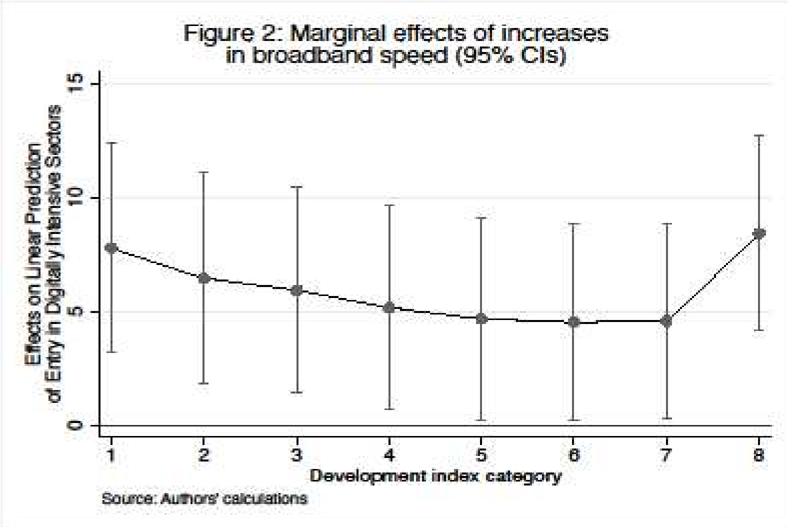
Variable	Coefficient	p-value	Standard error
Speed	6.80	0.000	2.371
Distance	-7.24	0.000	2.105
Density	8.19	0.000	2.498
Expenditure	3.90	0.000	0.665
Subsidies	-0.003	0.871	0.022
Wage	1.13	0.379	1.289
Number of observations	1920	1920	1920
Number of groups	480	480	480
Model diagnostics			
Wald chi^2 test	18750.88	p-value	0.000
Breusch-Pagan LM test	985.31	p-value	0.000

Note: Robust standard errors. Development index, county and year dummy variables included.

Our analysis also shows that a higher population density positively contributes to firm entry in digitally intensive sectors. This signals that the greater demand and workforce pool commonly associated with higher population density are relevant for more intensive firm entry in digitally intensive sectors. A somewhat smaller, but nevertheless positive effect, is also found for public investments in infrastructure. This suggests that public infrastructure complements private improvements in broadband infrastructure in facilitating the entry of digital entrepreneurs.

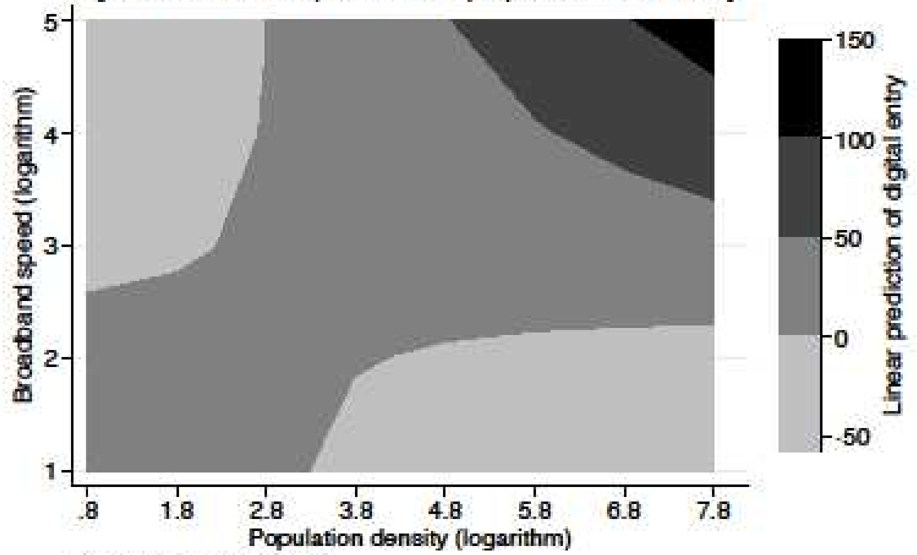
b. Mediating effects

To explore whether improvements in broadband speed vary along changes in other variables, we introduce mediating effects between broadband speed and selected variables of interest. Firstly, we explore whether effects of broadband speed vary across LGUs of different development levels, by introducing an interaction between development index variables for each LGU and broadband speed. Figure 2 presents the findings of effects of this two-way interaction and shows that the effects of increases in broadband speed are highest in the least and most developed LGUs although the effects remain significant for all groups of LGUs.



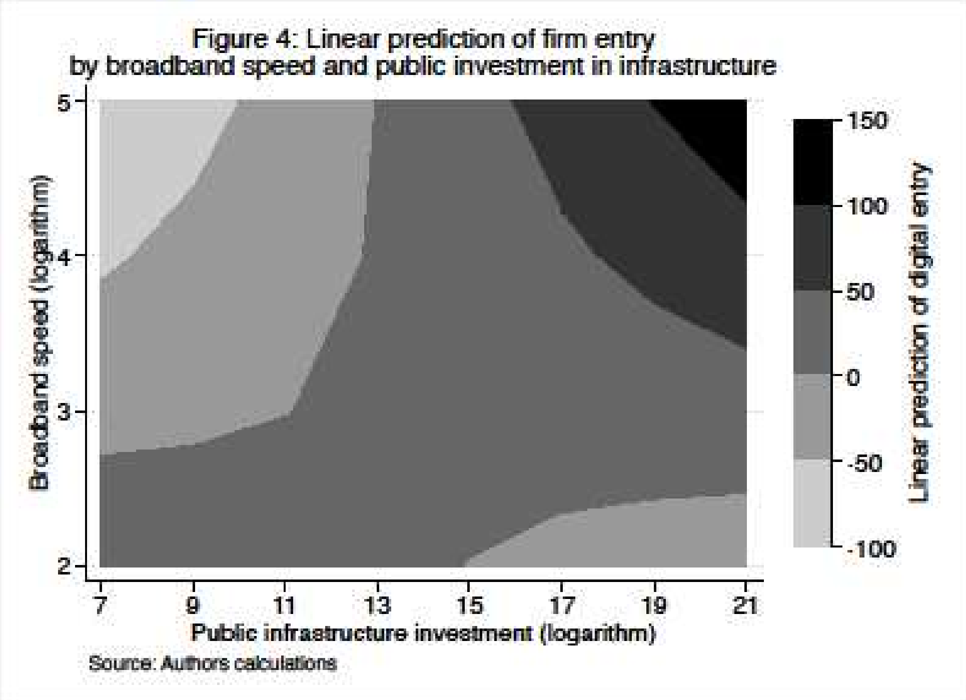
A further question of interest is the role of local population density and public investments in physical infrastructure. The heat map in Figure 3 reveals an interesting picture in this respect, as the light grey part of the map reflects negative effects. Less populated LGUs with high broadband speeds and densely populated LGUs with low broadband speeds have the lowest predictions for entry of firms. At the opposite end of spectrum, the highest chances for digital entry can be found in densely populated LGUs with high broadband speeds. These findings suggest that the benefits of broadband infrastructure are not evenly distributed across all LGUs, and that they gain the strongest positive effects only when complemented with the amenities of densely populated LGUs, such as higher demand and workforce pools.

Figure 3: Linear prediction of firm entry
by broadband speed and population density



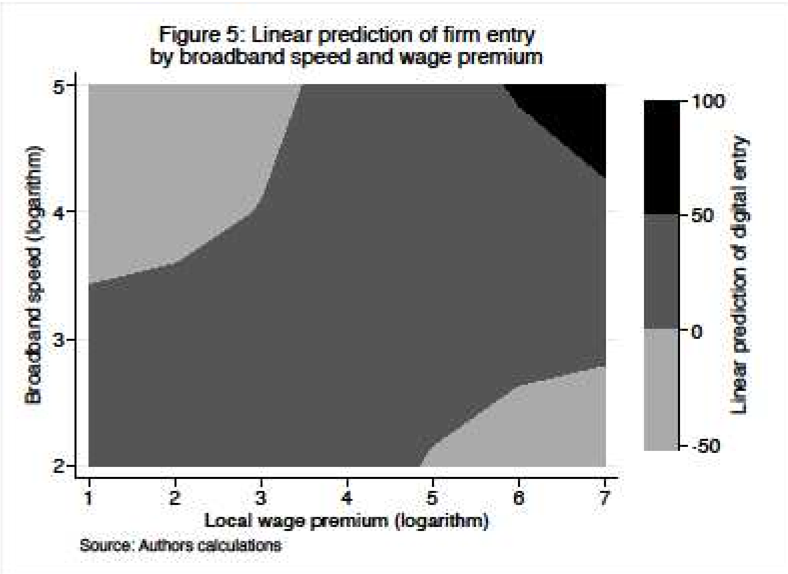
Source: Authors calculations

Figure 4 presents the heat map showing the interaction effects of improvements in broadband speed and increases in public infrastructure investments. Negative effects are found in those LGUs (light grey part of figure) where investments in broadband speeds are high but public investment in physical infrastructure is low and vice versa. This clearly signals complementarity in the effects of these private and public incentives for entry of firms in digitally intensive sectors. Further evidence is seen in that highest chances for firm entry are in areas with high shares of both types of incentives. This may also indicate that the investment gap needed to upgrade infrastructure in general is, on average, very high and demands more public and private investments to promote digital entrepreneurship at the local level.



Wage competitiveness is among the decisive factors for the establishment of businesses in a particular location. To explore whether local wage conditions matter for entry of our group of firms, we examine the interaction of the measure of wage premium with broadband speed and re-estimate the regression. Once again, the same pattern appears as in previous parts of the analysis (Figure 5). Both measures of broadband speed and local wage premium, and their interaction term, become highly significant once the interaction term is included. Secondly, one needs to reflect on our measure of local wage premium. As noted previously, the local wage premium is expressed as a percentage as the ratio between the local average wage and the national average wage for a given year. Values of this measure above 100 (corresponding roughly to a natural logarithm of 4.6) refer to cities and municipalities with above-average wages, while the opposite holds for areas where the measure has values below 100 (or less than 4.6 on the x-axis scale).

Figure 5 suggests that LGUs with below-average wages and high broadband speeds, and those areas with above-average wages but low broadband speeds are characterised by having negative values of linear prediction of entry in digitally intensive sectors. This signals that broadband infrastructure or human capital alone are not sufficient incentive for entry of firms in digitally intensive sectors. In addition, this finding further broadens our understanding of the prerequisites for a higher number of newly created digitally intensive firms. This corroborates the findings of Hasbi (2019) and McCoy et al. (2018). We also observe the highest share of digitally intensive firms created in LGUs with the highest broadband speed and highest wage premiums.



Together, these findings help to define a rather nuanced map of factors facilitating firm entry in digitally intensive sectors. Improvements in broadband speed are highly relevant for firm entry, but obviously not sufficient on their own. Improvements in broadband infrastructure best flourish in densely populated LGUs with better human capital and complementary public investment in physical infrastructure.

c. Spatial effects of improvements in broadband infrastructure

The section outlined the characteristics of LGUs with the highest potential for attracting new business establishments in digitally intensive sectors. One important insight from this part of the analysis is that on its own, digital infrastructure provides far weaker effects in those areas that are in the greatest need for the impulse to their economy.

Table 4 shows the results of the estimation based on spatial econometric analysis. Following common model diagnostics practice (LeSage and Pace, 2009; Elhorst, 2010; Belotti et al., 2017; Stojcic and Orlic, 2020), the spatial Durbin panel model was applied, as it enables the modelling of spatial effects of dependent and independent variables. Following Belotti et al. (2017) we first performed Wald test on spatial lags of regressors which suggested that these lags are statistically different from zero and that Spatial Durbin model should be preferred over spatial autoregressive model. Further testing of restrictions on spatial lag of dependent variable suggested that Spatial Durbin model should be given preference over spatial error model. Finally, in line with common procedure AIC and BIC criteria were employed to assess whether Spatial Durbin model should be preferred over spatial autocorrelation model. As noted previously, all these tests provided strong support to Spatial Durbin model allowing us to proceed with interpretation of results.

Starting with improvements in broadband speed, our key variable of interest, we obtain direct (local) effects comparable to those from the random effects estimation. There is also evidence of positive indirect (between cities and municipalities) effects, though these effects are limited to first (direct neighbours) and second (neighbours of neighbours) order neighbouring LGUs. It is thus likely that improvements in digital infrastructure also facilitate the entry of firms in digitally intensive sectors in the surrounding LGUs. Findings for other variables are also in line with expectations. Positive local and spatial effects of population density and public investment in physical infrastructure are found, as well as negative local and positive spatial effects of distance (suggesting that greater distance of other units from administrative centre facilitates entry in location *i*).

Overall, our findings offer a congruent story. Improvements in broadband speed have a positive effect on the entry of firms in digitally intensive sectors and this also extends into the surrounding areas, thus reflecting spatial linkages between firms. These effects, however, are attenuated if complementary incentives are present in other areas, such as proximity to administrative centres, public investment or availability of human capital.

Table 4: Spatial effects on firm entry in digitally intensive sectors

	First order neighbours	First and Second order neighbours	Full spatial correlation
Direct effects			
Speed	6.93*** (2.108)	8.22*** (2.119)	7.74*** (0.964)
Distance	-5.86*** (0.997)	-6.15*** (1.002)	-7.33*** (0.965)
Density	8.66*** (1.128)	8.39*** (1.126)	8.29*** (1.157)
Expenditure	3.42*** (0.755)	3.64*** (0.751)	3.74*** (0.778)
Subsidies	0.02 (0.141)	-0.01 (0.141)	0.003 (0.143)
Wage	1.50 (1.365)	1.81 (1.367)	1.95 (1.391)
Indirect effects			
Speed	9.94*** (2.103)	7.81*** (2.316)	-1.49 (5.549)
Distance	0.01 (0.066)	0.19 (0.136)	2.12*** (0.763)
Density	-0.01 (0.08)	-0.27 (0.192)	-2.39*** (0.878)
Expenditure	1.01 (0.769)	3.85*** (1.126)	7.08** (3.260)
Subsidies	-0.05 (0.252)	0.04 (0.484)	0.89 (1.252)
Wage	-8.03*** (2.297)	-16.66*** (3.297)	-27.29*** (8.213)
Number of observations	1920	1920	1920
Number of groups	480	480	480
Wald test all spatial terms	50.79***	45.52***	26.07***
Wald test Ho: (wX's=0) SAR vs SDM	36.56***	42.78***	23.39***
Wald test H_o: ($\theta = -\beta\rho$) SEM vs SDM	57.37***	48.44***	25.63***
AIC criteria SDM vs SAC	SDM: 16070.4 SAC: 16114.86	SDM: 16075.51 SAC: 16115.12	SDM: 16101.68 SAC: 16113.08
BIC criteria SDM vs SAC	SDM: 16325.8 SAC: 16337.27	SDM: 16331.27 SAC: 16337.52	SDM: 16357.44 SAC: 16335.48

Note: For expositional convenience coefficients on indices of local development, county and dummy variables are not presented. Standard errors in parentheses. ***,** and * denote significance at 1%, 5% and 10% levels. County, year and development index dummy variables included.

5. Concluding remarks

The objective of our paper was to explore one crucial aspect of digital transformation, the impact of improvements to digital infrastructure, measured as broadband speed on entry of firms in digitally intensive sectors of an advancing, efficiency-driven economy, using the case of Croatia. A unique dataset containing information on firm entry and broadband speed for the majority of Croatian LGUs was compiled for this purpose. The results of the benchmark random effects panel data model suggest that, on average, a 10 percent increase in broadband speed over the analysed period paved the way for the entry of 379 new firms in digitally intensive sectors in Croatia. The effects are highest when complemented with investments in physical infrastructure and when occurring in densely populated areas with a high level of human capital. To this end, our findings are consistent with those reported by other authors for advanced economies. Moreover, the beneficial effects are not limited within the LGUs, but also create spatial spillovers to neighbouring cities and municipalities.

Our findings call for greater investment in digital infrastructure. . This is not just because Croatia is lagging behind other EU countries in this respect, but also because the analysis presented here suggests that considerable benefits of such investments can be reaped by local economies and local entrepreneurs interested in starting digitally intensive companies. As mentioned above, our findings also suggest that improvements in digital infrastructure alone are not enough to stimulate stronger development of the digital economy in sparsely populated areas with low levels of human capital and limited potential for public investment. This, in turn, necessitates a broader combination of measures both from central and local governments aimed at ensuring adequate quality and quantity of labour supply, public infrastructure and administrative services. In addition, LGUs interested in establishing themselves as digital economy hubs should aim to develop a comprehensive strategic framework to lay the groundwork for key enabling technologies such as broadband infrastructure to yield stronger and more lasting effects.

In this context, the Croatian government can take advantage of the EUR 9.2 billion Digital Europe programme proposed by the European Commission for 2021–2027 Multiannual Financial Framework aimed at fostering strategic digital capacities and facilitating the wide deployment of digital technologies in EU Member States. Moreover, for remote areas to catch up with advanced parts of country on the wings of digital transformation incentives should be provided for private investors in digital infrastructure as administrative and financial obstacles to digital infrastructure developments in Croatia are among highest in Europe.

Our research provides the first assessment of the impact of broadband speeds on firm entry in Croatia and is the first to address the interactions and spatial effects of this process. While comprehensive, the research is not without its limitations. Its focus is on effects on firm creation, though future research should also explore how broadband infrastructure influences firm growth and survival. Another avenue worth pursuing concerns the effects of education and other measures of entrepreneurial system such as entrepreneurial zones. Subject to data availability, future research could also explore the effects of broadband infrastructure on organisational changes within enterprises, as digitally intensive firms typically have more hierarchical organizational structure.

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APPENDIX

1. The dataset

The analysis utilises several sources of data to explore how improvements in broadband speed facilitate the birth of new firms in these sectors. Our principal source of data is the firm database of the Croatian Financial Agency (FINA) for the period 2014–2017. The database provides financial information and a number of firm characteristics such as location (in terms of the LGU where the firm is established), sector and date of birth of Croatian enterprises. All firms are required to submit their annual reports to FINA, meaning that we are effectively dealing with an entire population of enterprises. This is another added value of our research.

Another source of data is information obtained from Hrvatski Telekom (Croatian Telecom) on the average broadband speed available at the LGU level in each of the analysed years. Croatian Telecom is the largest Internet provider in Croatia. Its infrastructure is used for access to end users by the majority of other providers in Croatia. Average broadband speeds are calculated for each year, meaning that this study uses the most reliable nation-wide source of information on broadband speeds in Croatia. By combining these two sources of data we are able to construct a unique database and, for the first time, to perform an analysis of the impact of improvements in speed of broadband on economic outcomes.

The data from FINA are available on all Croatian LGUs while the information on average available broadband speeds can be obtained only for 480 of 556 LGUs. The LGUs for which data on broadband speeds are not available are mainly small municipalities with little or no economic activity. Bearing this in mind we can state that our analysis covers 86% of all LGUs distributed across the country.

Several other data sources were additionally consulted. The distance of each municipality from county administrative centre was calculated by the authors using Google Maps data. Population density data was taken from Croatian Bureau of Statistics (DZS), while information on public expenditure on material assets for municipalities was provided by the Croatian Ministry of the Economy and Sustainable Development (MINGO). Data on development index levels for each city or municipality was taken from the Croatian Ministry of Regional Development and EU Funds (MRRFEU). This index is a composite indicator calculated from data in six categories: average income per inhabitant, average generic revenues per inhabitant, average unemployment rate, fluctuation of population, tertiary education of inhabitants and ageing index. On the basis of the index values, each LGU is assigned to one of eight development categories. Our categorical variables correspond to these development levels.

Table A1 provides the descriptive statistics for the main variables. For expositional convenience, descriptives are not presented for year, county and development index dummy variables.

Table A1: Descriptive statistics

Variable	Observations	Mean	Standard deviation	Min	Max
Entry	480	11.51	106.54	0	2594
Speed	480	24.03	10.28	7.3	94.4
Distance	480	36.98	28.33	1	207
Density	480	101.89	216.46	2.29	2965.01
Expenditure	480	6293	40979	1	886212
Subsidies	480	0.18	2.60	0	71.89
Wage	480	100	37.89	3.67	843.84

Note: Does not include development index, county and annual categorical variables. Variables presented in original form even when they enter models as logarithms.

BRZINA ŠIROKOPOJASNOG INTERNETA I OSNIVANJE NOVIH PODUZEĆA U DIGITALNO INTENZIVNIM SEKTORIMA

U članku se istražuje na koji način poboljšanja u digitalnoj infrastrukturi doprinose digitalnoj transformaciji hrvatske ekonomije. Pri tome se fokusiramo na uvjete pri kojima poboljšanja u brzini širokopojasnog interneta omogućavaju ubrzaniji ulazak novih kompanija u digitalno intenzivne sektore. U tu svrhu istražujemo vezu između prosječne dostupne brzine širokopojasnog interneta u jedinicama lokalne samouprave i osnivanja poduzeća u digitalno intenzivnim sektorima u razdoblju od 2014. do 2017. Rezultati našeg osnovnog modela sugeriraju da povećanje brzine od 10 posto korespondira s 0,68 novih poduzeća u prosječnoj lokalnoj jedinici. Povećanjem udaljenosti od administrativnog središta smanjuje se broj novoosnovanih digitalno intenzivnih poduzeća, dok veća gustoća naseljenosti i veća javna ulaganja u infrastrukturu doprinose povećanju broja novoosnovanih poduzeća. Interakcije među objašnjavajućim varijablama modela sugeriraju da poboljšanja u širokopojasnoj infrastrukturi rezultiraju najvećim brojem novoosnovanih poduzeća u gusto naseljenim lokalnim jedinicama, u lokalnim jedinicama s bolje obrazovanom radnom snagom i većim javnim ulaganjima u infrastrukturu. Korištenjem prostornog Durbinovog panel-modela nalazimo da poboljšanja u širokopojasnoj infrastrukturi utječu i na lokalne jedinice koje se nalaze u susjedstvu lokalne jedinice koja bilježi navedena poboljšanja u širokopojasnoj infrastrukturi.

Ključne riječi: ulazak poduzeća, digitalno intenzivni sektori, širokopojasna brzina, digitalna transformacija, Hrvatska, prostorna prelijevanja.