Evolution of smart village models in Hungarian Abaúj micro-region

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Within the framework of this study, dealing with the situation of the Abaúj micro-region, the authors would like to answer the question regarding a multiply disadvantaged area with low levels of economic and scientific innovation: whether social innovation can help in solving the problems and could it be the engine of change. To answer this question, the literature of the topic has been reviewed as a first step, and the „smart models", too, the ones that may be significant or could provide support during the developmental process. In this part, a consequent distinguishing among smart models that can be applied in villages and in larger cities has been applied. Based on the models and field research, the authors formulated a possible smart region model and prepared a network analysis model by the Gephi method, which gives a complete overview of the spatial availability of retail stores. The development and spatial distribution of networks opens up new possibilities. An important question in this new situation: how urban smartness affects the smartness of the region and its villages in their development, whether the multiplicative effect of the cities' smartness significantly improves the quality of life of those living in the surrounding settlements. The change of the urban-rural relationship creates the conditions for a more liveable city for the cities' inhabitants and a better quality of life for the residents of the villages; the authors aim to overview this issue within the framework of the study.

Keywords:
smart region,
smart village,
Abaúj micro-region,
multiply disadvantaged area,
network analysis model,
Gephi method,
spatial sustainability potential

Introduction to smart city models

The global economic crisis of 2007–2008 has resulted a paradigm shift also in the concept of the creative city, resulting the concept of the *smart city*, which is a partial rethinking of the previous approaches (digital city, intelligent city, smart city). It is difficult to find a common concept for the term in the literature (Fekete–Morvay 2019, Mitrofanova et al. 2021), even the pillars that make up the models are interpreted differently. The notion of a smart city is for example based on the Government Decree No. 56/2017. (III. 20.) as follows: „A smart city is a settlement or a group of settlements, which develops its natural and built environment, digital infrastructure, and the quality and economic efficiency of its locally available services by adopting novel and innovative information-technologies, in a sustainable way, through the increased involvement of its residents." This definition does not contradict the definition applied by the European Union (EU) [1]: „A smart city is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business." Of course, creativity, innovation, technological change and network development continue to be an integral part of urban development policy (Egedy 2017, Szalmáné Csete–Buzási 2020). Within the framework of this present study, we do not want to deal with the detailed interpretation of the creative city's concept and not with the follow-up of many other variants of the „smart city" concept in the literature. We only want to show a few smart city models based on which – in our opinion – a smart region or smart village model can be developed (see Table 1).

Table 1

Models of smart cities and communities

Smart Cities and Communities programs	Smart City Wheel (Cohen 2015)	The IBM Smart City model	Model of Frost–Sullivan (2013)	Nature Based Smart City (European Commission 2015)	Model of Giffinger et al. (2007)
Sustainable urban mobility: alternative energy, public transport: efficient logistics, planning	Smart economy	Governance	Governance and education	Brings the city closer to nature: a conscious connection of cycles and processes, paying attention on the ecological constraints	Smart economy

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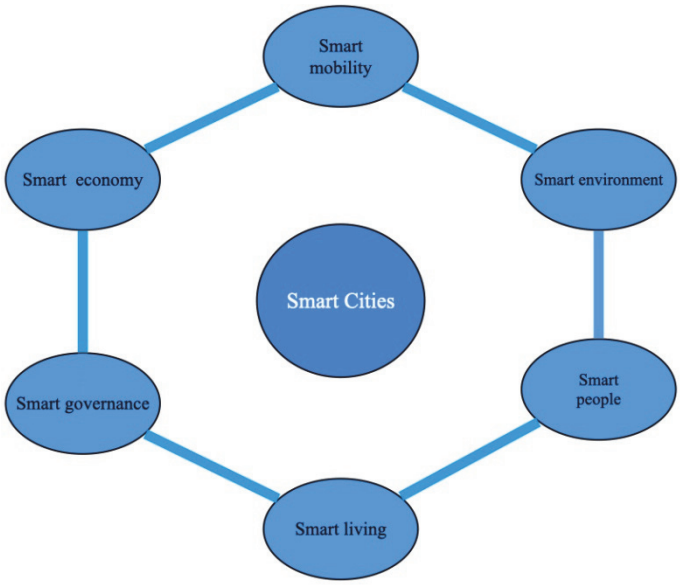
Communities programs	Smart City Wheel (Cohen 2015)	The IBM Smart City model	Model of Frost–Sullivan (2013)	Nature Based Smart City (European Commission 2015)	Model of Giffinger et al. (2007)
Sustainable energy, efficient buildings and districts	Smart environment	Civil and industrial users and the related infrastructure	Healthcare	„Green and blue" infrastructure approach	Smart mobility
Creation of integrated infrastructure in the fields of energy, transport, information and communication technology	Smart governance	IBM Smart Assessment	Buildings		Smart environment
Social care systems	Smart living/ lifestyle		Mobility		Smart people
	Smart mobility		Infrastructure		Smart living
	Smart people		Technology		Smart governance
			Energy and people		

Source: compiled by the authors based on Sallai (2016: pp. 7–8.)

Figure 1

Smart city model



Source: Giffinger et al. (2007).

Although the „smart city" models presented above are partly different, their main goal is to create and maintain an efficient city. Regarding smart cities, Giffinger et al. (2007) have made an attempt to rank the smart index of 70 European cities based on 6 basic pillars (Figure 1). By the ranking of the European medium-sized cities with a population of between 100,000 and 500,000 inhabitants the following aspects were checked such as creativity, flexibility, sustainability, coherence, security, quality of life and competitiveness.

We highlighted the Hungarian cities from the city ranking of Giffinger et al. (2007) in order to point out where Miskolc, as the centre of the examined creative region, is located in the ranking of the European and Hungarian cities.

Table 2

Characteristics of the Hungarian smart cities and their place in the European rankings

City	Smart economy	Smart people	Smart governance	Smart mobility	Smart environ-ment	Smart living	European ranking
Győr	46	68	62	37	41	63	61
Pécs	56	62	65	58	65	53	65
Miskolc	58	67	67	50	70	58	67

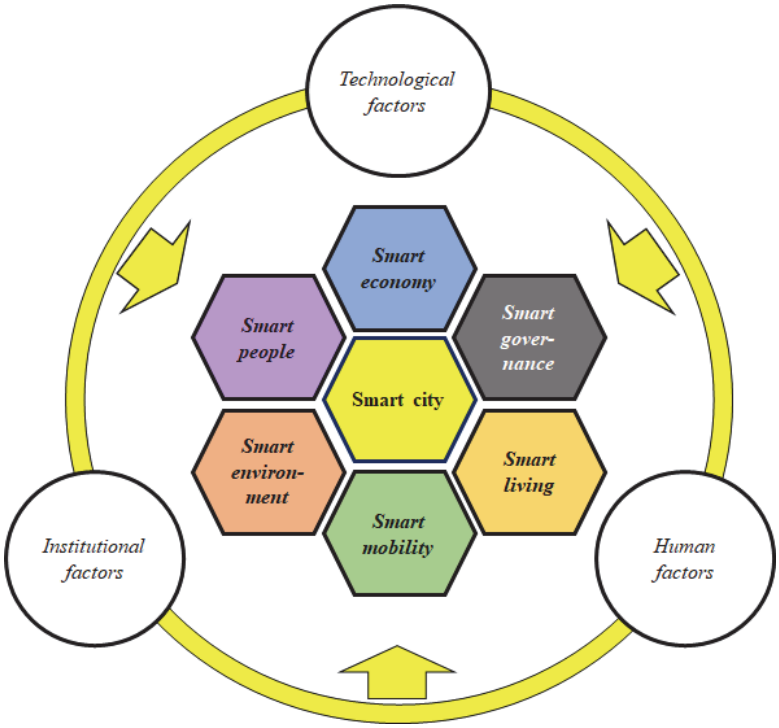
Source: Giffinger et al. (2007).

Based on its values, Miskolc ranks 67th in the overall ranking of the European medium-sized cities (Table 2), although based on some parameters, its position is more favourable. It is important to mention that as the centre of Borsod-Abaúj-Zemplén County, due to its relatively good position in smart economy and smart mobility, it has a significant impact for the development of its catchment area. In particular, the strengthening of its economy has been observed in the last years, which was significantly hit by the COVID-19 pandemic situation in the spring of 2020, which was reflected in the increase of the unemployment rate and the stagnation of the economy. Smart Cities in another approach (Horváthné Barsi–Lados, 2011) are municipalities that use the available technologies in an innovative way, thus creating a better, more diverse and sustainable urban environment. These cities use smart technologies to make the city's infrastructure systems and services more interconnected and thus more efficient (Horváthné Barsi–Lados, 2011). A research group at the University of Miskolc used also this approach. They applied the IBM smart city model for the Cserehát region (Tóth et al. 2015). The smart city model of Nam–Pardo (2011) is a kind of rethinking of the traditional Giffinger model, which improves the interoperability of urban services and subsystems (e.g. transport, public safety, energy, education, health and city development). Smart city strategies also require innovative collaboration with stakeholders, regarding the resources and services. Nam–Pardo (2011) have applied in their model a holistic approach and classified the smart city components into three key factors (Figure 2). These include

changes due to technological progress (e.g. effects of industry 4.0, artificial intelligence, the emphasis of IoT), changes in human factors (e.g. changes in labour market processes, migration indicators), and the institutional factors such as changes in the regulatory framework.

Figure 2

Smart city factors



Source: own edition based on Nam–Pardo (2011), European Parliament (2014), Szendi et al. (2020).

In 2014, the Sustainable Business Leadership Forum established the Smart Cities Maturity/Development Model, which analyses the development of smart cities in a four-step process (Table 3). The first stage can be interpreted in the form of basic urban resilience. This means access to the urban services. In the second phase, resource and energy efficiency will be achieved, which should be the basis of a future smart city. The third phase focuses on urban sustainability, while the last, fourth phase seeks to improve urban sustainability and achieve high resilience in a systems approach. According to the European Network for Rural Development (ENRD 2018), smart villages are communities created in rural areas that use innovative solutions to increase their resilience while building intensively on local strengths and opportunities. Thus, resilience would be very important for small settlements to increase their population retention and improve their competitiveness.

Table 3

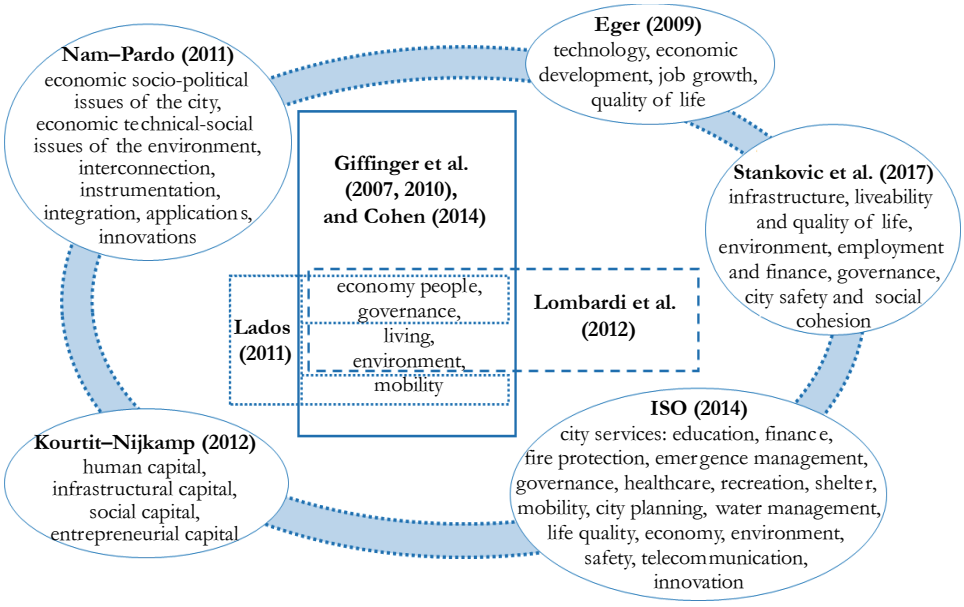
Smart cities maturity/Development model

Development model	1	2	3	4
	Basic urban services	→	→	High urban resilience
Key performance indicator (KPI) focus	Availability, accessibility	Efficiency	Behaviour	System approach
Success factors…	Available urban infrastructure, technologies, and urban services	Measuring resource and energy efficiency in the smart cities of the future	New opportunities to improve sustainability through people-to-people interactions	Sustainable use of resources and energy

Source: Own edition based on Kumar–Dahiya (2017).

Figure 3

Typology of smart city definitions



Source: own edition based on Hajduk (2016: p. 3.) and Szendi (2017).

Thus, there is no accepted concept in the literature for measuring the performance of smart settlements, and there are various solutions for calculating the values of each component and the complex index as a whole (Figure 3). A common feature of the concepts is that their aim is to determine the smart performance of settlements on

the basis of several components and indicators, relying on data based on both qualitative and quantitative scale.

Methodology

The study of the Abaúj region was carried out using the database of the TEIR, the Hungarian Central Statistical Office, and the data available on the Internet. By the calculation of the smart index, we used the basis of the regional average. For the analysis, we also used the possibilities offered by GIS (Mapinfo 12.5) and the Gephi method suitable for the analysis of network connections. In network analysis, our calculations are based on graphs that consist of vertices and edges. „The points are the data whose relationships we are examining. The edges are formed when we find a real connection between the analysed data. The purpose of using graphs is therefore to represent the different relationships among the data points" (Barabási–Bonabeau 2003, Lengyel et al. 2018, Zdanowska et al. 2020). The method used in our study is one of the classical methods, which is suitable for displaying spatial processes and transforming networks into maps (Geo Layout algorithm). The method was developed for typical network schemes of Gephi users (scalable and suitable for handling 10–10,000 nodes). In the Abaúj region, we have displayed 24 nodes using this method, where the nodes represent the settlements of the region. A sum of 56 edges belong in our case to these nodes, which shows the number of journeys among the neighbouring settlements. The aim of the method is to examine the possibility of travel and mobility between settlements and to apply this technique to show how problematic it is to visit grocery stores in the area and how much it worsens the quality of life of the inhabitants. This method is used to support the results of the smart-index calculation.

Smart index of the Abaúj micro-region, 2014, 2019

The present research was based on the project ideas „Generating Social Innovations in Borsod-Abaúj-Zemplén County", which was carried out in the University of Miskolc in the framework of the „Higher Education Institutional Excellence Program". Our model was built on the IBM Smart City model, which focused on rural areas (Ornetzeder et al. 2017, Slee 2019). An important step in this work is the situation analysis, which helps to understand the specific development of the Abaúj region and it's future potential. The Smart region model is practically an adaptation of the IBM Smart City model (Horváthné Barsi–Lados 2011) (Figure 4).

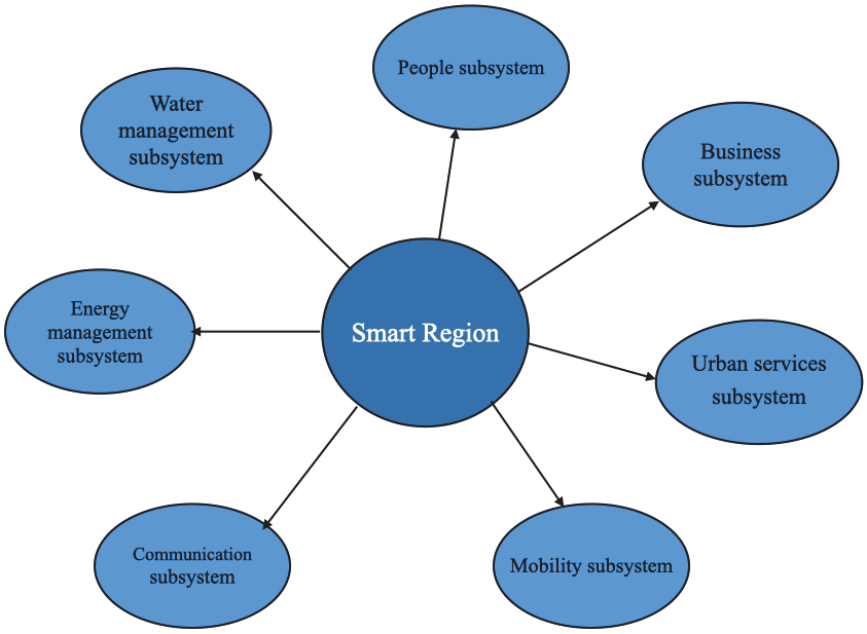
According to the IBM model (Dirks–Keeling 2009) the operation of cities is built on seven subsystems consisting of networks, infrastructure and environment:

1. people subsystem (health, education, public safety, satisfaction with local government services),

2. business subsystem, which besides the entrepreneurial activity includes also the city's policy and regulatory environment affecting business (business environment, administrative burdens),
3. urban services subsystem (management of public services, local government and administration),
4. mobility subsystem (number of passenger cars, road quality, airports, ports),
5. communication subsystem (broadband and wireless communication, telephone and computer use),
6. water management subsystem (water supply, sewerage),
7. energy management subsystem (gas and electricity supply, renewable energy resources).

Figure 4

Regional extension of the IBM Smart city model



Source: own edition based on Tóth et al. (2015) and Horváthné Barsi–Lados (2011).

A different number of indicators were added to each subsystem of the applied model (36 indicators were used for the complete analysis, Table 4), and the unweighted smart index of the Abaúj region was calculated finally based on the average values of each subsystem. The smart index of the Abaúj region followed the methodology of the Cserehát research.

Table 4

Components used by the creation for the smart index and their indicators

No.	Indicator
	People
1	Unemployed per 100 employees[a)]
2	Elderly per 100 active aged[a)]
3	Live birth per 1,000 inhabitants
4	Death per 1,000 inhabitants[a)]
5	Natural reproduction, or loss per 1,000 inhabitants
6	Jobseekers registered for more than 180 days per 1,000 inhabitants[a)]
7	Registered unemployed as a career starter for 1,000 inhabitants[a)]
8	Inhabitants per 100 dwellings*
	Energy management
1	Households consuming piped gas as a percentage of the housing stock
2	Annual gas consumption per household consumer[a)]
3	Annual electricity consumption per household consumer[a)]
	Communication
1	Internet subscriptions per 1,000 inhabitants
2	Internet subscriptions in xDSL network per 1,000 inhabitants
3	Internet subscriptions in cable TV network per 1,000 inhabitants
4	Proportion of dwellings connected to the cable television network as a percentage of the housing stock
	Mobility
1	Passenger cars per 1,000 inhabitants
2	Motor cycles per 1,000 inhabitants
3	Buses per 1,000 inhabitants
4	Proportion of passenger cars registered for the first time in Hungary
5	Proportion of built local governmental roads
	Business
1	Number of active enterprises per 1,000 inhabitants
2	Number of active enterprises with legal status per 1,000 inhabitants
3	Number of active social entrepreneurs per 1,000 inhabitants
4	Number of active private entrepreneurs per 1,000 inhabitants
5	Number of active enterprises with more than 50 employees per 1,000 inhabitants
6	Number of active enterprises in the information and communication sector per 1,000 inhabitants
7	Number of active enterprises in the professional, scientific and technical activities sector per 1,000 inhabitants
	Urban services
1	Local governments current revenues per 1,000 inhabitants
2	Local tax revenues of local governments
	Water management
1	Share of biologically or by advanced technology cleaned water among the waste water treatment
2	Ratio of dwellings connected to the drinking water-conduit network
3	Ratio of dwellings connected to the public sewerage network
4	The amount of water supplied to households per 10,000 inhabitants[a)]

a) In this case, the reciprocal value has been applied due to different scaling of the indicators.

During the calculation of the smart index, the values of all indicators were compared to the average of the Cserehát region. The reason for that was the comparability and accountability of the data measured in different units. The value of each subsystem is the average of the values calculated in the previous step, while the complex smart indicator can be computed as the average of the seven subsystems.

The calculation method follows the below-mentioned formulas:

Relative value of indicators:

$$x_{i(relative)} = + \frac{x_i}{\bar{x}_{Cserehát}} * 100 \quad (1)$$

Calculated value of subsystems:

$$Subsystem\ index\ (I_i) = \overline{x_1 \ldots x_n} \quad (2)$$

Complex smart index:

$$SI = \bar{x}(I_{people}, I_{energy}, I_{communication}, I_{mobility}, I_{business}, I_{urban}, I_{water}) \quad (3)$$

Based on the aggregated SMART indicator (Table 5), we have ranked the settlements in 2014 and 2019.

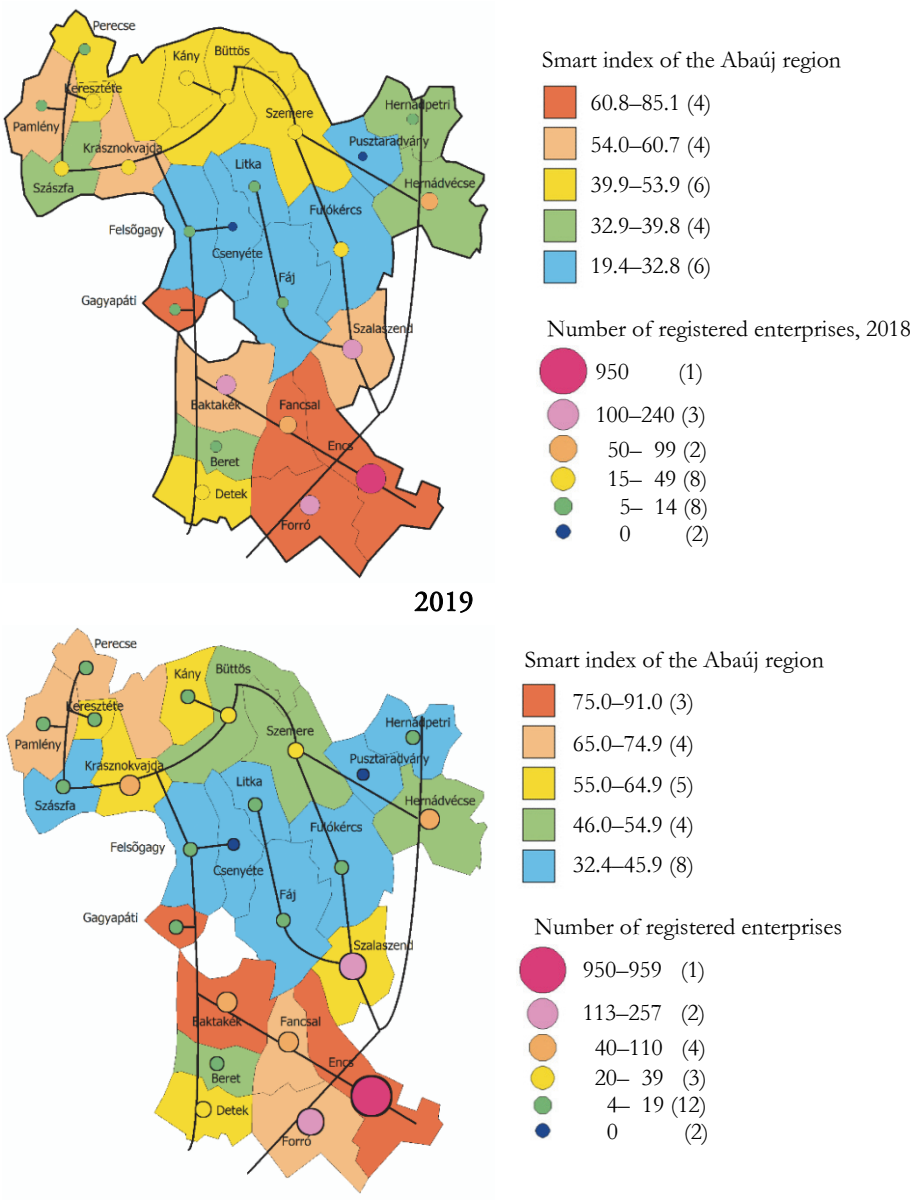
Table 5

Values of the smart index in the settlements

Settlement name	2014	Rank, 2014	Settlement name	2019	Rank 2019	Change in the ranking compared to 2014
Encs	85.1	1	Encs	91.0	1	0
Fancsal	81.9	2	Gagyapáti	83.9	2	–5
Forró	66.6	3	Baktakék	77.0	3	4
Gagyapáti	60.8	4	Forró	74.0	4	–1
Krasznokvajda	59.1	5	Pamlény	71.1	5	3
Szalaszend	58.8	6	Perecse	70.7	6	5
Baktakék	58.2	7	Fancsal	68.9	7	–5
Pamlény	54.6	8	Szemere	68.7	8	1
Szemere	54.0	9	Szalaszend	62.2	9	–3
Perecse	49.0	10	Krasznokvajda	61.8	10	–5
Kány	46.1	11	Kány	57.6	11	0
Büttös	40.8	12	Detek	56.6	12	2
Keresztéte	40.6	13	Keresztéte	55.7	13	0
Detek	39.9	14	Beret	49.6	14	3
Hernádpetri	39.6	15	Hernádvécse	46.8	15	1
Hernádvécse	39.1	16	Büttös	46.7	16	–4
Beret	36.7	17	Fulókércs	45.9	17	5
Szászfa	33.6	18	Litka	45.2	18	3
Felsőgagy	32.9	19	Szászfa	43.3	19	–1
Pusztaradvány	31.7	20	Csenyéte	42.8	20	4
Litka	30.7	21	Hernádpetri	41.5	21	–6
Fúlókércs	29.9	22	Felsőgagy	41.3	22	–3
Fáj	23.4	23	Fáj	36.1	23	0
Csenyéte	19.4	24	Pusztaradvány	32.4	24	–4

Figure 5

Smart index values in the settlements of the Abaúj region



In 2014, from the 24 examined settlements, only nine had a smart index value exceeding 50%, 15 settlements remained below this value and six of them were in the

region that performed significantly below the average (Csenyéte 19.4%, Fáj 23.4%, Fúlókércs 29.9%, Litka 30.7%, etc.). In 2019, the situation improved a bit in absolute terms, but the situation was still not very favourable. The main reason for the low smart index value is the relatively low value of the business subsystem; this subsystem includes among others the number of active enterprises per thousand inhabitants, and the number of enterprises with legal personality. The unfavourable position of other 2-3 pillars (e.g. water management, energy, people) worsens further the overall situation of these settlements. Based on the data of the Hungarian Central Statistical Office, there was not a single active enterprise in Csenyéte in 2014 and in 2019, but also in Pusztaradvány and Büttös we can talk about some micro-enterprises. The outstanding smart index of Gagyapáti (a „dead-end village") is explained by the good position of the energy and business component, mainly the successful operation of tourism enterprises. In the field of energy, this settlement has one of the lowest annual electricity consumption per household consumer, while in the business subsystem the number of active enterprises per thousand inhabitants, including the number of enterprises with legal personality, is 64.5 while the national average is 24.2. Encs, the only town in the region, is first in the overall ranking in 2014, which managed to maintain its position also in 2019, due to the relatively high number of active companies and its urban functions.

Based on the results of the Abaúj region smart index in 2014 and 2019, the following region types were distinguished (Figure 5).

- Northern part of the Eastern-Cserehát area with Krasznokvajda centre,
- Central part of the Eastern-Cserehát area with Csenyéte, Fáj, Litka, Fulókércs and Pusztaradvány,
- Southern belt of the Eastern-Cserehát area until the Hernád-valley with Encs centre.

Some settlements in the created territorial clusters show a smaller rearrangement from 2014 to 2019, but there was no significant change in the core of the clusters and Figure 5 also clearly confirms the structure of the categories. The given clusters have the following characters:

Central part of the Eastern-Cserehát area

The unfavourable values of the settlements located in the territory of the central part of the Eastern-Cserehát area are partly the consequences of their labour market situation, which is accompanied by an unfavourable demographic structure and lack of education. The lowest value of the smart index had Csenyéte in 2014 with 19.4%, which was improved to 42.8% to 2019, but this ranks only to the 20th place out of the 24 examined settlements. Here, the employment rate is the most unfavourable and the education attainment level is the lowest: among the population over 7 years, the number of people who have a primary school certificate is only 28% (Table 6).

Table 6

Employment in the central part of the Eastern-Cserehát area, 2021

(%)

Settlement	Unemployed	Inactive earner	Dependent	Sum
Csenyéte	19.66	22.83	49.81	92.31
Fáj	8.51	40.20	43.15	91.86
Pusztaradvány	9.45	21.51	35.71	66.67
Fulókércs	5.78	29.10	34.22	69.10

Source: own edition based on the [2].

Eight or nine tenths of the people living in the settlements of this territory have no earning job, the level of education of the people living here is also extremely low (Beluszky 2019). Due to their transport connections, the regions are almost closed, they are hardly connected to other regions, so they can hardly access even to the most necessary services. Some of the settlements of Central-Cserehát are inhabited; the „presence of poverty" is very strong in these settlements.

The people component of the smart index also reflects the unfavourable situation of the region's settlements. The number of live births per 1,000 inhabitants is one of the highest in the region in Csenyéte, as well as the number of inhabitants per 100 dwellings (712 people!). The situation is further worsened by the fact (which verifies also the deep poverty situation) that the number of internet subscriptions per thousand inhabitants is zero in Csenyéte, while in the case of Csenyéte and Pusztaradvány there are no active enterprises in 2019.

Northern part of the Eastern-Cserehát area

From the villages of this area, the settlement of Krasznokvajda may arise as a regional organizer in the Abaúj region – the neighbouring settlements are still closely connected to it through agricultural activities – which, based on its past is the centre of the *„Hétközség"*, and could lead the formation of the *„Northern Cserehát Union"*. The relatively favourable labour market situation strengthens Krasznokvajda's position further (in terms both of the employment and unemployment ratio); however, it is rather similar to the average of the surrounding settlements in terms of long-term unemployment and unemployment among the career starters.

The digital village program could play an important role in the process of becoming a smart village, as a centre of agriculture and as a traditional regional centre (this is supported by the outstanding number of internet subscriptions in Krasznokvajda from this Northern Cserehát region). It can organize the transportation of the surrounding villages e.g. with the car sharing program (the car stock in the area is below the national average), through phone or Internet orders. Rethinking and strengthening the village-care system could help to solve the above-mentioned transportation and supply problems, thus slowly starting the process of

becoming a smart area. Through this process, the image of villages could improve in the area, which in the case of other factors (e.g. tourism) could slowly follow the example of Alsómocsolád[1].

It would be important to utilize the Szentimrey Castle in Krasznokvajda for tourism purposes in the long run, which would provide new jobs for the locals, similarly to the Vécsey-Sardagna Castle in Hernádvécse. The area has many good characters, e.g. „silence, tranquillity, rich flora and fauna"; the better use of them could help the settlements to catch up. An example of this is Gagyapáti, where the pensions offer „peace and quiet" to the visitor. The Abaúj region offers many opportunities, but to become a smart region, there is a need for many local „heroes" who are able to form a „Union" of settlements and at the same time develop creative thinking in the region.

Southern belt of the Eastern-Cserehát area

Each region has a different development path. From the three clusters, the region of Encs is relatively in the best position, as it is shown also by its smart index (Encs 2014: 85.1%, 2019: 91.0; Fancsal 2014: 81.9%, 2019: 68.9; Forró: 2014: 66.6%, 2019: 74.0). With an average smart index value, Gagyapáti (2014: 60.8%, 2019: 89.8%), Baktakék (2014: 58.1%, 2019: 77.0%) and Szalaszend (2014: 58.8%, 2019: 62.2%) also belongs to this cluster. As a district centre, Encs has a dominant role not only in the southern belt of the Eastern Cserehát area, but also in the whole Abaúj region. As a city and district centre – it performs well compared to the weighted average of the Cserehát region (67%) – it has all the features that allows it to become the engine of the Abaúj region in the long run. In our view, two regions within the Abaúj region have a chance to become a smart region, the area of Krasznokvajda with the *„Northern Cserehát Union"* and the Encs centre on the southern belt of the Eastern Cserehát. In the region, Encs has most of the active enterprises. It is the only settlement in the region where, according to 2019 data, there was an enterprise employing more than 50 people. In addition, the good character of the southern belt is further strengthened by its favourable geopolitical situation within the region (primary main road, main road No. 3; and the proximity of the M30 Miskolc-Kassa motorway, which is expected to be built by 2022).

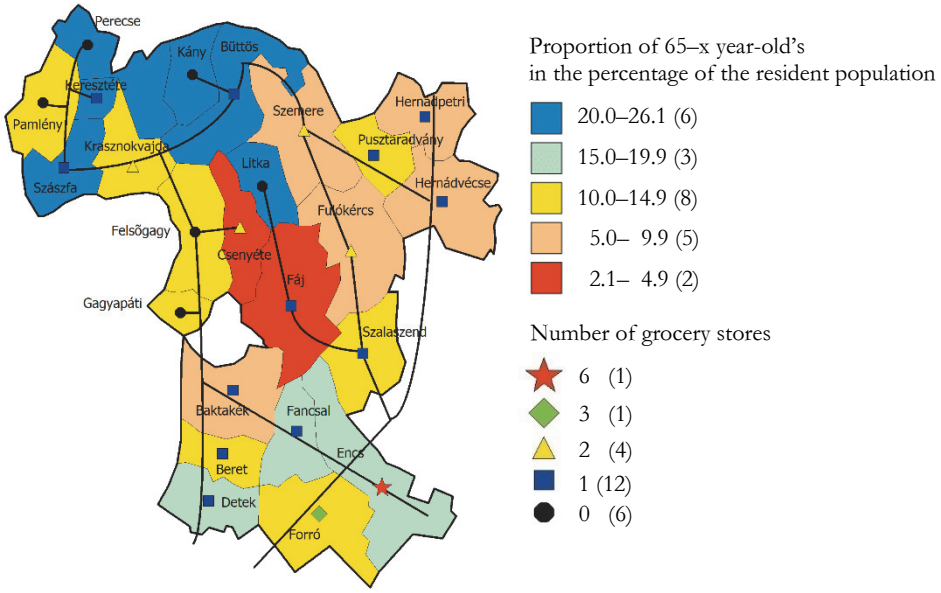
[1] Alsómocsolád is a „dead-end village" in northern Baranya County with a population of about 300 people. Over the past decades, it has tried to find a new way to stop the decline of the village's population, for which a total of 2.5 billion HUF budget of 50 EU tenders offered an excellent opportunity. The rethinking of the village life comfort (housing, services, income generation and community relations) was formulated with the help of a new smart region – smart village model. Their model was so successful that it was also presented at the Smart Villages conference in Brussels in 2019.

The smart indices of the Abaúj region confirm the findings of „Typology of Rural Settlements in Hungary" made by Pál Beluszky–Tamás Sikos T. (1982, 2011), according to which it is still true today that: „the villages of the region are in a very poor labour market situation, generally in poor condition, one part of them has a growing population, while another part consists of small villages affected by demographic erosion". Only 27.1 percent of the settlements' population has an active earner, the proportion of with some aid supported and pensioners in the Encs district exceeds 56.8 percent in 2019, which has the direct consequence that the income of the region's population is also extremely low. Based on the statistical data, the social indicators of the settlements also show an unfavourable value, e.g. the proportion of graduates is only 17 percent. There are visible traces of poverty in the image of the settlements, the buildings are „inhabited" and the poverty is noticeably present in a significant part of the settlements. As we have formulated before, the settlements seem to be living almost to the end of their days. However, the demographic processes contradict this, as population growth can be registered in some villages of the region, so there is a positive natural reproduction, while in other villages the aging process is decisive. Changes in the area's population began in the 1990s, when poor, unskilled, unemployed masses with many children were pushed out of the cities, mainly Roma population, for whom low property prices meant a favourable settlement in small villages. The real estate stock of the settlements in the area started to decline, as the incoming population accelerated the emigration of the native population and the residential properties of the „old village" recovered quite slowly. The process was further worsened by the fact that in poor villages it was possible to replace the old houses with new low-cost real estates, which further ruined the village image. The following chain characterizes the demographic processes of the villages in the region: depopulation → degradation → the migration of poverty → population growth → youthful age structure → high natural reproduction. A good reflection of the described processes is Figure 6, which clearly shows the settlements in the Northern Cserehát with a high proportion of elderly population, as well as the group of villages characterized by a positive natural reproduction (Csenyéte 41.4%, Fáj 23.8%).

Some provoking facts: between 2001 and 2019, Kány lost 37.4%, Szászfa 39.2%, Litka 36.8%, Büttös 34.8% of its population. The aging process of the settlements is also obvious, despite the fact that in some cases the increase in the number of the Roma population within the settlement also led to an increase in the natural processes, which masks the process of a visible aging in the settlements. In 2011, e.g. the number of children per one hundred families was in Fáj (240), Gagyapáti (233) and Csenyéte (216). In almost all of these settlements, the proportion of children was over 20%. The high number of children and the low number of active earners also indicates the presence of poverty in the settlements.

Figure 6

Territorial distribution of the 65–x year-old population of the Abaúj region and the location of grocery stores, 2019



Source: own edition based on the data of the Hungarian Central Statistical Office.

Table 7

Some interesting data of the „*Hétközség*"

Settlements	Population			Proportion of 60–x year-old		In case of route optimization, the shortest distance in minutes to the district centre, 2021	Number of grocery stores
				2001	2021		
	1949	2001	2019	%			
Büttös	501	256	174	30.5	30.5	29.15	1
Perecse	271	29	23	35.2	30.4	30.43	0
Keresztéte	166	28	36	42.3	41.6	34.68	1
Pamlény	416	54	52	38.9	19.2	46.30	0
Szászfa	528	176	113	30.7	28.3	43.35	1
Kány	297	86	57	40.7	31.5	33.30	0
Krasznokvajda	808	447	504	17.7	17.6	27.28	2

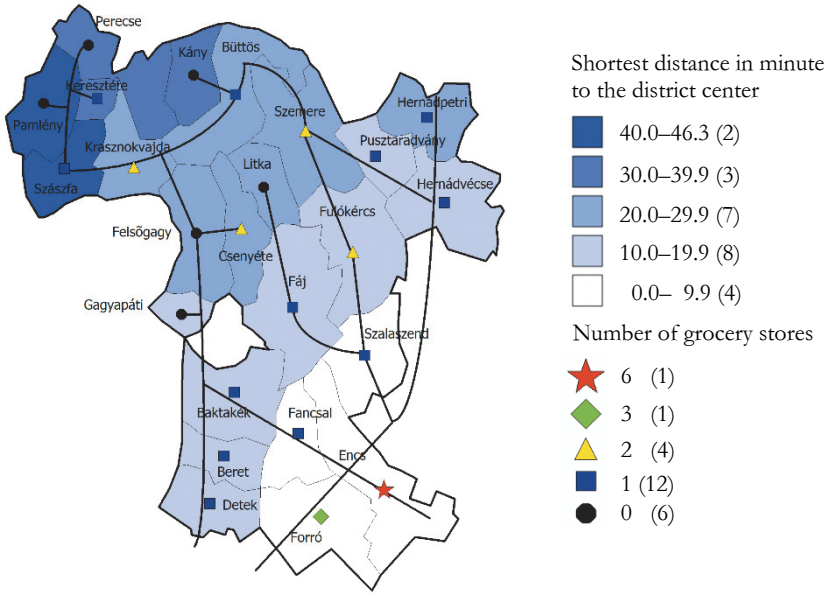
Source: [3–6].

The elderly population is not very mobile, however, the supply of grocery stores in the area is low. The transport relations of the settlements with the district centres and their neighbouring settlements cannot be called of adequate quality. The data given in Table 7, the shortest journey in minutes to the district centre, suggests that although the Encs district centre is quickly accessible from the villages of the

Northern Cserehát, this is accompanied by an extremely unfavourable frequency of transport routes, it can only be achieved through a full day of travel. It worsens the quality of life of those living in the area.

Figure 7

Number of grocery stores in the Abaúj region and the length of the shortest journey to the district centre in minutes, 2018



Source: own edition based on the data of the Hungarian Central Statistical Office.

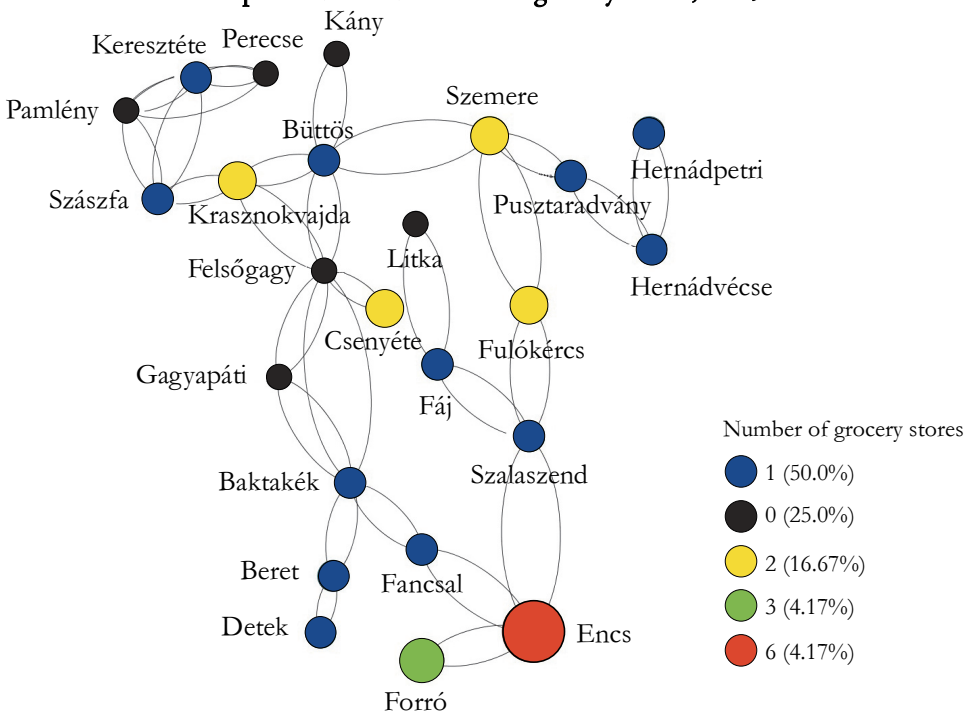
Figure 7 shows the length of the shortest journey in minutes. The values show that there are only three settlements within the district that are in a favourable position (Forró, Fancsal, Szalaszend), from which the shortest travel time to the district centre is within 10 minutes. However, in reality, this does not mean that the frequency between the journeys is similar, because often several hours of waiting time elapse between the given ones.

The villages of the *„Hétközség"* are in the worst situation; from here, it is the most difficult and complicated to reach the district centre, Encs. Krasznokvajda is the central town of the *„Hétközség"*, 25.2 km away from Encs. The passenger car stock does not improve the situation either, as the number of cars in the villages of the Abaúj region is lower than the national average, which makes it more difficult to find employment and visit retail and service units. Nowadays, the residents of the settlements are also having trouble accessing quickly the grocery stores of the neighbouring settlements. In the area, only Encs has some store network, as here, there are six grocery stores (five of which are part of a national network: Spar, Penny Market, CBA, Real, Coop) and a number of other retail units, whose product range

far exceeds that of other municipalities in the region. Six of the 24 settlements of the Abaúj region (Kány, Perecse, Pamlény, Felsőgagy, Gagyapáti and Litka) does not have a single grocery store at all, which is related to the size and aging population structure of the settlements. In these small villages, the income is so low, that they are unable to maintain even a small shop. This is practically only possible in the county centre and the district centre, but to this centres the inhabitants of the villages have to travel 50-80 km for a bigger shopping (also by Egri–Kőszegi 2020). The people, who have their work tied to the county centre, are lucky, as they are able to link commuting to work with food purchases. However, the majority of people living in the settlements is either shopping locally if they have a shop, or they have to travel to a neighbouring settlement, but this is not easy because of the quality of current transport network connections (Figure 8). This shows also the figure of the transport network, which represents the density of connections. Here we can see that instead of dense relations, the connections among the settlements are rare, the accessibility among them is poor.

Figure 8

The transport network of the neighbouring settlements in the Abaúj region and the spatial distribution of the grocery stores, 2019



Note: The edges between the settlements indicate the number of journeys, while the colours indicate the number of shops.

Source: own edition based on the data of the Hungarian Central Statistical Office.

For more intensive connections, minibuses operated by village caretakers could be used and equipped with car sharing[2] smart applications or frequency identifier (FID) technology or other applications that could help this process (Oszkár, Lyft, BlaBlaCar, Uber). In this way, it would be easier for the residents to reach the settlements where the grocery store operates or where the range of products is of a higher standard. Although the area has a system of mobile store network, which helps a lot in the supply of small villages, it also contributes significantly to the further decline of the store network. It is true that it would be more convenient for the inhabitants of small villages to shop locally, but for economic reasons this is practically impossible in the settlements due to the extremely low purchasing power, the shops are unable to extract the basic costs necessary for their operation. Nowadays, small businesses have such costs and expenses that it is simply not worth maintaining and operating a small business in a significant part of the small villages. Therefore, in the case of micro villages, but even in small villages, it would be necessary further strengthening the previously mentioned network of mobile shops, despite the above-mentioned negative effects. Inevitable, a huge advantage of mobile shops is that they „go home" and their product range is richer than that of shops in the small villages. Moreover, they are able to quickly adapt to the needs of the local residents, which, completed by the opportunities offered by e-commerce, could certainly help the operation of the mobile shop system (Wi-Fi, orders via website, web shops) to provide better life quality to the residents of the area. Cooperation with mobile shops could offer a solution in the near future and open new routes for e-commerce.

Results and conclusions

In order to transform a region to a smart region, several criteria must be met, but the most important of all is to have a local „hero" who can shape the life of the narrower region (village) and have a positive impact on the life of the whole region or part of it. In the following, we formulate a smart region model that based on our opinion can be applied in the development of smart villages (Figure 9).

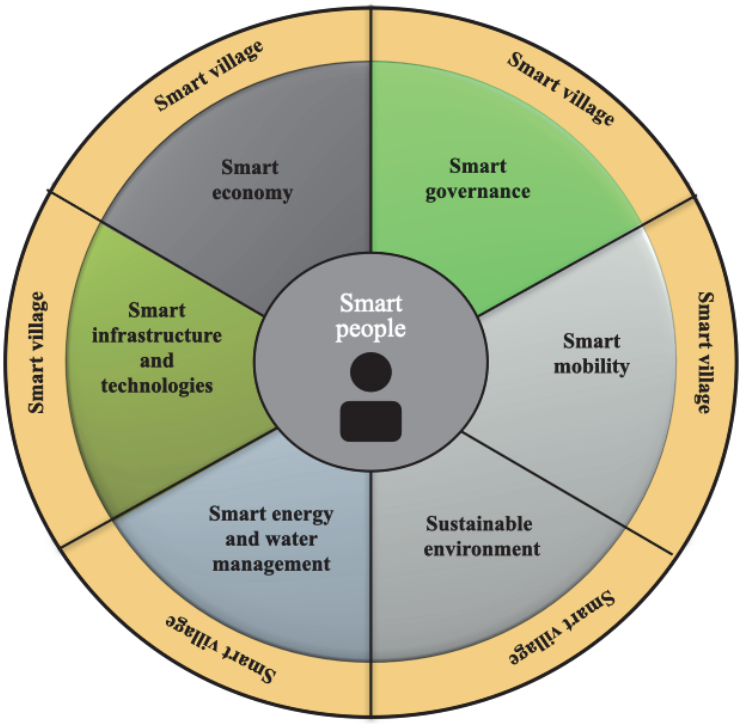
The central element of the model is *the creative person*, under whose guidance the development of smart villages and their efficient operation can be realized. The model consists of the following elements: smart governance, smart mobility, sustainable environment, smart energy and water management, smart infrastructures and technologies, and smart economy. Of course, a modern digital environment is

[2] With the help of the car sharing or minibus program, motorists and village caretakers could instantly post advertisements about their planned trips and search for passengers for a further destination, and those wishing to travel could join it or search for suppliers to help them make their journeys. This possibility should be extended to the minibuses available in the village caretaker systems, and they can be used in a connected manner with other municipalities.

necessary for the smart elements working, but it has not been implemented yet in the settlements of the Abaúj region. In the case of e-government, only an outdated computer park is available, most computers are older than 3 years. It is also a special problem that most municipalities only post new information on their website monthly or less frequently. Progress in the life of the regions could be facilitated through digital technology, e.g. in the field of transport using smart applications. This could also help to make access to food and services more efficient. Currently, the standard of basic food supply in the Abaúj region is differentiated, people living at different levels of settlements have access to basic goods in very different ways. Nowadays, the existence or absence of grocery stores in settlements largely depends on the population and income conditions of the settlements. Thus, it does matter whether the given inhabitant of the region lives in a settlement close to a city or in a poor settlement of the area with poor traffic conditions, as the possibility of accessing basic goods is very different in space and time. Grocery stores are not able to settle in the small villages of the Abaúj region due to the economic and efficiency indicators, which is accompanied by the low numbers and aging population of the settlements and the extremely weak purchasing power.

Figure 9

Smart region model



The development of a mobile retail system could do much to improve the level of supply by shifting retail towards a „smart system". Currently, the studied Abaúj region is still far from the possibility of becoming a smart region through a smart village or settlement, but it has two areas that have potentials. The focus on these settlements (human and financial resources) could improve the catch-up of other villages and, in the long run, the region to become a smart character.

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