Using smart people to build smarter: How smart cities attract and retain highly skilled workers to drive innovation (Belgium, Denmark, the Netherlands, Poland)

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Abstract
Smart cities have been heralded as new powerhouses of economic growth and their capacity to fill this promise strongly depends on how attractive they are to highly skilled people. In fact, talented professionals can be regarded as their precondition and the fuel of innovation. In this article, we try to articulate how outstanding smart cities have managed to consolidate and retain a highly skilled graduate workforce. To this end, we analyse recent institutional developments in the cities with smart ambitions that achieve the highest smartness scores and compare them to parallel developments in those that obtain the lowest scores or no score across four countries: Belgium, Denmark, the Netherlands and Poland. Taking from theories of economics of agglomeration and urban economics, and following a careful review of the relevant literature, we first highlight reasons that draw highly skilled workers to a smart city before identifying the cities which have proven most able to capitalise on them. In line with existing theories, this article finds that cities which enjoy greater administrative autonomy tend to successfully use this leeway to implement pro-growth policies and amplify them *via* a regulatory setting that itself encourages business development. Hence, our conclusion provides recommendations towards a pathway of reforms for smart cities willing to authorise more comprehensive policies in order to boost their attractiveness as locations of employment and reach their stated objectives.

Keywords: human capital, e-governance, statistics.

1. Introduction: Smart cities, a human capital
The notion of smart city encompasses both commercial and societal challenges, as well as consumer aspirations. In our previous study [1] we highlighted the need for a more inclusive structuring of smart cities. The potential for Smart Cities that are adaptable to the new global economy and that enable citizens to use digital technologies is enormous, and there are critical opportunities [2]. According to a United Nations 2016 estimate, six out of ten people on Earth will live in metropolitan settings by 2030. Cities are hubs of innovation and creativity, but they face significant challenges as a result of rapid urbanisation including a strain on available natural resources, the effects of climate change, growing demand for city services such as transportation, health, housing, social care, and issues of social cohesion [3, 4].

In order to capitalise on smart cities economically, it must be ensured that working people are recognised as a source of innovation capable of generating a sustainable regional and global competitive advantage. Additionally, it seems logical that education at all ages and levels as well as the development of knowledge and skills in a large sense and employability should be prioritised in the development of smart cities. Technologies and governments can help galvanise the connection between learner and teacher or educational institution and learning [5].

Career dynamics in smart cities, especially when considering their synergetic sustainability, require a systemic approach in which the dynamic fit or match between person and environment is taken as a central element. Striving to achieve long-term mutual benefits for the worker and the smart city therefore involves a continuous balancing act between workers' skills, talents and needs (well-being included) and the more general systemic needs of the smart city, at least in terms of human resources [6].

2. Smart cities as sustainable clusters high-competence individuals

The idea that careers change along with changes in the environment is certainly not new [7] and career theorising has moved beyond "organisational careers" to consider job sequences that transcend organisational boundaries to also include non-work-related experiences [8]. Numerous career theories and concepts have been put forward to account for the evolution of careers in the modern globalised and digital world, most notably the protean career [9, 10], the boundaryless career [11], and the kaleidoscope career [12].

In smart cities, careers need to be considered from a point of view that places a priority on dynamic fit or match between person and environment. The most valuable resource in smart cities, according to Hobfoll's [13] conservation of resources theory applied to career development [14], is knowledge. As a result, long-term advantages to residents and the smart city can only be achieved if this resource is abundant. Striking a lasting balance between the worker's abilities, skills, and needs (including their well-being) on the one hand and the more general systemic needs of the smart city on the other hand involves constant trade-offs, at least in terms of human resources. Theoretically, this equilibrium could be seen as a search for systemic fit. Sociotechnical design theories [15] and dynamic person–environment fit theories [16] may shed light on how to achieve these mutual benefits and long-term synergy. Smart cities are multifunctional (in that they reflect the complex interaction of technological, social, environmental, and economic factors), multilayered (they involve residents, organisations, and communities), and networked systems. The strong emphasis on entrepreneurship in smart cities [17], rapid technological advancements, and multiple stakeholders' involvement in career development all contribute to the development of a complex and dynamic career ecosystem for citizens. Career theories and conceptions, whether implicit or explicit, place a premium on three critical components of such complex career ecosystems: (1) individuals must develop and maintain employability; (2) they must be resilient throughout their careers and as such recover rapidly after setbacks (adaptability and flexibility); and (3) those individuals must make wise professional choices in order to achieve viability (connectivity). These important components of smart city job growth also apply to sustainable careers.

The smart city offers ample opportunities for career development and various employment options for high-skilled as well as low skilled workers. More importantly, it is able to sustain them in the long run. Theorizing about sustainable careers [18, 19] in fact builds rather fluently on developments in both the literature on contemporary careers and the sustainability debate, which also concerns itself with the health and well-being of people [20]. Sustainable careers are defined as “sequences of career experiences reflected through a variety of patterns of continuity over time, thereby crossing several social spaces, characterized by individual agency, herewith providing meaning to the individual” [21]. Sustainable careers serve as the means towards individual health, happiness and productivity, and towards more systemic outcomes in the economic, social and environmental domains [22].

Although it focuses on individuals as central career actors, the sustainable careers model takes into account a variety of contextual influences that shape career dynamics [23]. Considering the smart city as a setting in which sustainable careers (may) develop and concurring with De Vos et al. [24] and Newman [25], we propose that sustainable careers are mutually beneficial for the person and the smart city. In order to jointly achieve this sustainability synergy, smart cities as career ecosystems should facilitate long-term employability, nurture flexibility and adaptability in terms of career choices, and foster intelligent career choices by keeping citizens connected with all the stakeholders involved in career development.

Some examples of Smart cities employment opportunities include ICT, Big Data and High-Tech coding. Career-wise, one might consider ICT-literate professionals who feel at ease in the smart city environment and who are prone to contribute to the further development of its features by sheer nature of their knowledge-intensive employment. The fact that smart cities attract highly educated individuals [26] demonstrates supplementary fit [27], where certain individual characteristics (in this case, a high level of education and high ICT literacy) fit the characteristics of other individuals living in such smart urban areas. Individuals with limited ICT literacy may for their part perform critical jobs for the city such as plumbing, housekeeping, and senior care and support, demonstrating a complementing person–smart city match [28]. Their functions are just as critical to (smart) cities as those of employees in knowledge-intensive firms since they provide complementary skills and competences necessary to the smart city's continued operation (demand–ability fit; [29]).

One of the demographic segments most affected by the economic shocks are the youth [30]. Their opportunities have diminished as a result of the previous and current global economic downturns: some of them have had to emigrate, others still remain unemployed. All of them are victims of this situation, which at the time of writing seems appears to be changing. Tackling youth unemployment is one of the main drivers of the enthusiasm *vis-à-vis* smart cities [31]. This goal could be achieved by means of promoting informal courses to advance ICT skills among the youth. One distinctive feature of a smart city is the availability of working spaces and employment positions for younger generations who followed specific training courses [32]. There is an clear link between the influence of information and communication technologies (ICTs) skills on youth employability [33].

As a result, a critical additional challenge for smart cities is to develop into self-sustaining clusters of embodied competence.

3. Smart cities as an HR ecosystem

Smart cities as complex career ecosystems naturally need to provide enough work-related opportunities to withstand competition from other innovation hubs, but this is hardly sufficient: if they want to match the aspirations of their elective inhabitants overall, the cities must also cater to their extraprofessional needs and expectations e.g. in terms of leisure activities, nursery and schooling for children, or quality of life. In line with Hollands' [34] conceptualisation, a smart city is essentially entrepreneurial and business-oriented, but at the same time it should prove to be a safe environment for citizens, and create the conditions for high standards of living through an efficient use of urban resources and services [35, 36]. In our systemic analysis, we consider that the measurement of person–smart city fit reflects a continuous search for a dynamic and multidimensional equilibrium between citizens and their urban environment. Such an equilibrium is a key antecedent of sociotechnical synergy and ultimately of joint career and smart city sustainability.

In terms of career dynamics, the adequation of highly educated individuals and smart cities is well established [37]. In line with the person-environment fit rationale, urban areas labeled as smart cities tend to attract particularly well educated individuals for two reasons [38, 39]. First, these areas—as career ecosystems—tend to attract highly educated individuals because complex organisations operating in them require a more qualified employees who possess the knowledge and skills to sustain their functioning (i.e. demand–ability fit) [40]. Secondly, they attract highly educated individuals—as high education tends to be a shared population attribute (i.e. supplementary fit)—because smart cities offer services and a lifestyle more suited to fulfill the demands of highly educated and digitally literate individuals (i.e. need–supply fit) [41]. In contrast, the smart urban environment generates various incongruences for less qualified and/or ICT-illiterate populations [42]. With respect to career advancement opportunities, the latter struggle to participate and thrive in the local labour market (demand–ability misfit).

Several studies have demonstrated that the combined presence of an artistic or intellectual community and a technological community in one area constitutes a major draw [43, 44]. Specifically, places that feature universities, consumer service amenities and a tolerant attitude towards social diversity have been shown to be key factors in attracting and retaining talent [45, 46, 47]. Glaeser [48] furthermore highlights the importance of "skilled cities", which offer cross-pollination of learning among skilled workers, and climatic conditions to explain why many people flock to sunbelt cities or places where cultural facilities can compensate for a less ideal weather. Clark et al. [49] claim that amenities in the form of urban attractions, such as parks, art galleries and orchestras, drive urban growth in cities that become "entertainment machines" in the process. Using a stage-based model for regional development, Florida, Mellander, and Stolarick [50], examined how "technology, talent and tolerance" affect regional development together and found that tolerant attitudes and the prevalence of certain occupations such as computer scientist, engineer or management consultant among inhabitants were indeed correlated to a positive outcome.

Empirical evidence shows that employment growth, work productivity, quality of life and percentage of college graduates in cities are factors that are strongly and positively entwined [51, 52]. Henceforth, the person–city incongruences affecting the less educated and/or ICT-illiterate individuals extend beyond the simple issue of a career-location misfit. The focal recreation venues found in smart cities (i.e. mostly commercial leisure spaces which exclude poorer individuals through pricing and access policies) seem aimed at the wealthy middle class exclusively (need–supply misfit) [53, 54].

The search and sometimes almost quest for supplementary fit might also be responsible for the social and spatial fragmentation documented in smart cities [55, 56, 57, 58] in that highly educated individuals tend to cluster and live in particular districts that appear unwelcoming to less educated people. In the more general urban context that includes, among others, migration and the challenges associated with it, this demographic and spatial separation in urban environments presents significant limitations for social harmony and individual well-being [59, 60, 61].

Lastly, information is used to generate economic wealth, as well as well-being for citizens [62, 63]. In light of the smart cities' focus on information processing, knowledge and the effective utilisation of knowledge are both central to and emblematic of the sustainability of these complex systems [64]. Because "careers are constructed at the boundary between the individual and the social world in which the individual participates" [65], smart cities are digitised and knowledge-centered career ecosystems that provide a good fit especially for ICT-literate individuals who, by definition, work in knowledge-intensive organisations. By contrast, other occupational groups comprising less educated workers may, again, experience a lack of fit with these smart urban environments. Moreover, a lack of fit in the near-term may actually jeopardise later economic growth as well as dampen prospects for social equity and a "healthy" urban environment [66, 67].

It therefore seems theoretically evident that smart cities do not benefit all types of workers equally, especially if one sees them as elite career ecosystems. Several individual-level studies of entrepreneurs have linked innovation and educational attainment [68, 69], which starts to show how the above differences of fit can be quantified. If more educated workers are more innovative and cities are important to innovation, then it follows that highly educated workers are incentivised to move to more populous and organisationally significant places to maximise their innovative potential. Given the reliance on advanced information processing and their focus on innovation, smart cities attract highly educated people who are usually employed in the knowledge-driven high technology sector and creative industries [70].

Unlike cities in general, where the literature is mixed about whether agglomeration is central to innovation. Lee and Rodríguez-Pose [71] find no evidence that urban firms in creative industries introduce any more product or process innovations than rural firms, supporting the findings of others that have questioned the link between urban settings and innovation [72, 73, 74]. On the opposite side of the argument, Crescenzi et al. [75] find a relationship between physical proximity and collaborations between inventors.

4. Are smart cities really a hub for value

In order to assess the extent to which smart cities are hubs for highly skilled workers first and foremost, we gathered statistics and compared data regarding higher education attainment in cities that are (i) widely considered and labeled as smart, (ii) that used to be widely labeled as smart but have fallen behind, and (iii) that have never been classified as or officially claimed to be smart. Unfortunately, the data we were able to gather from Belgium, Denmark, the Netherlands and Poland through institutional requests was varied and therefore had to be considered separately.

The data differ both in terms of geographical area size taken into consideration and in terms of highest educational increment attainable. Likewise, we were only to learn the total number of inhabitants holding a higher education degree in the case of Belgium whereas we instead received data concerning specific courses attended in 2020 and/or 2021 from the other three countries.

As per the tables below, the G column is the crucial index for this comparison. It is obtained through division of the figure indicating advanced higher education attendance (whether it represents the whole amount of higher graduates living in the area or the number of courses attended during a specific academic year) by the total population of the corresponding NUTS3 or city. We can then calculate averages of the values for this index in smart cities and non-smart cities, which allows us to compare them and look for any discrepancy.

Our hypothesis is verified if:

$$\frac{G_{S1} + G_{S2} + G_{S\ldots} + G_{Sn}}{(Sn)} > \frac{G_{N1} + G_{N2} + G_{N\ldots} + G_{Nn}}{(Nn)} \tag{1}$$

Or

$$\frac{\left(\frac{F_{S1}}{E_{S1}}\right) + \left(\frac{F_{S2}}{E_{S2}}\right) + \left(\frac{F_{S\ldots}}{E_{S\ldots}}\right) + \left(\frac{F_{Sn}}{E_{Sn}}\right)}{(Sn)} > \frac{\left(\frac{F_{N1}}{E_{N1}}\right) + \left(\frac{F_{N2}}{E_{N2}}\right) + \left(\frac{F_{N\ldots}}{E_{N\ldots}}\right) + \left(\frac{F_{Nn}}{E_{Nn}}\right)}{(Nn)} \tag{2}$$

Where:
G – the density index of higher graduates
S – data related to a Smart City
N – data related to a Non-Smart City agglomerate
n – the total number of cities take into consideration
F – number of higher graduates/graduations
E – population

Once proven that smart cities have a greater density of higher graduates than non-smart cities, it is crucial to ensure this increase is not merely caused by an increase in city size. Larger urban areas, whether smart or not, tend to attract a more skilled and educated workforce than average, which is why we need a falsification method. We therefore checked the respective Pearson correlations for:

- A proof, calculated by taking into account the G index and the Smart score, the latter being assigned as follows: 1 for cities that are included in the IMD 2021 list, 0.5 for cities that are not mentioned in the IMD 2021 but were once part of other lists (such as the ESM 2013), 0 for cities that have never been listed

- A counterproof – taking into account population data and the H Index which shows the number of higher graduates per 100,000 inhabitants (standardiser); this allows us to consider the variations related to population only

Thus our hypothesis is verified if:

$$\frac{\sigma GD}{\sigma G \sigma D} > \frac{\sigma HE}{\sigma H \sigma E} \tag{3}$$

Or

$$\frac{\sigma\left(\frac{F}{E}\right)D}{\sigma\left(\frac{F}{E}\right)\sigma D} > \frac{\sigma\left(\frac{F}{E} * 100{,}000\right)E}{\sigma\left(\frac{F}{E} * 100{,}000\right)\sigma E} \tag{4}$$

Where:
D – the Smart Score
H – the standardiser average of higher graduates/graduations

4.1 Belgium

Regarding Belgium, population and higher graduates data are for 2021 and cover the whole NUTS3 region, not just the city. This is due to the availability of data in NUTS3 subdivision. Data from Belgium are the most relevant to our study as they inform us on the actual number of people with a degree living in a given area.

Table 1. Belgium

A	B	C	D	E	F	G	H
City	Smart City ranking	NUTS3	Smart score	Population	Higher graduates	Index (F/E)	Index (F/E)*100,000
Brussels	52 - IMD 2021	BE100	1	1,226,329	216,646	0.1767	17,666
Ghent	17 - ESM 2013	BE234	0.5	565,571	124,455	0.2201	22,005
Bruges	35 - ESM 2013	BE251	0.5	283,590	57,192	0.2017	20,167
Antwerp	Non-Smart City	BE211	0	1,062,427	187,304	0.1763	17,630
Liège	Non-Smart City	BE332	0	627,304	106,260	0.1694	16,939
Charleroi	Non-Smart City	BE322	0	432,660	54,269	0.1254	12,543
Hasselt	Non-Smart City	BE221	0	432,163	75,229	0.1741	17,408
Mechelen	Non-Smart City	BE212	0	348,999	66,640	0.1909	19,095
Namur	Non-Smart City	BE352	0	319,928	61,570	0.1924	19,245

Mons	Non-Smart City	BE323	0	259,351	40,844	0.1575	15,749
Sint-Niklaas	Non-Smart City	BE236	0	257,085	40,715	0.1584	15,837
Soignies	Non-Smart City	BE325	0	192,708	29,667	0.1539	15,395
Thuin	Non-Smart City	BE326	0	152,509	24,510	0.1607	16,071
Tournai	Non-Smart City	BE327	0	147,936	25,082	0.1695	16,955
Bastogne	Non-Smart City	BE342	0	50,438	7,499	0.1487	14,868
SMART CITY AVERAGE		0.1995					
NON-SMART CITY AVERAGE		0.1648					
DIFFERENCE		17%					

Source: Statbel

Table 2. Belgium Proof & Counterproof

Value	Proof	Counterproof
r.	0.455901138	0.239560337
N number	15	15
T Statistic	1.846874992	0.889652444
Degrees of freedom	13	13

Source: Author own work

The 17% difference between the higher graduates concentration averages favours smart cities, which therefore result in being a hub for highly skilled workforce. The Pearson Correlation shows that the concentration of higher grades in smart cities is not related to a bigger population.

Notably, Belgium is one of the best examples to corroborate our thesis, because the data at our disposal shows the exact number of actual inhabitants who live in the NUTS3 and that hold a higher graduation degree : the following examples use different basis.

4.2 Netherlands

Similarly to the Belgian data, Dutch population and master's degrees figures for the year 2021 cover the NUTS3 and not just the individual cities. The classification used at the Dutch Bureau of Statistics makes a distinction between vocational and general higher education diplomas. We chose to only include Wetenschappelijk Onderwijs (WO) programmes, which are research-oriented and aimed at developing abstract, analytical, and theoretical skills unlike the more practical and trade-specific Hoger Beroepsonderwijs (HBO) degrees. The WO numbers presented refer to graduates at a master's level to highlight where highly specialised workforce is located.

Eindhoven, while being classified as a smart city, was not included in the Dutch table since it is located in the south-eastern province of North Brabant along with other non-smart Cities, therefore making it impossible to unbundle the NUTS3 data at our disposal.

Table 3. Netherlands

A	B	C	D	E	F	G	H
City	Smart City ranking	NUTS3	Smart score	Population	Higher graduates	Index (F/E)	Index (F/E)*100,000
Amsterdam	17 - IMD 2021	NL329	1	1,396,239	7,234	0.0052	518.11
The Hague	23 - IMD 2021	NL332	1	887,863	2,067	0.0023	232.81
Rijnmond	27 - IMD 2021	NL33C	1	1,461,412	3,777	0.0026	258.45
Utrecht	Non-Smart City	NL310	0	1,361,153	4,649	0.0034	341.55
Arnhem & Nijmegen	Non-Smart City	NL226	0	744,715	2,440	0.0033	327.64
Twente	Non-Smart City	NL213	0	631,733	1,280	0.0020	202.62
Flevoland	Non-Smart City	NL230	0	428,226	366	0.0009	85.47
North Overijssel	Non-Smart City	NL211	0	377,292	277	0.0007	73.42
North Limburg	Non-Smart City	NL421	0	283,350	233	0.0008	82.23
Haarlem agglomerate	Non-Smart City	NL324	0	230,734	317	0.0014	137.39
SMART CITY AVERAGE		0.0034					
NON-SMART CITY AVERAGE		0.0018					
DIFFERENCE		47%					

Source: Centraal Bureau van Statistiek

Table 4. Netherlands Proof & Counterproof

Value	Proof	Counterproof
r.	0.53584323	0.819294365
N number	10	10
T Statistic	1.795051666	4.041546936
Degrees of freedom	8	8

Source: Author own work

As for the Netherlands, the data at our disposal concerned all people who obtained a WO master's degree in 2021 and lived in a NUTS3 agglomeration. There is a considerable difference of the order of 47% between the graduates-concentration averages in favour of smart cities, which serves to confirm that the cities are hubs for the highly skilled and educated. The Pearson correlation, however, shows that much of this "attractiveness" correlates with a city's population size. This doesn't fully invalidate our hypothesis as there are in fact two main factors creating statistical distraction: first of all, the fact that the Rotterdam urban area itself—where most of the graduates live—is far smaller than its NUTS3 entity (NL33C) which includes surrounding rural areas, thereby lowering the average *G index* (WO-masters/Population). Secondly, the number of *WO-masters* obtained in the Hague are reduced compared to an average city because the University of the Hague doesn't offer most humanistic and technological curricula. Local students in these fields instead attend a detachment of the neighbouring University of Leiden and are counted as graduates in Leiden at the end of their studies. This is also the reason why we decided not to include Leiden's NUTS3, NL331.

4.3 Denmark

Unlike in Belgium and the Netherlands, some data exist both for a NUTS3 and the conventional urban level in Denmark. This country reshaped its administrative regions a few years prior leading to significant change in the Danish NUTS3 arrangement. We opted for a comparison between the most populous cities on their own because the current NUTS3 subdivision does not lend itself to statistical research for the sake of this paper. Given the array of data available, we decided to only consider PhD programme numbers so as to obtain obtain values showing where particularly specialised and skilled people live.

Table 5. Denmark

A	B	C	D	E	F	G	H
City	Smart City ranking	NUTS3	Smart score	Population	Higher graduates	Index (F/E)	Index (F/E)*100,000
Copenhagen	7 - IMD 2021	.	1	1,345,562	12,499	0.0093	928.91
Aarhus	1 - ESM 2013	.	0.5	285,273	4,865	0.0171	1705.38
Aalborg	3 - ESM 2013	.	0.5	119,862	1,553	0.0130	1295.66
Odense	6 - ESM 2013	.	0.5	180,863	1,718	0.0095	949.89
Esbjerg	Non-Smart City	.	0	71,698	249	0.0035	347.29
Randers	Non-Smart City	.	0	62,802	241	0.0038	383.75
Kolding	Non-Smart City	.	0	61,638	240	0.0039	389.37
Horsens	Non-Smart City	.	0	61,074	243	0.0040	397.88
Vejle	Non-Smart City	.	0	60,231	411	0.0068	682.37
Roskilde	Non-Smart City	.	0	51,916	897	0.0173	1727.79
Herning	Non-Smart City	.	0	50,565	156	0.0031	308.51
Silkeborg	Non-Smart City	.	0	49,747	336	0.0068	675.42

Hørsholm	Non-Smart City	.	0	47,680	320	0.0067	671.14
Helsingør	Non-Smart City	.	0	47,257	355	0.0075	751.21
Næstved	Non-Smart City	.	0	44,331	168	0.0038	378.97
SMART CITY AVERAGE		0.0122					
NON-SMART CITY AVERAGE		0.0061					
DIFFERENCE		50%					

Source: Danmarks Statistik

Table 6. Denmark Proof & Counterproof

Value	Proof	Counterproof
r.	0.475859437	0.210008226
N number	15	15
T Statistic	1.950760615	0.774466321
Degrees of freedom	13	13

Source: Author own work

In the tables above, the data concern all people living in a certain city in 2021 who attended a PhD programme. There is a considerable difference of 50% between the higher-graduates-concentration averages in favour of smart cities, which, again, underlines their status as hubs for highly skilled workforce. In addition, the Pearson correlation shows that the concentration of higher degrees found in smart cities is independent of their population size.

4.4 Poland

For Poland, the population and graduates at master's degree level data for the year 2020 pertain to the NUTS3, not to the cities themselves. Here, we decided to consider only master's programmes. At the time of writing, the values for 2020 were the latest data available.

Table 7. Poland

A	B	C	D	E	F	G	H
City	Smart City ranking	NUTS3	Smart score	Population	Higher graduates	Index (F/E)	Index (F/E)*100,000
Warsaw	75 - IMD 2021	PL911	1	1,792,120	24,113	0.0135	1345.50
Krakow	80 - IMD 2021	PL213	1	777,266	15,976	0.0206	2055.41
Rzeszow	49 - ESM 2013	PL823	0.5	636,553	4,731	0.0074	743.22
Szczecin	51 - ESM 2013	PL424	0.5	398,412	2,963	0.0074	743.70
Bydgosko -toruński	Non-Smart City	PL613	0	770,735	5,137	0.0067	666.51

Katowice	Non-Smart City	PL22A	0	724,874	4,725	0.0065	651.84
Lublin	Non-Smart City	PL814	0	709,130	7,502	0.0106	1057.92
Łódź	Non-Smart City	PL711	0	673,826	6,550	0.0097	972.06
Wrocław	Non-Smart City	PL514	0	642,283	11,842	0.0184	1843.74
Radom	Non-Smart City	PL921	0	598,895	599	0.0010	100.02
Gdańsk	Non-Smart City	PL634	0	597,034	6,039	0.0101	1011.50
Poznań	Non-Smart City	PL415	0	532,351	11,530	0.0217	2165.86
Białystok	Non-Smart City	PL841	0	505,970	3,138	0.0062	620.19
Częstochowa	Non-Smart City	PL224	0	503,477	1,248	0.0025	247.88
SMART CITY AVERAGE		0.0170					
NON-SMART CITY AVERAGE		0.0090					
DIFFERENCE		47%					

Source: Główny Urząd Statystyczny

Table 8. Poland Proof & Counterproof

Value	Proof	Counterproof
r.	0.353085398	0.215845235
N number	14	14
T Statistic	1.307327206	0.765760653
Degrees of freedom	12	12

Source: Author own work

The data at our disposal showcased all people who have achieved a master's degree in 2020 and live in a certain NUTS3. Observing the results, there is a considerable difference of 47% between the higher-graduates-concentration averages in favour of smart cities, once more underlining their status as hubs for highly skilled workforce. *r* confirms the concentration of higher grades in smart cities is not related to a bigger population, but to them being a smart cities.

5. Shaping smart cities through public policies, a mixed result?

Statistical results obtained and showcased in the tables above prove that smart cities are definitely hubs for highly skilled human resources. Interestingly, even cities that were considered smart in rather old listings (ESM 2013) seem to retain some of their attraction for highly skilled persons. This can be seen for instance when inspecting the Polish table, where the *G Index* (density of higher graduates) drops considerably when we compare Warsaw (75 – IMD 2021) and Krakow (80 – IMD 2021) to Rzeszow (49 – ESM 2013) and Szczecin (51 – ESM 2013), but remains at levels that still reflect a capacity to acquire or retain high-competence inhabitants. These figures nevertheless imply that a smart city has

to keep up with society developments and technological advances if it is to maintain and reinforce its status as a knowledge hub. But how can we explain these results more precisely?
City and regional officials are keen to attract highly educated workers to their jurisdictions for several reasons. First, a large literature supports the positive association between college graduates and economic growth in cities and regions [76, 77, 78, 79, 80]. This aligns with a greater body of literature that links human capital to economic development at the national level [81, 82]. Further, the intuitive nature of the relationship between a well-educated workforce and economic prosperity appeals to the broader public, possibly rendering policy interventions targeting highly skilled workers more politically consensual and feasible. Lastly, since education levels are a strong predictor of the propensity to migrate [83, 84, 85], policymakers may view policy programmes aimed at attracting well-educated workers as likely to succeed.

Policymakers, however, may have little influence on the numbers of well-educated immigrants effectively arriving in their cities. In the late 20th century, the largest American cities were lagging behind smaller and medium-sized metropolitan areas in terms of economic growth [86]. Previous research has shown college graduate shares to be diverging across metropolitan areas over the past several decades [87, 88]. Because greater proportions of highly educated workers are correlated with employment growth in cities [89, 90], researchers in both Europe and the United States have become curious about the migration decisions of university graduates [91, 92, 93, 94]. Betz et al. [95] focuses on the aggregate characteristics of cities that attract well educated workers.

Winters [96] finds that smart cities are growing in part because students who come for their higher education tend to stay after graduation, increasing the share of MSA population with college degrees. Betz et al. [97] also show this is not likely due to postgraduates (master's level) staying in the city in which they graduated, as they find a negative relationship between initial MSA share of population with graduate or professional degrees and growth in graduate or professional share in the full 2000–2010 model. Betz et al. [98] also show that while larger cities have an advantage in attracting highly educated workers, trends post-2000 may suggest a turn-around from the patterns of the latter half of the 20th century.

What people shaping the future smart cities are looking for may not be found in the contents of public policy nor in the size of their urban agglomeration. An extremely clear-cut example of such reality can be found in England, in an extensive study done by Paul Swinney and Maire Williams in 2016 [99]. While London lost the most students after their secondary school graduation, the study pointed to a quarter of all new university graduates from UK universities working in London six months after university graduation, which surpassed the 19% proportion of British jobs that were based in the capital. According to the same study, London's overrepresentation of new graduates is a result of two factors: the city's ability to retain its students, and its ability to pull in graduates from elsewhere. Of all the graduates who moved after university, 22% moved to London, and it received large contingents of graduate students from almost all UK cities, with the exceptions of Ipswich (East Anglia) and Warrington (Cheshire). In fact, while "large cities attracted a lower share of all working graduates, relative to share of jobs, irrespective of their degree and institution […] they were most successful at attracting those students that achieved a lower second-class degree or lower from a non-Russell Group university.” (The Russel Group can be described as the British equivalent of the US Ivy League). On the contrary, graduates from very reputable universities moved to fill positions in London. “52% of [Oxford and Cambridge] graduates who moved after graduation were working in London six months after completing university.” In the same study, the first ten cities that gained university graduates according to a HESA survey had very different profiles: yet the study concludes “It is not that cities outside London do not retain graduates; it is that they do not retain the majority of those students that move to their city to study. Besides London, those were, by order of magnitude: Manchester (4.5M pop. metropolitan area and top 50 university) Leeds (1.7M pop. metropolitan area), Bristol (600k pop. metropolitan area), Edinburgh (400k pop. metropolitan area, top 50 university), Belfast (500k pop. metropolitan area), Liverpool (800k pop. metropolitan area), Newcastle (700k pop. metropolitan area), Oxford (170k pop. metropolitan area, top 50 university), Aberdeen (200k pop. metropolitan area), Cambridge (150k pop. metropolitan area, top 50 university), Cardiff (447k pop. metropolitan area), Glasgow (1M pop. metropolitan area). These gains are extremely limited compared to the London ones: Manchester, the second graduate earner, only gained one tenth (around 4000) of graduates compared to London (40,000 a year). Of all the bouncers, 40 per cent were working in London six months after graduation.” Note: the city population figures in brackets were added to the original text. Cities such as Aberdeen and Norwich, medium to small cities by UK standards and yet listed smart cities, were able to retain most of their incoming graduates, while larger cities that did not qualify as such failed to do so.

6. Wages and amenities: building up smart cities one graduate at a time

In the United States, Borjas et al. [100] found that regions which offer higher wages for skilled labour attract more skilled internal migrants than regions with lower wages for skilled workers. There isn’t as much evidence for this relationship in Europe as regional wage differentials are typically smaller. Yet, a recent extensive analysis published by Arntz et al. [101] finds that highly skilled workers in Germany are attracted to regions with higher wages and employment probabilities, but also to places with greater wage and employment inequalities. The result is a self-reinforcing process that leads to greater regional employment and skill disparities. The reasons for this seem extremely varied; findings vary but still suggest a general link between educational attainment, wages and settlement choice [102, 103, 104, 105, 106, 107, 108, 109].

In a similar fashion, Berry and Glaeser [110] find that cities with higher initial shares of university-educated workers saw greater increases in the proportion of university-educated workers living in them during the 1970s, 1980s, and 1990s, pointing to differences in human capital across cities. They attribute the persistence in human capital to skilled, but immobile, entrepreneurs increasingly hiring well-educated workers. Winters [111] also finds skilled cities are becoming more educated over time in his investigation of migration into and out of so-called “smart cities” (Winters defines smart cities as those that have a high percentage of college graduates). He finds that those cities are growing in part because they are able to retain recent graduates from local universities, who had originally moved there to pursue higher education.

Moretti [112] finds educated that workers generate productivity spillovers in industries outside those in which they work, suggesting workers would be more productive, earn a higher wage, and thus have an incentive to move to cities with more highly educated workers. Spillovers aside, if amenities such as retail shopping, restaurants, entertainment venues and cultural offerings are normal amenities and graduates are associated with their availability, we would see a disproportionate level of high skill workers migrating in places with more graduates. Indeed, Adamson et al. [113] find urban amenities dominate productivity effects and urban dis-amenities. In a European context, Niedomsyl and Hansen [114] find that jobs are more important than amenities to highly skilled workers.

Amenities and jobs are associated with higher levels of degree attainment and thus develop potential channels through which highly educated cities might attract highly educated workers and help to explain the findings brought by Berry and Glaeser [115] and Winters [116]. Dalmazzo and Blasio [117] identified an urban rent premium for educated workers in Italy, suggesting valuation of city amenities increases with education, which is consistent with Glaeser et al.'s [118] conjectures for the United States. Adamson et al. [119] find that amenity factors are a considerable attraction for higher-skilled workers to US metropolitan areas, though they also find skill-biased productivity factors are especially important for the very largest metropolitan areas in attracting a better-educated workforce. Florida [120] and Florida et al. [121] argue that diverse urban environments and concentrations of the creative class, which are closely associated with educational attainment, are attractive to both additional creative class workers and to firms that employ them.

In short, smart cities continue to grow (and outgrow other cities) not because of their environment, but because of the higher wages and better amenitie they offer.

7. Conclusion

Although it emerges from the data gathered and analysed in this article that smart cities clearly tend to be career hubs for highly skilled people, and that their power of attraction depends on their ability and willingness to keep ahead of changing demands in technological and social domains over time, the exploitable resources around this topic are still very scarce and fragmented. Further research is therefore needed to extend the factual basis of the trend we observe.

A critical question in the context of smart cities is how to manage professional communities, co-creation, and the centrality of skills and talents optimally while preserving the dynamic adaptation and preservation of the city's systemic fit with its residents. In such a dynamic environment, co-optimisation of social and technological subsystems [122] is an iterative process that can be facilitated by network-centric structuring [123]. The network-centric organisation of key stakeholders (employers, local governments and representatives of communities) has the potential to establish a flexible social structure capable of fostering a sustainable career ecosystem collegially. Power and authority could be distributed more evenly throughout these networks in order to increase civic engagement and participation in career communities (with opportunities for skill exchange and development across organisational, occupational, and sectoral boundaries; [124] and finessing urban governance (with opportunities to contribute to the decision-making process related to technological developments in the smart city; [125]).

These network initiatives have already show promise. Forum Virium Helsinki, for example, brings together local businesses, public authorities, citizens, and smart tech users to form a collaborative network that bring new opportunities forward in relation to business development, product and service development, and user engagement in support of its smart city initiative [126]. However, such networks are often difficult to maintain, as network collaboration usually loses its charm when one participant has to finance it indefinitely. For example, in experimental smart city projects such as PlanIT Valey (Portugal), networks connecting governmental agencies with local businesses and knowledge institutes lost impetus when political and financial support dwindled [127]. We anticipate numerous prerequisites for the emergence of such career-supporting networks, drawing on insights from the network-centric organising literature.

To begin, continuous coordination between local government and private employer stakeholders is critical [128, 129]. Thus, the network-centric organisation of talents and careers can provide a more structural answer for preserving the centrality of talents and skills and assisting citizens in smart cities who face ever more frequent redefinitions of their jobs and skills. Additionally, the network-centric approach to talent and career organisation can aid in minimizing segregation in the smart city. More vulnerable populations (low-educated and IT-illiterate) will be integrated into the web of knowledge sharing, becoming a part of the flexible and dynamic process of career cocreation, hence reducing job market exclusion based on educational attainment. We recognize, however, that network collaboration is a costly undertaking, and thus that ongoing financial and political support is critical for the development and maintenance of successful collaborative relationships [130].

Secondly and most importantly, collaboration requires a sufficient level of trust between the network's stakeholders and partners [131]. Without trust, the parties' commitment are harmed and collaboration suffers. Trust is not a given from the start of interorganisational collaboration; in order to nurture and sustain it among the parties and stakeholders involved constant reflection on the collaborative process and outcomes [132]. Additionally, the governance and management of such networks must be open; network leaders must "do what they preach" in order to assist the trust-building process.

Leading this type of network entails organizing, facilitating, and exchanging people's abilities and skills. The network administrative organisation (NAO) model appears to be the most fit for this leading function in a smart city [133]. This model aims to effectively manage shared objectives, complicated issues, and the network's strategy, as well as to secure financial and administrative processes that will emerge as the network grows. Network leaders or facilitators can build a reflective space [134] in which constant monitoring of relational dynamics and network results is possible in order to quickly foresee or correct deviations in worker unbalance.

Overall, network-centric organisational structures for talents and vocations can pave the way for a more integrative and inclusive approach to sustaining a dynamic demand–supply connection for labour in smart cities. Thus, career transitions can become collaboratively regulated, co-created, and a true sense shared duty for all stakeholders. The Nordic countries' low unemployment rate and high employability rate [135, 136] are attributed, among other things, to a more centralised approach to managing industrial relations (the human–resources need–supply fit), as these relations are rooted in a well-developed corporatist structure involving continuous communication and collaboration between state, employers, and unions [137].

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