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Mountain Index Business Model Nexus Internet of Things Development and Sustainability

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Abstract: The paper proposes an aggregate index for a model regarding mountain business development through the Internet of Things (IoT) and Information and Communication Technology (ICT). The paper presents an aggregate index, built from unequal indices, which sustains the business development model in the mountain area, primarily through ICT and IoT. The proposed model is predictive. The paper contains relevant data related to the Eurostat index Business Demography and activities of ICT and IoT for some European mountain areas. Data have been processed and simulated in Excel, SPSS, and Make fractal software. The article performed exploratory and quantitative analysis, using statistics and forecasting techniques based on ANOVA. The indicator, the first in the specific literature, and its application developed a considerable model of the mountain business, in the 2022 context, declared by the United Nations as the" International Year of Sustainable Mountain Development"

Keywords: Aggregate Index • Business Intelligence • Degree of IoT Penetration in the Mountain Area • Internet of Things • Mountain Business

Introduction

The research results show that IoT penetration in mountain areas represents a business model and could be set as an aggregate index from unequal indices, specific for mountain science (Im) (Rad et al. 2018). IoT is an integral part of ICT, and its application to the mountain area is being implemented with difficulty. Factors that attenuate or block the application of IoT in business model context - the degree of IoT penetration in the mountain area, which is the aggregate index - respectively ICT in the mountain area refer to some unequal indices, namely technology of that area, the degree of business development in the area and the technical difficulties that block Internet access or radio frequency identification. The research aims to present the steps for IoT development in the mountain area, especially in the business sector. In the current pandemic context, the mountainous areas of the world present major importance because it offers the cleanest solutions for the development of life, being the least polluted.

IoT, through the business sector development, has a strong impact on the lives of all consumers in business model context (Hanafizadeh et al. 2020). Since 1999, when Kevin Ashton laid the groundwork for this paradigm at the Massachusetts Institute of Technology's Auto-ID Center, IoT has been useful in connecting various electronic devices, including non-computer ones, to the Internet using radio frequency identification technology (RFID) to achieve intelligent access and management. (Kramp et al. 2013)

As an integral part of the ICT sector, the IoT segment has developed considerably from 2008 to the present. The most important contribution to the development of this segment has been made by ICT companies and consumers of IoT products. Internet access is the key coordinate in IoT implementation.

The paper proposes the development of a model regarding the degree of IoT penetration to consumers in the mountain area, but especially to the systemic business practice. The mountain area is essential because it covers 22% of the Earth's surface, totaling a population of 915 million people (representing 13% of the world's population). This area has special importance for the high quality provided by the mountain products, especially because it provides about 60-80% of the planet's freshwater (Nordregio 2014). Regarding the European territory, the mountain area covers 40.6% - 1900 thousand km2 (European Union 27, Norway, and Switzerland), representing a total of 19.1% of the population - meaning 94.3 million people (Romeo et al. 2015).

Due to the harsh development conditions in the mountain area, the population in this area, implicitly entrepreneurs, has a high degree of resistance to change (most mountain entrepreneurs do not master the current technologies). Conservatism is considered natural in mountain business model, resulting from the spatial isolation of entrepreneurs, but also in terms of separation from the large market in low-lying areas.

Background

The purpose of IoT implementation in enterprises, and in industrial purposes, aims to develop an efficient economic chain, where the activity of the company is pursued from the stage of supply of raw materials, their transformation into finished products, and distribution to consumers (development and verification of the entire supply chain - enterprise distribution) (Vimal et al. 2021). IoT performs analyses and estimates intelligent processing capabilities for business model.

In a supply-distribution chain developed by IoT, entrepreneurs will be able to track their business in a business model context and products through RFID tags. As a result, companies will reduce operating costs and improve productivity through closer integration with enterprise resource planning and other systems (Wu et al. 2020). Moreover, the maintenance of the equipment will be facilitated by connected sensors, allowing real-time monitoring of the technical condition and performance of the equipment in the enterprise. (Liu et al. 2021; Kramp et al. 2013)

Another defining feature that affects mountain business model is the aging population of this area. Worldwide, there is a need for a strong infusion of funds and smart solutions for rural business model. But, especially at the European level, attracting entrepreneurs to rural areas is a necessity. Entrepreneurs, especially young people, will have the ability to develop mountain business models by applying clustering solutions. More applications of artificial neural networks should be developed for different areas (Cheng et al. 2018), especially for the mountain areas. Mountain entrepreneurs organized in clusters and cooperation organizations could be one of the major solutions for mountain repopulation.

Mountain business model can become competitive and less defaulted in relation to hilly or plain areas by applying the circular economy. The circular economy has major importance in the implementation of IoT in the mountain area. Models for predicting enterprise default (Lee et al. 2019) could impact circular mountain business model.

The authors propose that the degree of IoT penetration for enterprises in mountain areas (Im8) depends on several relevant factors, among which can be mentioned the technology of that area, the degree of business model development in the considered area, and the technical difficulties that block Internet or RFID access. Regarding the degree of IoT penetration in mountain areas (the aggregate index), the paper proposes indicators that quantify the difficulty of achieving IoT:

• Mountain altitude (Im1)
• Mountain slope (Im2)
• Average of local elevation range (LER) (Im3)
• Attenuation signal due to the mountain area (Im4)
• Internet access (Im5)
• Degree of penetration with smart technology (Im6)
• Rate of active enterprises in the mountain area in the field of ICT (Im7).

Focusing on the presented information above, the paper is facing the following research hypothesis (RH):

RH1. IoT influences mountain business model more than hilly and low-land business model

RH2. The degree of IoT penetration for enterprises in mountain areas (Im8) is influenced by some subsequent indicators (Im1, Im2, Im3, Im4, Im5, Im6, Im7)

RH3. The proposed indicator is applicable to the European mountain business model

Materials and methods

IoT decisively affects contemporary society. It is not just a technique or technology that achieves certain pragmatic objectives, mainly related to business model. IoT goals undermine the security, confidentiality, and concept of the company regarding data storage and tracking. IoT affects both consumers and manufacturers alike.

IoT constantly faces heterogeneous scenarios involving various stakeholders. The main actors are of course businessmen, but consumers and public entities are also important players. These services must be associated with educational programs that explain what is happening in reality so that the degree of anxiety of users is considerably reduced.

The IoT paradigm takes into account many technologies applicable to the population, but especially to enterprises, such as devices, protocols, services, and networks - namely, RFID, active sensors, biometrically linked smart camera data, 2D and 3D barcodes, and 6LoWPAN (IPv6 technology superior to low-power personal wireless networks) or ZigBee. (Kramp et al. 2013)

The IoT applicable to the mountain area takes into account several indicators mentioned above and which are theoretically delimited below.

The mountain altitude (I_m1) is a given value and falls within the specific altitudes that delimit the mountainous areas of the world. The food and Agriculture Organization of the United Nations classifies the mountain area into seven classes, used in Table 1. (Nordregio 2014)

The slope of the mountain area (I_m2) is a numerical value that shows the inclination and direction of a line taken into account in the mountain area. This depends on the altitude values, maximum and minimum, for the two points considered, but also on the distance between the two points. (Weisstein 2015)

The average local altitude (I_m3) measures the height deviation within the amplitude of distance from the ground and is the most common algorithm of topographic relief. (Statista 2020)

Signal attenuation in the mountain area (I_m4) in the case of IoT takes into account an attenuation coefficient of frequency and amplitude, the distance from the signal transmission source to the signal reception source, and the density index of a forest (especially, in the case of forested mountain areas).

Internet access (I_m5) is an indicator that takes into account the number of internet users in an area related to the total number of inhabitants living in that zone.

The degree of penetration of smart technology (I_m6) refers to the smart electronics in a given area (the number of homes that have smart electronics) and the total number of homes in that zone. (Eurostat 2021)

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The rate of active enterprises in the mountain area in the field of ICT (I_m7) is an indicator that takes into account the population of active enterprises in that mountain area in relation to the total population of active enterprises (Liesbett et al. 2016).

Table 1. Mountain peaks considered for Im8 analysis, according to classes (c) (Britannica 2020)

Mountain area	c1: ≥4500m	c2: 3500-4500m	c3: 2500-3500m	c4: 1500-2500m	c5: 1000-1500m	c6: 300-1000m	c7: max 25km c6
Austria	-	Großglockner (3798m)	Olperer (3476m)	Rettlkirchspitze (2475 m)	Großer Sulzberg (1400m)	Schöpfl (893m)	Area Schöpfl
Czech Republic	-	-	-	Sněžka (1603m)	Praděd (1491m)	Javořice (837m)	Area Javořice
Croatia	-	-	-	Dinara (1831m)	Viševica (1428m)	Psunj (984m)	Area Psunj
France	Mont Blanc (4808m)	Barre des Écrins (4102m)	Pic Bayle (3465m)	Pic de Soularac (2368m)	Grand Ballon (1424m)	Ardennes (550m)	Area Ardennes
Italy	Grenzgipfel (4618m)	Monte Cervino (4478m)	Dreiherrnspitze (3499m)	Castello di Moschesin (2499m)	Monte San Vicino (1469m)	Monte delle Felci (962m)	Area Monte delle Felci
Poland	-	-	Rysy (2503 m)	Kasprowy Wierch (1987 m)	Kopa Bukowska (1320 m)	Flaki (803 m)	Area Flaki
Portugal	-	-	-	Pico (2351 m)	Lombada Grande (1486 m)	Pico da Vara (947m)	Area Pico da Vara
Romania	-	-	Moldoveanu (2544m)	Retezat (2482m)	Gutâi (1443m)	Drocea (836m)	Area Drocea
Slovakia	-	-	Gerlachovský štít (2655m)	Batizovský štít (2448 m)	Prosecne (1372 m)	Porona (378m)	Area Porona

The paper contains relevant data related to the Eurostat Business Demography and Enterprise Activity index in the ICT sector for the mountainous areas of some European countries, such as Austria, the Czech Republic, Croatia, France, Italy, Poland, Portugal, Romania, and Slovakia (Eurostat 2021). The countries taken into consideration presented mountain statistics to the European Commission, the others not reporting for this area. The data have been taken from Eurostat and were statistically processed and analyzed in light of significant indicators summarized by the European Commission for the IoT sector (an integral part of ICT) related to mountainous areas in Europe. The software used for statistics, forecasting, and fractal representativeness were Excel, SPSS, and Make fractals.

The authors consider that the mountain development model for *the degree of IoT penetration in mountain areas* (I_m8) must be constructed taking into consideration *the mountain altitude* (I_m1), *the slope of the mountain area* (I_m2), *the average of local altitude* (I_m3), *signal attenuation due to the mountain area* (I_m4), *internet access* (I_m5), *the degree of penetration of smart technology* (I_m6) and *the rate of active ICT enterprises in a mountain area* (I_m7).

Thus, the proposed relationship for quantifying *the degree of IoT penetration in mountain areas* (Im8) presents the following form:

$$I_m8 = \frac{1}{Im1} + \frac{1}{Im2} + \frac{1}{Im3} + \frac{1}{Im4} + \frac{Im5}{100} + \frac{Im6}{100} + \frac{Im7}{100} \quad (1)$$

where

I_m1. *Mountain altitude* is a given value

I_m2. *The slope of the mountain area* is calculated according to the formula

$$I_m2 = \frac{Im2max - Im2min}{ds(max, min)} * 100 \quad (2)$$

where

I_m2max – maxim altitude

I_m2min – minim altitude and

$d_s(max,min)$ – the distance between the maxim point and the minim point of the altitude (Wu et al. 2018)

I_m3. *The average local altitude* is calculated according to the maximum altitude and takes into account the minimum altitude (Statista 2020)

I_m4. *The signal attenuation due to the mountain area* is calculated according to the formula

$I_m4 (L) = \mu D I_d$

indices calculated by association with the model presented in (Wright et al. 2018), where

$\mu = \mu_v + \mu_\lambda$

μ - general coefficient of attenuation (ISO 1989)

μ_v - coefficient of attenuation for frequency

μ_λ - coefficient of attenuation for wavelength

Thus, the general attenuation coefficient is calculated taking into account the attenuation coefficient for frequency and the attenuation coefficient for wavelength, as follows (ISO 1989) and author processing:

$$\mu_v = -\frac{1}{\phi e,v}\frac{d\phi e,v}{dz} = -\frac{1}{\frac{\delta\phi e}{\delta v}}\frac{d\left(\frac{\delta\phi e}{\delta v}\right)}{dz} = -\frac{1}{\frac{\delta(\frac{\delta Qe}{\delta t})}{\delta v}}\frac{d(\frac{\delta(\frac{\delta Qe}{\delta t})}{\delta v})}{dz}$$

and

$$\mu_\lambda = -\frac{1}{\phi e,\lambda}\frac{d\phi e,\lambda}{dz} = -\frac{1}{\frac{\delta\phi e}{\delta\lambda}}\frac{d(\frac{\delta\phi e}{\delta\lambda})}{dz} = -\frac{1}{\frac{\delta(\frac{\delta Qe}{\delta t})}{\delta\lambda}}\frac{d(\frac{\delta(\frac{\delta Qe}{\delta t})}{\delta\lambda})}{dz}$$

where δ – partial derivate

$\phi e,v = \frac{\delta\phi e}{\delta v}$ (ISO, 1989)

$\phi_{e,v}$ – frequency spectral flow

$\phi e,\lambda = \frac{\delta\phi e}{\delta\lambda}$ (ISO, 1989)

$\phi_{e,\lambda}$ – wavelength spectral flux (ISO 1989)

$$\phi e = \frac{\delta Qe}{\delta t}$$

ϕ_e – radiant energy emitted, reflected, transmitted, received

D – the distance from the source of the signal to the source of the signal and is a value taken from geographical maps, google, and so on.

I_d – the density index of a forest, calculated according to the formula (Birsan G, 2018)

$I_d = N_{terain}/N_{table}*100$

N_{terain} – number of trees in the field

N_{table} – number of trees per hectare given by the production tables, for a stand with the same composition, age, and class of production.

I_m5. *Internet access* = (number of internet users in an area / number of inhabitants in that area) * 100 (authors - (Eurostat 20

I_m6. *Degree of penetration with smart electronics* = (number o total number of homes in that area) * 100 (authors – (Eurostat 2 (3)

Results

Depending on the indicators proposed for the construction of business model development in the mountain area through IoT and ICT, it is observed that for the listed countries, a certain number of mountains (mountain peaks) can be part of the current model taking into account the values of *altitude* (I_m1), *slope* (I_m2), *local altitude* (I_m3) and *signal attenuation due to the mountain area* (I_m4), all within FAO margins (Table 1; Fig. 1). The selection of the analyzed mountain peaks was performed considering the degree of representativeness or the highest altitude, respectively, the smallest, in the mountain ranges of the studied countries. Due to climate change, global warming, and other natural or human interventions, the earth's mountains will become more eroded. Given that the degree of erosion of the studied mountain ranges presents a medium level, the representativeness of the peaks was achieved by fractal representation, which has the quality to capture the surfaces studied in dynamics and uncertainty (current and forecasting surface representativeness) (Fig. 1 - Fractal representation of the mountain peaks for the classes considered for I_m8 analysis).

As seen above, the highest degree of erosion should be met at the 1st, 2nd, and 6th mountain altitude classes. Given this outlook, calculations in future papers about I_m8 will have to consider lower altitudes for these classes. The researches show that higher altitudes present lower IoT and ICT. This challenge will be solved when satellite telecommunications will have better coverage in the mountain area.

Specifically, for *signal attenuation due to the mountain area* (I_m4), the forests represent an important factor of signal attenuation. (Britannica 2020)

In the European areas considered for this study, the signal attenuation index is also influenced by the structure of the component flora. Thus, in areas with low hills (up to 600 m, for example, classes 6 and 7), trees with rich leaves predominate and considerably attenuate the signal used for IoT (examples of such trees: oak, garnet, hornbeam, linden, maple, and ash). In the European mountainous regions (up to 1200 m), belonging to classes 5 and 6, grow trees that have leaves and stems in considerable areas, such as beech, which is mixed with sessile oak and other species of oak descend in the lower hill regions. Above mixed with conifers, beech can climb to the upper limit of the forest.

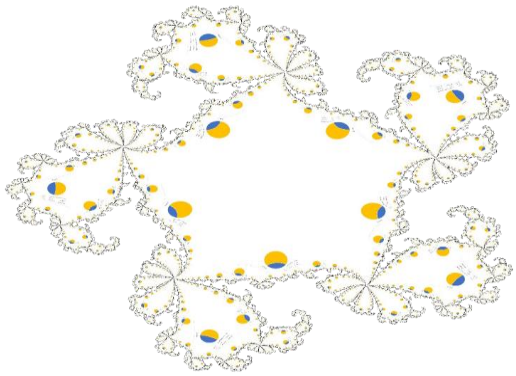


Figure 1a. Fractal representation of the mountain peaks for class 1 considered for I_m8 analysis

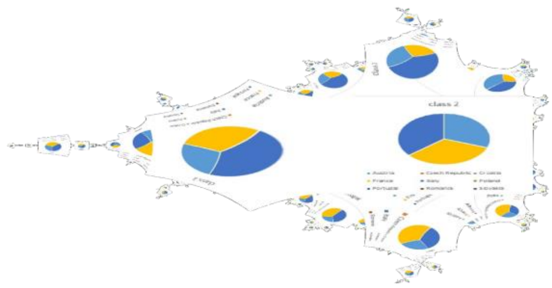


Figure 1b. Fractal representation of the mountain peaks for class 2 considered for I_m8 analysis

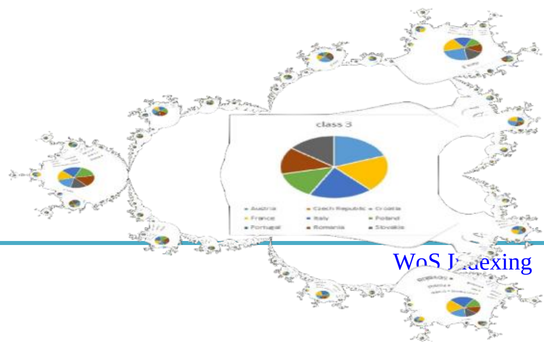


Figure 1c. Fractal representation of the mountain peaks for class 3 considered for I_m8 analysis

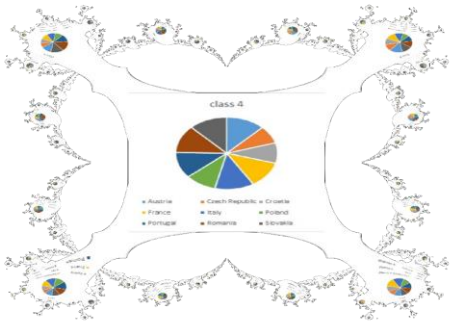


Figure 1d. Fractal representation of the mountain peaks for class 4 considered for I_m8 analysis

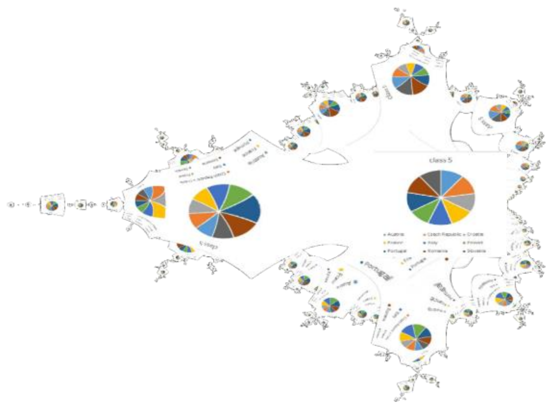


Figure 1e. Fractal representation of the mountain peaks for class 5 considered for I_m8 analysis

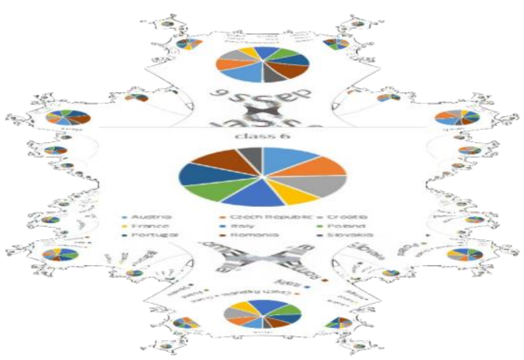


Figure 1f. Fractal representation of the mountain peaks for class 6 considered for I_m8
Source: Authors according to Eurostat (2021)

Softwoods (spruce, more widespread in the Carpathians, especially in the Eastern larch, fir, in some places, and pine) grow up to 1700 - 1800 m. The leaves of these trees are not so rich, but the stems and branches create problems to attenuate the signal. Among the grassy plants at these altitudes are characteristic ferns and, in the glades, the red fescue. In areas higher than 1800 meters above class 4 inclusive, alpine and subalpine vegetation develops, for example, dense and short meadows, juniper bushes, mountain peony, blueberry, and juniper. These are not major signal attenuation problems, but the area itself is dominated by large cliffs that attenuate considerably the IoT signal.

Another indicator considered for the I_m8 index is *Internet access* (I_m5). To do business properly, entrepreneurs need IoT, which is also dependent on this index. The situation of internet access of enterprises for the analyzed countries presents an acceptable situation.

According to Eurostat, the percentage of enterprises with internet access (enterprises with more than ten employees including and excluding those in the financial sector) has a high share in the analyzed countries, as follows: Austria 100% (2006) and 99% (2019), Czech Republic 97% (2016) and 98% (2019), Croatia 98% (2016) and 91% (2019), France 100% (2016) and 99% (2019), Italy 98% (2016, 2019), Poland 96% (2016) and 94% (2019)), Portugal 98% (2016, 2019), Romania 83% (2016) and 84% (2019), Slovakia 96% (2016) and 97% (2019). Enterprises that use a computer with internet access (enterprises with more than ten employees including and excluding those in the financial sector) have a high rate, as follows: Austria 100% (2006) and 99% (2019), Czech Republic 99% (2016) and 99%

(2019), Croatia 100% (2016, 2019), France 100% (2016, 2019), Italy 99% (2016, 2019), Poland 99% (2016, 2019) and 94% (2019), Portugal 99% (2016, 2019), Romania 99% (2016) and 98% (2019), Slovakia 99% (2016) and 100% (2019). Companies that provide employees with access to organizational emails, documents, and applications (companies with more than ten employees including and excluding those in the financial sector) showed considerable value in 2016, respectively: Austria 59%, the Czech Republic 71%, Croatia 56%, France 43%, Italy 56%, Poland 78%, Portugal 55%, Romania 30%, Slovakia 61%. Companies that use a computer and provide employees with access to organizational email, documents, and applications (companies with more than ten employees including and excluding those in the financial sector) were significant in 2016, respectively: Austria 59%, Czech Republic 72%, Croatia 61%, France 43%, Italy 56%, Poland 82%, Portugal 56%, Romania 34%, Slovakia 62%. Companies that use a computer and provide employees with access to organizational email, documents, and applications (companies with more than ten employees including and excluding those in the financial sector) had high shares in 2016, respectively: Austria 60%, Czech Republic 73%, Croatia 61%, France 43%, Italy 57%, Poland 83%, Portugal 56%, Romania 35% and Slovakia 63%. (Eurostat 2021)

The degree of penetration for smart electronics (I_m6) depends on the smart electronics manufactured or imported. Regarding manufactured smart electronics, Eurostat presents some annual statistics for the manufacturing industry. Thereby, computers, electronics, and optical products fabricated between 2008 and 2018 fluctuated for the Czech Republic -11.25%, France -43.51%, Croatia -39.66%, Italy -30.96%, Austria 0.17%, Poland 82.53%, Portugal -28.19%, Romania -29.08%, Slovakia 642.91%; electronic components and boards of Czech Republic 10.48%, France -25.03%, Croatia 72.34%, Italy -22.80%, Austria 20.72%, Poland 102.99%, Portugal -19.25%, Romania 6.63%, Slovakia 534.52%; computers and peripheral equipment with France -33.10%, Croatia -43.29%, Italy -61.76%, Austria -35.19%, Poland 102.54%, Portugal -41.07%, Romania -50.00%, Slovakia 1150.00; communication equipment with Czech Republic -26.61%, France -57.54%, Croatia -53.70%, Italy -38.73%, Austria -5.26%, Poland -29.19%, Portugal -53.33%, Romania -48.67%, Slovakia 1369.57%; consumer electronics with Czech Republic -48.96%, France 60.12%, Croatia 1600.00%, Italy -14.98%, Austria 16.13%, Poland 142.11%, Portugal -60.53%, Romania 7.69%, Slovakia 405.00%. (Eurostat 2021)

Specifically, for video recording or reproducing apparatus, whether or not incorporating a video tuner (8521), the import had high values in USD thousands and tones for the 2019 year, as follows, Austria 23309 USD thousand TSD (427 tones), Czech Republic 17042 (411), Croatia 3976 (91), France 84051 (2113), Italy 51773 (1718), Poland 48509 (1522), Portugal 9880 (1577), Romania 15666 (429), Slovakia 17524 (969). (Trademap 2021)

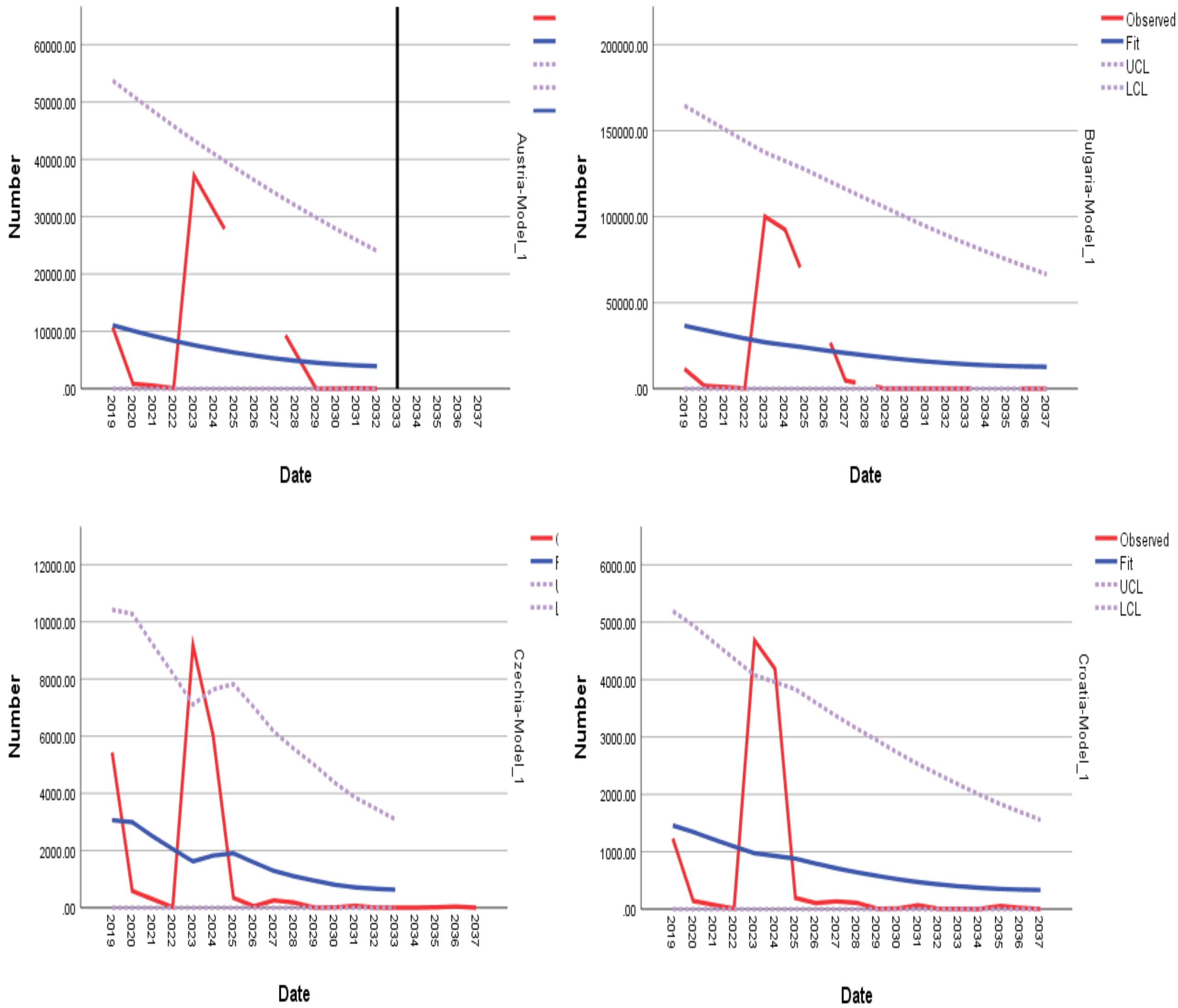
As seen, local production decreases significantly, but the imports of automatic data processing machines (computers and similar) and video apparatus from different countries (especially Asia) increase meaning.

The indicator with the greatest relevance in the context of the development of the IoT segment within the ICT sector (*Rate of active ICT enterprises in a mountain area* - I_m7) is the *population of active enterprises in t - number*. This indicator shows the potential development of IoT and ICT in the mountain area.

At the European level, the population of active enterprises in the mountain area occupied 2016 important shares in the total population of active enterprises, respectively, Bulgaria

79.39%, Italy 41.70%, Austria 38.95%, Spain 56.62%, Romania 28.30% and Slovakia 41.83%. In other countries, the population of active enterprises in the mountain area had a lower penetration of the business model sector, so in the Czech Republic the percentage was 11.66%, in France 15.76%, Croatia 17.18%, Poland 3.84% and Portugal 13.61%. (Eurostat 2021)

The analysis of the studied countries presents specific statistics for the mountain area ICT sector. According to ANOVA (ANalysis Of Variance and Covariance) and applying regression principles, the model fit postulates that a variance has a mean of the fitted values equal to the mean itself. Thereby, model fit statistics of the mean, respectively, and percentile 5 are presented in Table 2 (Eurostat 2021).



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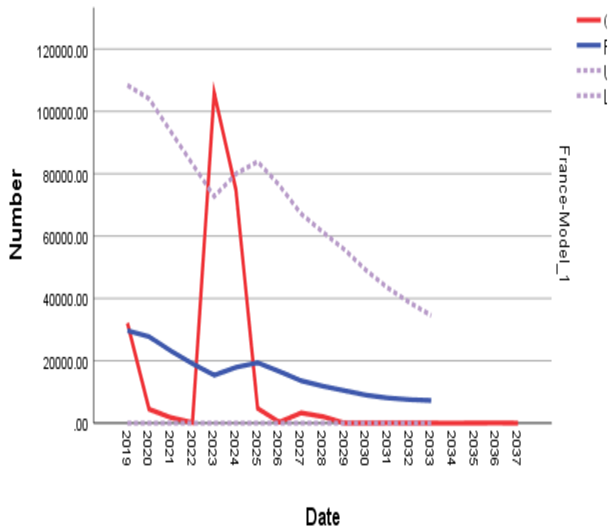

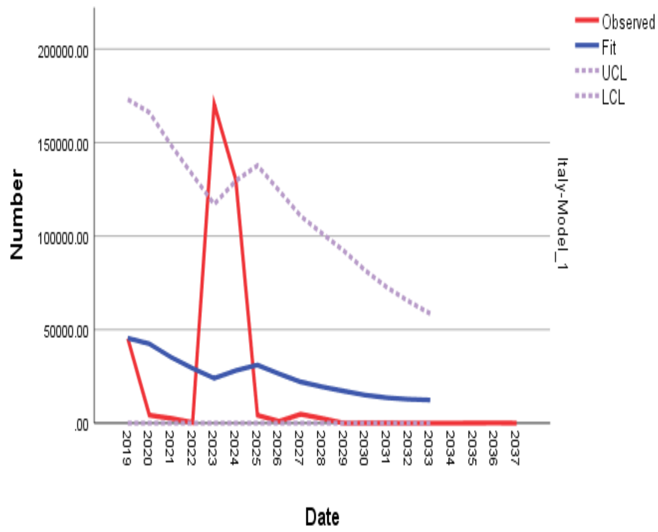

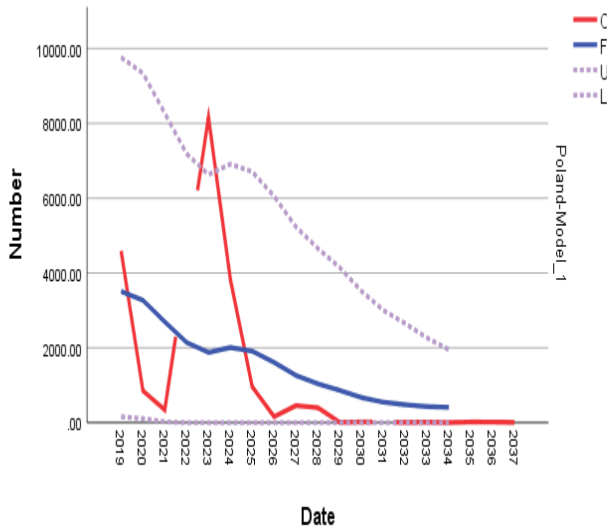

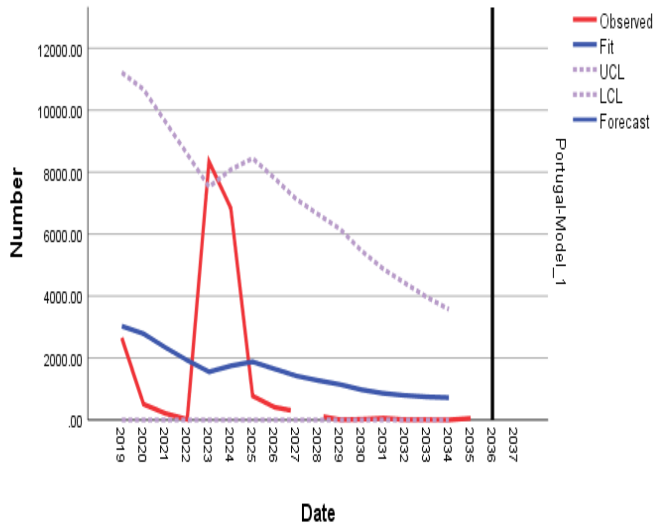

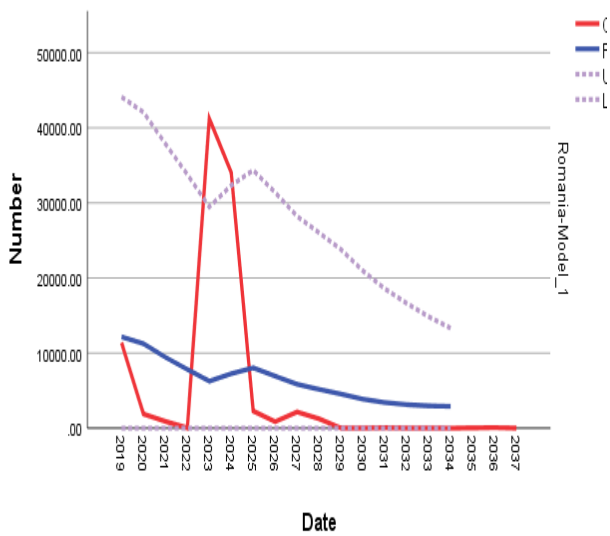

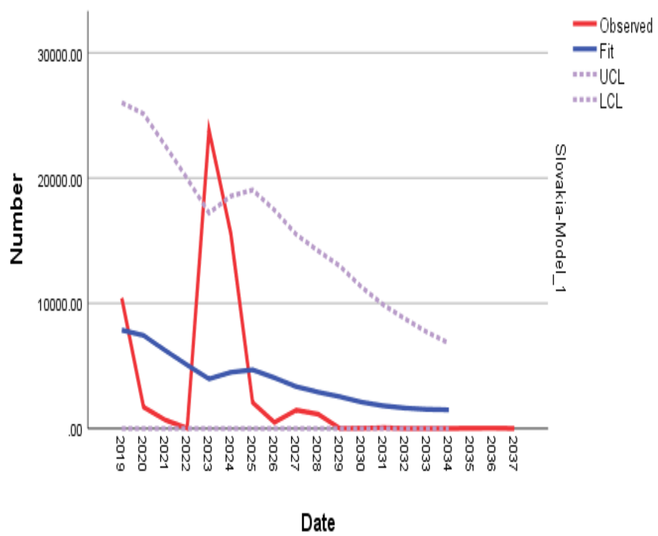

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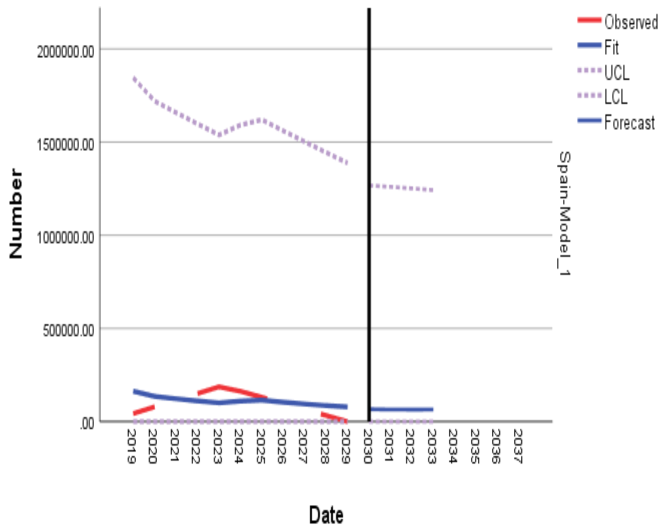

Figures 2. Statistics and forecasting models for the population of active enterprises of ICT sector in mountain area of the European analyzed countries (2019-2037)

Source: Authors according to Eurostat (2021)

Table 2. Statistics for the ICT sector in the European mountain area, according to Eurostat

Country	Stationar R-squared	R-squared	Root Mean Square Error	Mean Absolute Percentage Error	Maximum Absolute Percentage Error	Mean Absolute Error	Maximum Absolute Error	Bayesian Information Criterion
Austria	.267	.043	12953.127	121623.14	943357.862	8086.914	29589.768	19.426
Bulgaria	.492	.013	38470.502	78465.276	327897.026	29306.33	73049.592	21.529
Czechia	.681	.107	2834.848	4775.996	18847.752	1964.095	7559.655	16.261
Croatia	.649	.093	1359.930	4493.438	27017.137	880.431	3709.254	14.740
France	.631	.038	32649.212	34898.835	163411.349	20451.381	90577.215	21.148
Italy	.634	.026	54224.288	93648.089	498633.987	33708.193	146579.800	22.163
Poland	-.024	.200	2258.946	4469.520	36259.937	1472.641	6290.453	15.822

Portugal	.645	.036	2781.240	6900.482	46998.483	1860.552	6789.220	16.238
Romania	.640	.038	12912.245	28500.516	240386.754	8023.334	34976.430	19.278
Slovakia	.674	.088	6863.672	14235.786	123168.056	4412.703	19860.388	18.015
Spain	-	-.249	124044.4	615596.58	2462032.15	84396.176	119810.676	24.150

The analyzed data show that the model fits correctly into the country models without errors. All presented values are in normal parameters and the variability of the returned data around its mean is explained with high precision. According to ANOVA analysis, statistics, and forecasting, the studied countries will perform quickly in the ICT sector in the mountain area. Only Spain, due to the depopulation of the mountain area, will perform slower than the others.

As seen in Fig. 2 (Statistics and forecasting models for the population of active enterprises of the ICT sector in the mountain area of the European analyzed countries, 2019-2037) the ascending trends in the European analyzed countries will be met only for one-two years, after that the trend will be descending before 2026, except Austria which will be until 2029. Subsequent previous to 2037, the ICT sector will not develop anymore, which is explainable, because the majority of the mountain areas will be technological by then and will advance significantly 5G and satellite communications.

Discussion

RH1. IoT influences mountain business model more than hilly and low-land business model

The proposed aggregate indicator takes into consideration subsequent indicators which have convenient values for the hilly or low-land area. Mountain altitude (I_m1), Mountain slope (I_m2), Average of local elevation range (LER) (I_m3), and Attenuation signal due to the mountain area (I_m4) are indicators with values almost inexistent for the hilly and low-land areas. Due to the natural handicap of the mountain area, Internet access (I_m5), Degree of penetration with smart technology (I_m6) and Rate of active enterprises in the mountain area in the field of ICT (I_m7) have fewer values than in the hilly or low-land areas. This means that the aggregate indicator will have a smaller value in the mountain area. Consequently, mountain area will present generally low values than hilly or low-land area, meaning that the degree of IoT penetration for enterprises in mountain areas (I_m8) present additional difficulties in high-land areas. Concluding, the business model and general socio-economic life are more difficult to sustain in the mountain area.

RH2. The degree of IoT penetration for enterprises in mountain areas (I_m8) is influenced by some subsequent indicators (I_m1, I_m2, I_m3, I_m4, I_m5, I_m6, I_m7)

The I_m8 indices have been constructed taking into consideration the real values of the ICT sector, not the nominal or forecast assessments. Following the exploratory analysis for mountain classes 1, 2, and 3, carried out on the sites that transmit images from the considered areas (webcams that transmit images in real-time or recorded from certain areas of the mountains presented above), it was observed that access to the Internet is provided only occasionally for tourism and protection of life and the environment.

The exploratory analysis was performed by accessing the internet pages of each mountain locality presented in the previous table. The most important obstacle in achieving IoT at such altitudes is the jamming of the signal due to numerous factors taken into account when constructing the I_m8 indicator (*degree of IoT penetration in mountain areas*). From the 4th class, the IoT starts, although the internet signal is fluctuating and permanently depends on certain factors mentioned in I_m8. For businesses, IoT is easily achieved in mountain business model areas of classes 5, 6, and 7. However, in some areas with high forest density, IoT is also difficult to achieve in mountain areas of classes 5, 6, and 7.

RH3. The proposed indicator applies *to the European mountain business model*

Specifically, for the European mountain area, in the period 2008-2016, the evolution of the population of active enterprises in this zone experienced significant increases in countries such as Bulgaria, 123.50%, Romania 98.50%, Slovakia 85.86% and weakly significant in Spain 28, 77%, Austria 13.39%, Portugal 9.42%, and in Italy there was an insignificant decrease of -2.02%. (Eurostat 2021)

Statistics and forecasting model for the 2037 horizon presents descending trends for the mountain area ICT sector (considering the 19th indicator presented above), as far as 2022, in Austria, Bulgaria, Czech Republic, Croatia, France, Italy, Portugal, Romania, and Slovakia, while Poland as far as 2021. Spain is the only European country with continuous minor ascending trends and it will be taken into consideration with linear values of ICT degree penetration in the mountain area.

Conclusion

Business model development in the mountain area is difficult to achieve, especially due to the weak development of ICT and IoT. In this context, mountain entrepreneurs need to be supported in implementing IoT.

The challenges facing mountain business model entrepreneurs refer to competition with business companies in hilly or plain areas (for whom business is easier), as well as the application of technologies in harsh conditions (mountain areas are known to have a natural handicap in the application of technology). (RH1)

Following the quantitative and exploratory analysis of the paper, regarding the regional analysis, it should be recalled that IoT for mountain areas of classes 5, 6, and 7 is better done in Austria, France, and certain regions of the Czech Republic, Croatia, Italy, Poland, Portugal, Romania, and Slovakia, countries where internet access has considerable shares. In contrast, in some mountainous areas belonging to poor regions in the Czech Republic, Croatia, Italy, Poland, Portugal, Romania, and Slovakia, IoT is difficult to achieve, and in this case due to low internet access and smart electronics penetration. (RH2 and RH3)

The main conclusion of the study is postulated by the need to develop ICT and IoT in the mountain areas so that mountain entrepreneurs can be competitive in a market with fierce competition from other entrepreneurs.

At the exploratory and quantitative level, this model presents a series of limitations as numerous mountain sources to visit, as well as statistical data collection and simulation. In subsequent papers, the indicator will present additional validation to implement it in the European and world mountain areas.

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