

Digital twin dialogues on regional development – an interpretative text conversation between humans and chatbots

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Abstract

This paper presents a controlled AI-experiment investigating text interpretation in the context of the regional development literature. With the rapid advancement of digital technology applications, text interpretation and generation have become increasingly prevalent, offering profound implications for scientific research in the social sciences, including regional science. Our study seeks to explore commonalities and disparities in textual summaries of previously published material in the domain of the regional development literature, employing a trial study approach on a given recent publication on regional competitiveness so as to compare human-made and machine-made (chatbot) summary texts. We adopt two distinct guiding principles for narrative textual interpretation: a methodological perspective and a normative framing of content. This leads to different types of summaries. Next, through subsequent digital text analysis methods, viz human-based interpretative analysis, content cloud analysis and frequency analysis, we analyze and compare the outcomes of this experiment. The results of our text analysis were finally also assessed by a small expert panel. Our findings reveal notable differences between human-made and machine-made summaries, showcasing variations in writing style, substantive content, perceived meanings, and reader interpretations. These discrepancies are also influenced by the above-mentioned methodological perspective and normative framing that are applied to the scientific publication concerned. In general, our comparison highlights that while human-made texts tend to be more content-rich, machine-made texts exhibit greater richness in form and coverage. Our results suggest that such contrasting differences offer a mutually complementary value in text interpretation. This study contributes to the understanding of text interpretation processes and sheds also light on the evolving dynamics between human and machine-generated interpretations in the academic discourse on regional development.

Keywords: regional development, digital twin, man-machine interaction, text analysis, content cloud, methodological perspective, normative framing

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1. The trend breach in text content analysis

Digital technology has profoundly impacted our world. In the current of this trend shift, digital textual analysis has over the past years exhibited a revolutionary development, starting off from text translation to text interpretation and nowadays to text generation (Bhatia et al., 2019; Szegedy et al., 2016; Zhang et al., 2019). According to Vaswani et al. (2017) the critical tool in this revolution is the transformer, a self-learning natural language processor that is in particular based on parallel interpretative and contextual processing and on transformation of words and texts, rather than on a sequential analysis of the meaning of individual words. The foundation of this new development can be found in computational neural network analysis, which was initially used to identify quantitative patterns in complex and big data systems (Hinton et al., 2006; Krizhevsky et al., 2017; Sarker, 2021; Shin et al., 2016). This neuroscience inspired approach is in recent years extended towards the extraction of substantive and coherent meaning of texts and towards generation of new texts, based on combinatorial cognitive and learning-oriented models (see e.g. Haykin, 2008; Tunstall et al., 2022). The rising popularity of GPT (Generative Pre-trained Transformer) techniques shows convincingly the power of computer-based knowledge generation (Kung et al., 2023), known as AI (Artificial Intelligence). The current fashionable Open AI inspired chatbot ChatGPT is most likely the beginning of a new era of novel knowledge acquisition and transmission, a trend in which also pedagogical (dynamic) data visualizations will likely enjoy a rapid rise in popularity (see e.g. Dasgupta et al., 2023; Gong et al., 2019; Hughes et al., 2013; Kasneci et al., 2023; Mollick & Mollick, 2023; Ware, 2020).

In recent years, the use of AI approaches has seen an unprecedented rise, a growth that over the past decades was accelerated by advances in computer capacity, big data analytics, computer design, and artificial neural network modeling (Dasgupta et al., 2023; Fischer & Gopal, 1993; Hecht-Nielsen, 1990; Kasneci et al., 2023; White, 1989). It was also used extensively in regional science and transportation science (Hensher & Ton, 2020; Himanen et al., 1998; McFadden, 1974; Yang et al., 1993). The rising popularity of complexity theory – the study of nonlinear dynamic and interactive systems and networks – has meant another boost to the operational contribution of AI to pressing and complex societal and ecological problems (Dwivedi et al., 2023; Reggiani & Nijkamp, 2009).

The transition to numerical, nowadays computer-based analysis of qualitative texts has already quite a long history. One of the pioneers in identifying patterns in written texts was Zipf (1949), who employed essentially a cost minimization approach ('the principle of least effort') to trace used patterns and regularities in written material. Starting from a totally different perspective, Shannon (1948) introduced the entropy principle to assess in quantitative terms the statistical information content of a message, while more recently Kahneman (2011) used heuristic principles from cognitive and neural psychology to trace the information

trajectories of the human brain. All these approaches have been extensively employed in empirical research over the past decades. With the emergence of digital technology – and in particular AI – it seems likely that quantitative information and text research will show a rapidly rising use trajectory in many sciences in the years to come (Dwivedi et al., 2023; Kung et al., 2023; Schuetz & Venkatesh, 2020).

Text analysis seeks to understand the meaning, content, context and literature positioning of a written document (e.g. book, article) (Chui et al., 2022; Dwivedi et al., 2023; Markov et al., 2022; van Dis et al., 2023). It is not a mechanical machine-like endeavour, as it aims to evaluate critically a text and to identify potential biases, inconsistencies or limitations in the written material under consideration (Akter et al., 2021; Heikkilä, 2023). The reason for a careful textual inspection is that any text may have specific – often subjective – agendas, factual or deliberate biases, and inconsistencies or omissions, that can influence the conclusions (Chen et al., 2023; Hamilton, 2022; Hartman et al., 2023). Analysing texts from independent and multiple perspectives and employing various judgement angles can help mitigate potential biases and may facilitate a more comprehensive understanding of the contents (Hamilton, 2022).

In the meantime, a novel type of substantive text analysis has emerged, based on an interpretative digital examination of text meanings or verbal expressions, which has amongst others led to the rapid rise of mood or sentiment analysis in the social sciences (see e.g. El-Ansari & Beni-Hssane, 2023; Haque et al., 2022; Shah et al., 2023). This new development has found many applications in marketing, in consumer research, and in experimental and behavioural studies in social psychology (Buhalis & Sinarta, 2019). The smart and consistent interpretation and summary of large volumes of written text – often too large to be captured by the limited storage capacity of human brains – has in recent years prompted intriguing questions on the intelligence of humans versus machines (Korteling et al., 2021). Is the human brain superior to machine learning principles or AI in understanding, summarizing or interpreting a written message? To address these questions, we will in the present paper focus on the quality of text information on a given issue – namely regional development – provided by a chatbot as compared to human-generated information, based on a sequential dialogue centering on a systematic common information reference base (cf. Suchman, 2006). Consequently, the present study is essentially a ‘digital twin’ experiment in the form of a ‘double mirror’, in which existing texts are summarized in an interplay between two twin sources of reasoning, namely humans and machines, in order to trace both similarities in understanding texts and differences in content originality.

It goes without saying that the quality of text analysis – and the results from comparative text studies – depends on the quality of the input texts (see also Dong et al., 2018; Kelly, 2014; Martin et al., 1996; Moore et al., 2021; Quintans-Junior et al., 2023; Taecharungroj, 2023). It is also clear that the interpretations and conclusions drawn from this textual analysis will vary depending on the perspective

of the reader and on the judgement or evaluation principles adopted (Taecharungroj, 2023). There are of course multiple viewpoints to evaluate a text, so that some degree of subjectivity is always present. Then the challenging question is whether a human-made text analysis produces more insightful findings and content-rich conclusions than a machine-made text.

The approach adopted in the present paper is the following. We take an existing and open access scientific text on regional development, written by a few experts in regional science. Next, we seek to analyse and interpret the content of this human-made text in a series of steps based on a human-machine interplay. In our empirical study we will use a short, published text (approx. 2000 words) – written by the present two authors (in cooperation with Paul Romer, Yonda Yu, Ying Xue and Ye Fan) – on the theme of: *Regions of Hope and Glory?* (Nijkamp et al., 2022). This text was summarized in the publicly downloadable Newsletter of the Regional Science Association International (November 2022). This note offered a strategic summary of the main regional economic and policy issues and lessons from the First Global Conference on Regional Development, held in Shenzhen from December 3-5, 2021. This summary text is freely online accessible. We used this simple text as the source for our virtual thought experiment, on the basis of principles outlined in Section 2.

These principles will form the anchor points for the man-machine interaction – in the form of a ‘digital twin’ or ‘double mirror’ experiment – for a comparative text analysis in this study. This paper is organized as follows. After this introductory part, the methodological approach to our text analysis will be explained in greater detail (Section 2). Next, the results of a combined human-machine exercise will stepwise be presented (Section 3), followed by an interpretation and comparative similarity analysis (Section 4). A concluding contribution with a retrospect and prospect will be offered at the end.

2. Design and interpretation of texts

2.1. Setting the scene

The assessment of the quality and reliability of information distilled from existing texts needs to take into consideration that if the information content, underlying arguments or substantive bases present in a text are flawed, biased or based on unreliable sources and instructions, the resulting outcomes and conclusions will also be flawed, biased, or unreliable (Tinsley & Weiss, 1975). Consequently, data accuracy, scientific reasoning and logic, bias and subjective perspective, and contextual relevance have to be critically examined. This issue is known in the literature from computer science and information theory, as the ‘*garbage in, garbage out*’ (GIGO) principle (Babbage, 1864; Bender & Friedman, 2009; Dastin,

2018; Geiger et al., 2020; Jacobs & Wallach, 2019; Leydesdorff et al., 2020; Mellin, 1957; O’Hurley, 2014; Riff et al., 2013).

To provide in general a transparent logic for a solid text analysis, a two-stage approach will be adopted, comprising a *methodological* perspective and a *normative* perspective, successively.

In the first step, some generally accepted methodological judgement principles are taken into consideration for a meaningful comparative and evidence-based research endeavour, notably: *contextualization* of the study, *conceptualization* of its contents, and *operationalization* of research aims to be tested (see e.g., Geiger et al., 2020; Goodwin, 1994; Jacobs & Wallach, 2019). Using these three principles as foundation stones, we will now describe our *methodological* approach, based on the postulate that any scientific product in published form may be examined and interpreted from at least one of the three above mentioned methodological evaluation principles or scientific anchor points:

- *Contextual summary: a relevant and focused contextualization of the publication.* This should be based on the existing body of relevant scholarly literature and on the wider societal or historical science environment, in order to understand and appreciate the appropriate scholarly positioning and novelty of the research endeavor concerned. The focus of this contextual interpretation should be on the broader force field that is critical in shaping and understanding the evolution of regions in an open global space-economy.
- *Conceptual summary: a solid and original conceptualization of the research objectives and questions.* A theory-inspired framing should guide the scientific study at hand, in order to understand the study’s scientific contribution to – and advancement in – the body of existing knowledge as well as its degree of realism or applied viability. Regional growth is the core concept, but it is unequally distributed, both locally and globally. Clearly, regional policy has also several practical limitations.
- *Operational summary: an evidence-based operationalization of the scholarly contribution at hand to the research aims.* This task also includes appropriate data collection methods and statistical-econometric techniques for validation. A real-world profiling is needed in order to understand its appropriateness for empirical confirmation (including realistic policy support), or at least for an evidence-based plausibility test. Solid data-based statistical and modeling approaches are a basic ingredient.

These three methodological assessment criteria will form the first-layer foundation stones for the ‘digital twin’ experiment in the present study. This experiment will next be followed by a second layer, viz. a *normative value system* experiment (Blodgett et al., 2020) in which the actors (humans and chatbot) are asked to provide a subjective summary based successively on three distinct value-loaden framings or policy interpretations, viz. *economic market principles*, *concerted policy interventions*, and *technocratic control and command measures*. Therefore, we

introduce here three distinct normative (subjective) content evaluation principles in order to test whether such a value-loaden framing is significantly influencing text meanings and interpretations, based again on both human-made and machine-made viewpoints. We introduce here these three normative anchor points in slightly more detail:

- *Market-Based interpretation: economic freedom in the multiregional space-economy.* This principle – based on liberal market principles – is the standard basis for an efficiency-oriented growth of regional-economic systems and of individual regions. It will favour socio-economic wellbeing and development in the multi-actor space-economy and will ensure a satisfactory distributional balance.
- *Policy-Control interpretation: policy interventions in an unequal spatial-economic system.* Spatial disparities in economic development – ranging from local to global – call for a coordinated (or concerted) regional-economic policy. Active policy involvement will also favor sustainability and inclusiveness (‘no left behind regions’ or ‘no spatial discontent’), and will serve both the regions and their inhabitants.
- *Technocratic interpretation: technocratic control and command systems.* Regional-economic policy will create balanced, sustainable and inclusive spatial development, if it is governed by advanced data-analytics and sophisticated modelling. Such evidence-based approaches need the use of (spatial) econometric modeling techniques, including data mining tools, AI-inspired decision support methods, or social physics approaches. Such advanced tools will generate sufficient knowledge to control the complex space-economy and its regions.

These two layers – which will be handled consecutively – form the architecture of our human-machine text experiment on regional development.

2.2. Structure of the study

In our experimental study the following steps will be undertaken in examining this *RS-AI* (Regional Science (RS) – Artificial Intelligence (AI)) nexus: (i) *summary analysis*, (ii) application of *methodological requirements*, and (iii) introduction of *normative-interpretative framings* (see e.g., Bender & Friedman, 2018; Mitchell et al., 2019).

Summary analysis

The present authors first describe the rationale of the background text concerned. The overview essay under study, on ‘*Regions of Hope and Glory?*’, considers the region as a spearhead of socio-economic and technological progress in an uncertain environment. It presents mainly two issues, viz. (i) the basic generic

driving forces for accelerated regional development, and (ii) the problem of spatial equity by addressing explicitly socio-economic distributional issues. Clearly, this scientific essay itself is purely a human-made product, which in our comparative experiment will first be summarized in a very compact form of 100 words (by both human brains and a chatbot). This focused summary is needed for transparency, time savings and text comparability reasons.

In our applied textual study we use – as indicated above – a given open-access text of a scientific study on regional development as a reference frame for our ‘*digital twin*’ experiment. To test the robustness of our analysis in a consistent and transparent way, we will – as mentioned above – reduce the original text to a summary of about 100 words. We undertake then successively two steps:

- a human-made ‘neutral’ substantive summary and interpretation of the original text comprising about 100 words, prepared by a scientist/expert in the field.
- an independent computer-made ‘neutral’ summary/interpretation of the same text (also in about 100 words), using Large Language Models (LLMs) as the ‘creator’ of this summary/interpretation.

These summaries are next used for a comparison of the (dis)similarities in scope, form and content, based on an interpretative analysis, a content cloud analysis and a frequency check. This is then followed by an expert panel assessment of results for both the human-made and the machine-made summaries.

Methodological angles

As mentioned above, we apply the three methodological perspectives containing the scientific angles from which the concerned text is to be examined, viz. *contextual* analysis (with a focus on external backgrounds or expert knowledge shaping the contents), *conceptual* analysis (with a focus on theoretical framing and novel combinations from the literature), and *operational* analysis (with a focus on practical applicability or policy relevance of the summary text in the real world).

We will, as mentioned before, subject the essay concerned to both a human-made and machine-made scrutiny test by adopting for each of the above three methodological angles successively a compliant cognitive summary reference perspective, with a view to trace differences in the ultimate phrasing and meaning of the initial text. In other words, we pursue a controlled experimentation on text meanings based on a qualitative sensitivity analysis by means of both human cognitive and machine-made (or AI) techniques. In this way we are able to trace contrasts in texts generated by human brains versus a chatbot, for each of the three methodological angles (context, concept, operational nature). Thus, each of these three types of analysis (contextual, conceptual, operational) of the original text will be executed by using LLMs, with the request to produce in each case a focused content-rich text (of about 100 words). This experiment needs to be pursued of course on the basis of exactly the same summary instructions for both humans and

machines. This methodological experiment will next be followed by the next layer, namely the *normative* framing exercise.

Normative framing

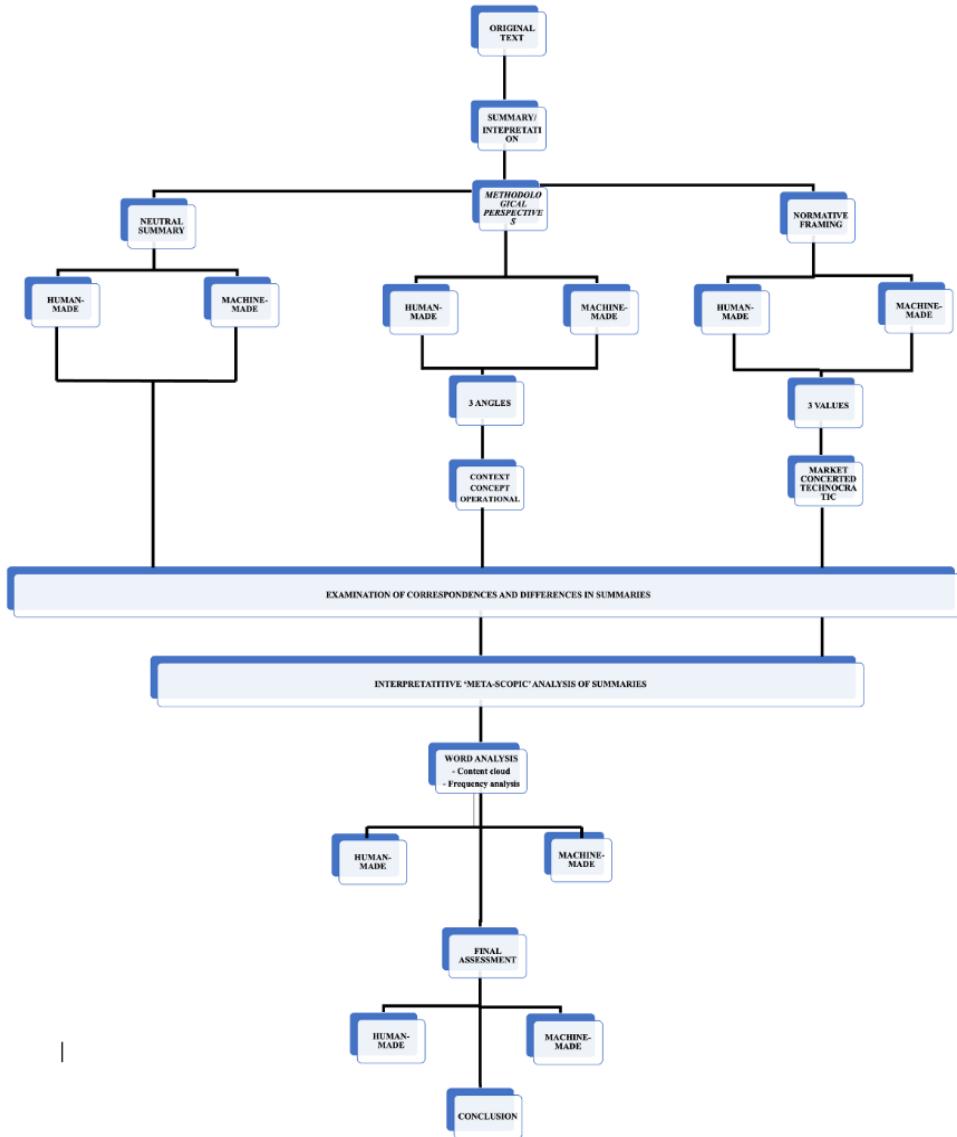
It goes without saying that in any human-made text – and in the interpretation thereof – subjective value elements do – directly and indirectly – normally play a direct or indirect role. It seems plausible that textual expressions produced by a ‘world of wisdom’ (Surowiecki, 2005) collected by AI-powered language models does not necessarily embody individual value-loaden texts, unless ChatGPT is explicitly instructed to do so. It may thus be interesting to confront subjective text judgement by humans with supervised text interpretations in an AI context (using of course the same instructions). And therefore, by way of experiment, we will instruct both a human being and machine to explicitly introduce and digest – after the abovementioned ‘neutral’ summary of the given text – also pre-specified normative elements into a machine-made summary of the reference text. We thus instruct both humans and a chatbot to take also account of explicitly articulated value-loaden perspectives in summarizing or interpreting a text based on the three abovementioned criteria: *market principles* (with neo-liberal drivers in regional growth), *active government interventions* (with effective policy measures and instruments) and *technocratic solutions* (with a heavy public and societal reliance on quantitative knowledge-based approaches).

In conclusion, our study of texts is based on two mutually complementary stage-wise approaches, viz. a *methodological research approach* and the introduction of a ‘*subjective*’ (value-loaden or normative) *interpretation*. This stepwise analysis is sketched in Figure 1.

2.3. Synthesis

In summary, both humans and ChatGPT are asked to produce several summary texts, each about 100 words, in which the original ‘*Regions of Hope and Glory?*’ note is summarized on the basis of each of the three above mentioned *methodological* angles, while also each text summary experiment is ‘coloured’ or evaluated from the three abovementioned distinct *normative* perspectives. These results will next be mutually compared in the sequel of this study, using again various forms of human-made and digital text analysis, as depicted in Figure 1.

Figure 1. The human-machine mirror approach ('digital twin')



Source: authors' representation

This experiment will thus be undertaken by involving both humans and chatbots in this exercise. To avoid a confounding problem, the human-made experiment is done independently (without mutual information sharing) from the

computerized text analysis, and vice versa. So, the ultimate aim of this paper is to play a man – computer game and to explore similarities and commonalities in text outcomes, by using an existing common publication on regional development issues as a joint frame of reference.

3. Comparative text analysis: experimental results

3.1. Neutral text summary: human brains vs. machine-made

In this section we will present summary interpretations of the original text from the essay ‘*Regions of Hope and Glory?*’, produced by the human brain and AI, successively. In both cases, the same *instruction* for producing a summary interpretation was given to both the chatbot and to a real-world expert-scientist: This instruction was:

Summarize and interpret the essay on ‘Regions of Hope and Glory?’ by focusing in particular on:

- the economic, social and technological background of regional development.
- the choice of appropriate focal points of economic growth in relation to effective policy regarding sustainability and poverty.
- the multi-level interaction mechanism of spatial-economic growth ranging from micro- to macro-scale.

We will now present the neutral summaries produced by both the *human brains* of an expert and a chatbot. These two experiments were thus done independently.

Human-made neutral summary

“Regions are spearheads of sustainable development. But in several cases they do not meet such high expectations; then there is a ‘regional problem’. A thorough analysis of underperforming regions – supported by evidence-based data systems – needs insights into background conditions (e.g. peripherality, pandemics), but also into human-made conditions facilitating or hampering a healthy growth (e.g. digital access, livability, education). Territorial capital (e.g. natural resources, entrepreneurial spirit) as well as institutional quality (e.g. focused incentive systems) are key success factors for a balanced socio-economic and ecological development. Digital technology may nowadays also become a core constituent of accelerated and balanced growth. Smart regions are at present the promises to achieving the goal

Machine-made neutral summary

“The essay meticulously unpacks insights from the inaugural Global Regional Development Conference, a monumental milestone in regional science. This conference served as a beacon, attracting leading experts worldwide to confront pressing regional development challenges. Organized by prestigious academic institutions, it embodies a collective commitment to address spatial welfare disparities within the dynamic global landscape. Through its deliberations, the conference contributes to the ongoing scholarly discourse on regional evolution within the expansive open global space-economy, underscoring the intricate interplay of economic, social, and environmental forces shaping regions’ trajectories and offering

of regions of ‘hope and glory’, provided effective policy-making is realized in tandem with the goal of mitigating deplorable spatial poverty conditions. Shared regional capacity building is ultimately a mission for the entire space-economy on our planet”.

profound insights for future research and policy initiatives.”

At first glance, both summary texts are rather different, both in style and content. This will be further examined in our textual interpretative analysis in Section 4.

3.2. Text summaries from three methodological anchor points: human brains vs. machine-made

As argued above, three methodological angles will be employed to understand and interpret the scientific text at hand: namely *contextualization*, *conceptualization* and *operationalization*. In the human-made experiment, for each at the three angles a separate and independent expert on regional development was employed. The related instructions for the three corresponding types of text summary were already given in Subsection 2.1; they form the angles from which both human brains and a chatbot should summarize the given base text. As mentioned, the two cognitive sources – human brains and chatbot – have to operate separately from each other. The results are as follows.

Human brains: contextual summary

“The future of regions will depend on the governance capacity in promoting the sustainable development and the performance in using the territorial tangible and intangible resources, including the institutions and X-factor capitals. Considering the high variety of systems and decision-making mechanisms, across the nations and regions, it is important to identify the optimal framework of institutional system and decision-making mechanism for achieving the “well-being4all” in a context of sustainable and inclusive growth. A key challenge will be the unequal development of nations and regions and the differences between the performance capacity of regions, generating in time the increasing of wellbeing gaps.”

Machine-made: contextual summary

“The essay ‘Regions of Hope and Glory?’ is set against the backdrop of the first Global Regional Development conference in Shenzhen, China, in 2021. The external background includes the global challenges such as economic recovery, pandemics, and digital advances that shape the discourse on regional development. The conference, organized by institutions like the Talent Institute (Shenzhen) and Tsinghua University (Beijing), reflects a global effort to address spatial welfare disparities. The external context of the COVID-19 pandemic adds urgency to discussions on resilience and adaptive regional policies.”

Human brains: conceptual summary

“Regional development is a relevant topic for research and policy. This was the main subject of the Global Regional Development Conference, held in Shenzhen with Paul Romer, Nobel laureate in Economics, who has largely contributed to this field. In the conference, various scholars underline the types of territorial capital that drive regional development. They are productive, human, technological, environmental, institutional and X-factor capitals. The last two factors need more investigation. The results of regional development varies across regions and depend on the access of regions to the types of territorial capitals. Therefore, a balanced investment in those capitals is needed.”

Human brains: operational summary

“Hosted in Shenzhen from December 3-5, 2021, the hybrid First Global Regional Development Conference focused on regional resilience in the face of global challenges, leveraging indigenous resources, addressing social inclusion, promoting sustainable development, and calling for leadership and intelligent policy responses. Emphasizing Shenzhen’s success, Paul Romer highlighted the importance of coordinating elements for collective benefits, unlocking public governance capacity, and fostering sustainable urban and regional development. Other scholars later emphasized territorial capital, efficiency-enhancing competition strategies, and digital technology for balanced, inclusive, and sustainable regional development.”

Machine-made: conceptual summary

“At its core, the conference grappled with probing regional resilience, identifying critical success factors, and reimagining governance paradigms. It underscores the imperative of leveraging territorial resources, encompassing institutional and intangible “X-factor” capital, to foster sustainable regional growth across diverse contexts. By framing regional growth within this theoretical construct, the conference offers profound insights into the complex dynamics driving regional development. Moreover, it critically examines the uneven distribution of regional growth and the pragmatic limitations inherent in regional policy implementation, paving the way for nuanced discussions on enhancing regional development outcomes and informing future policy frameworks.”

Machine-made: operational summary

“Grounded in evidence-based methodologies, the essay champions robust data collection and analysis techniques to comprehensively grasp and address regional development challenges. It advocates for international collaboration as a linchpin for fostering sustainable and inclusive regional development initiatives. Furthermore, the essay heralds the forthcoming second Global Conference in Regional Development as a pivotal platform for advancing discourse on regional and urban planning amidst heightened uncertainty. By operationalizing scholarly contributions with rigorous statistical and modeling approaches, it underscores the pragmatic applicability of research findings in informing policy decisions and interventions aimed at steering regions towards equitable and resilient futures, offering practical guidelines for policymakers and researchers alike.”

It appears again – from a first reading of these summary texts – that there are salient differences between these $2 \times 3 = 6$ summaries, in both style and substance. These differences will be addressed in greater detail in Section 4.

3.3. Text summaries based on three normative framings: human brains vs. machine-made

This subsection will present the summary outcomes based on a value-loaden interpretation of the original essay, for both the human brains and a machine. Clearly, in both cases the same instructions had to be followed, as presented in Subsection 2.1. The three normatively coloured summaries of the text generated by human brains are presented below.

Human brains: market-based interpretation

“Participants at a global conference in 2021 discussed the critical success factors that enable regions to be competitive in the global marketplace, while at the same time guaranteeing social inclusion of its residents and ensuring sustainability. Six types of territorial capital can be identified. The biggest challenges concern institutional and X-factor capital. Regions must nurture creative and charismatic leaders, but these can only be effective when they are assisted by growth-friendly institutions. Geography matters, but great leaders can mobilise territorial capital by efficiency-enhancing competition to overcome geographic disadvantage and to strengthen institutions. Embracing new digital technologies will be very important.”

Machine-made: market-based interpretation

“The essay emphasizes economic freedom within the multiregional space-economy, advocating for liberal market principles to drive efficiency-oriented growth. By adhering to these principles, regions foster socio-economic well-being and ensure equitable resource distribution, enhancing resilience and stability. Embracing market-based mechanisms unlocks inherent growth potential and facilitates balanced resource distribution, paving the way for sustainable development across diverse regions. It suggests that policies rooted in market principles can effectively navigate the complexities of regional economies, fostering growth while maintaining a fair distribution of resources and opportunities, thereby promoting overall prosperity.”

Human brains: policy-control interpretation

“A Shenzhen Conference on ‘Regional of Hope and Glory’ in 2021 examined the questions of building regional resilience, using indigenous resources for regional competitiveness, creating regional leadership for intelligent policy and actor-based development, and traditional support systems for sustainable and inclusive regional development pathways. Responding to the questions, Paul Romer cited Shenzhen as an example of effective urban and regional governance creating a high-talent-based sustainable regional economy. At the same time, other scholars emphasised a pool of territorial capitals, including x-factors (creative leadership as critical capital), institutions, and digital technologies in charting out pathways of sustainable regional development.”

Machine-made: policy-control interpretation

“The imperative of strategic policy interventions to address spatial-economic disparities and promote inclusive development is underscored. Coordinated regional-economic policies tailored to diverse challenges ensure equitable socio-economic progress and prevent marginalization. Effective policy control fosters long-term growth and prosperity, enhancing socio-economic resilience and overall well-being. It emphasizes the role of proactive policy measures in steering regional development towards equitable outcomes, highlighting the need for adaptive strategies that respond to evolving economic landscapes and prioritize the welfare of all regions and their inhabitants.”

Human brains: technocratic interpretation

“Artificial intelligence (AI) can help address the current sustainability and resilience challenges facing regions. Simultaneously, AI has downsides, such as bias and opaqueness, which can obstruct such efforts. Governance is needed to mitigate the negative implications of AI, with institutions reflecting the “rules of the game” being fundamental in this regard. Yet, AI is in and of itself an institution with rules embedded in it. In this sense, it can facilitate “algorithmic governance,” helping to regulate regional trajectories in an automated and positive way. But humans must remain in the loop to ensure the “right” rules are in such systems.”

Machine-made: technocratic interpretation

“Advanced data-analytics and modeling techniques shape regional-economic policy, informing formulation and implementation. Evidence-based approaches, including spatial econometric modeling and AI-driven decision support methods, enable effective governance of complex economic systems. Leveraging these tools ensures optimal resource allocation and sustainable growth trajectories, fostering resilience and prosperity across diverse regions. It suggests that leveraging technology and data-driven insights can enhance policymakers’ ability to navigate the complexities of regional economies, promoting informed decision-making and facilitating the achievement of balanced and inclusive development goals.”

It turns out that also in this case there are salient differences between human- and machine-type expressions. From the neutral, methodological and normative experiment, we have now in total ($2 + 2 \times 3 = 8$) distinct summary texts of about 100 words each. These will now be subjected to a scrutiny text in Section 4 (following the steps from Figure 1).

4. Comparative ‘Meta-scopic’ assessment

In Section 3 a set of distinct summaries of a scientific text has been produced. It is useful, however, to call for a ‘second-opinion’ on the validity of these summaries in the light of the contents of the original essay. This type of meta-analysis is performed here by both a scientific expert and a chatbot, who had to work independently. The results of this interpretative ‘meta-scopic’ experiment will be concisely reported in Section 4, following the same logic as in Section 3.

4.1. Assessment of the human-made vs. machine-made ‘neutral’ summaries

This section provides an interpretative analysis of an expert-made assessment and a ChatGPT-generated assessment of the original essay, against the backdrop of the summaries provided in Section 3. We start with the two distinct *neutral* summaries. By juxtaposing these summaries, we are able to evaluate their value in capturing the essence and nuances of the essay’s key themes.

Human brains: neutral 'meta-scopie' interpretation

“In the human-made summary, the author emphasizes the important role of regions in driving sustainable development and confronts the challenges encountered by underperforming regions. Through an analysis rooted in evidence-based data systems, both natural and human-made factors influencing growth are scrutinized. Key concepts such as territorial capital and institutional quality emerge as vital determinants for achieving socio-economic and ecological progress. Moreover, the potential of digital technology to facilitate accelerated and balanced growth is underscored. The mention of ‘smart regions’ and a call for effective policy-making to alleviate spatial poverty conditions lend a forward-looking perspective. Ultimately, the shared regional capacity building is posited as a global imperative.”

Machine-made: neutral 'meta-scopie' interpretation

“The Machine-generated summary explores the complex dynamics of global regional development, advocating for a holistic approach to economic growth. It acknowledges the multifaceted nature of capital, encompassing various forms such as productive, human, technological, environmental, institutional, and intangible X-factor capital. Emphasis is placed on the significance of good governance, transparent regulations, and innovative leadership, alongside the proposition of a ‘Quadruple Helix’ institutional model involving government, industry, academia, and the public. The summary mirrors the essay’s focus on comprehensive strategies spanning micro to macro scales, aiming for inclusive and resilient regional development.”

From reading these ‘meta-scopie’ interpretations, it becomes clear that they adeptly capture the core themes of the original essay. However, the human-made summary offers a more detailed and nuanced interpretation, introducing specific concepts like territorial capital, institutional quality, and digital technology. It explicitly addresses ‘smart regions’ and emphasizes the importance of effective policy-making to combat spatial poverty conditions. Conversely, while the machine-generated summary encompasses the main points of the essay, it provides a slightly condensed overview without delving into specific concepts highlighted in the human-made summary. Overall, both summaries effectively convey the essence of the original essay, with the human-made summary providing a deeper exploration of key ideas.

4.2. Assessment of the human-made vs. machine-made methodologically-oriented summaries

In this section, we assess the human-made versus machine-generated *methodologically-oriented* summaries from Section 3 across the three dimensions: contextual, conceptual, and operational. Through this comparative analysis, we may evaluate the merits of each approach in encapsulating the core themes and insights of the original essay on regional development. We start with the *conceptual* interpretation.

Human brains: contextual ‘meta-scopie’ interpretation

“In the human-made contextual summary, the emphasis lies on the governance capacities crucial for promoting sustainable development and optimizing territorial resources, including tangible and intangible assets. It underscores the importance of identifying optimal institutional frameworks and decision-making mechanisms to achieve inclusive growth and sustainable well-being amid diverse regional contexts. Additionally, the summary acknowledges the challenge posed by unequal development among nations and regions, contributing to widening well-being disparities over time.”

Machine-made: contextual ‘meta-scopie’ interpretation

“The ChatGPT-generated contextual summary contextualizes the essay within the framework of the inaugural Global Regional Development conference held in Shenzhen, China, in 2021. It highlights global challenges such as economic recovery, pandemics, and digital advancements as influential factors shaping discussions on regional development. Organized by reputable institutions like the Talent Institute (Shenzhen) and Tsinghua University (Beijing), the conference signifies a global endeavor to address spatial welfare disparities, with the COVID-19 pandemic adding urgency to the discourse on resilience and adaptive regional policies.”

We observe that both summaries effectively contextualize the essay within the broader landscape of regional development. However, the human-made summary provides a more focused examination of the governance capacities and institutional frameworks necessary for sustainable development. It explicitly addresses the challenge of unequal development among regions, offering a nuanced perspective on well-being disparities. In contrast, the machine-generated summary offers a broader overview of the external factors influencing regional development, emphasizing the global context and urgency for adaptive policies. Overall, both summaries contribute valuable insights to the discourse on methodologically-oriented regional development strategies. Next, we move to the *conceptual* stage.

Human brains: conceptual ‘meta-scopie’ interpretation

“The conceptual summary from the human-made perspective encapsulates the essence of the conference by emphasizing the exploration of regional resilience, identification of critical success factors, and reimagining of governance paradigms. It underscores the significance of leveraging territorial resources, including institutional and intangible “X-factor” capital, to foster sustainable regional growth within diverse contexts. Furthermore, the summary critically evaluates the uneven distribution of regional growth and acknowledges the practical constraints in regional policy implementation. This conceptual framework lays the foundation for nuanced discussions aimed at improving

Machine-made: conceptual ‘meta-scopie’ interpretation

“The ChatGPT-generated conceptual summary delves into the core themes addressed at the conference, focusing on probing regional resilience, identifying critical success factors, and reimagining governance paradigms. It emphasizes the importance of leveraging territorial resources, which encompass institutional and intangible “X-factor” capital, to drive sustainable regional growth across diverse contexts. By framing regional growth within this theoretical framework, the summary offers profound insights into the complex dynamics of regional development. Additionally, it critically examines the uneven distribution of regional growth and highlights

regional development outcomes and informing future policy frameworks.”

the pragmatic limitations inherent in regional policy implementation. These discussions pave the way for nuanced considerations in enhancing regional development outcomes and shaping future policy frameworks.”

We note that both the human-made and machine-generated conceptual summaries effectively encapsulate the core themes addressed at the conference. They both highlight the importance of probing regional resilience, identifying critical success factors, and reimagining governance paradigms. Additionally, both summaries emphasize the significance of leveraging territorial resources, including institutional and intangible “X-factor” capital, to drive sustainable regional growth. However, while the human-made summary offers a more nuanced evaluation of the uneven distribution of regional growth and practical constraints in policy implementation, the machine-generated summary provides a comprehensive overview of these themes with profound insights into the complex dynamics of regional development. Overall, both summaries contribute valuable perspectives to the discourse on conceptual frameworks for regional development. Finally, we proceed to the *operational* text interpretation task.

Human brains: operational ‘meta-scopie’ interpretation

“The operational summary from the human-made perspective provides a detailed overview of the First Global Regional Development Conference held in Shenzhen from December 3-5, 2021. It outlines the conference’s focus on regional resilience amid global challenges, emphasizing the utilization of indigenous resources, addressing social inclusion, and promoting sustainable development. Keynote speaker Paul Romer highlighted the importance of coordination for collective benefits, unlocking public governance capacity, and fostering sustainable urban and regional development, particularly citing Shenzhen’s success. Subsequent discussions by scholars underscored the significance of territorial capital, competition strategies, and digital technology for achieving balanced, inclusive, and sustainable regional development.”

Machine-made: operational ‘meta-scopie’ interpretation

“The machine-generated operational summary underscores the essay’s commitment to evidence-based methodologies in comprehensively understanding and addressing regional development challenges. It advocates for international collaboration as crucial for fostering sustainable and inclusive regional development initiatives. Additionally, it highlights the forthcoming second Global Conference in Regional Development as a vital platform for advancing discourse on regional and urban planning amidst heightened uncertainty. By operationalizing scholarly contributions through rigorous statistical and modeling approaches, the summary emphasizes the practical applicability of research findings in informing policy decisions and interventions. It offers practical guidelines for policymakers and researchers to navigate towards equitable and resilient regional futures.”

We observe that both the human-made and machine-generated operational summaries effectively outline the objectives and key discussions present in the

background document. They both highlight the conference’s focus on regional resilience, leveraging indigenous resources, addressing social inclusion, and promoting sustainable development. Additionally, they both emphasize the importance of international collaboration and evidence-based methodologies in informing policy decisions and interventions for equitable and resilient regional futures. However, while the human-made interpretation provides specific insights from the basic essay, the machine-generated description offers a broader perspective on regional development and the pragmatic applicability of research findings. Overall, both interpretations contribute valuable insights to the discourse on operational strategies for regional development.

In conclusion, the comparative analysis of human-made and machine-generated methodologically-oriented ‘meta-scopic’ text interpretations reveals complementary perspectives on regional development strategies. The human-made summaries excel in providing detailed analyses and nuanced evaluations, focusing on specific aspects of regional development. On the other hand, machine-generated descriptions offer broader perspectives and comprehensive overviews, capturing the essence of regional development in a more holistic manner. Both approaches contribute valuable insights to the discourse on regional development, catering to the diverse needs of policymakers and researchers. By combining these perspectives, a more comprehensive understanding of regional development can be achieved, facilitating informed decision-making and advancing the field.

4.3. Assessment of the human-made vs. machine-made normative-based summaries

After the study of neutral and methodologically-oriented features in the text summaries, this section explores the comparison between human-made and machine-made *normative-based* summaries in the regional development literature. Through this assessment, we aim to uncover how both approaches interpret and summarize textual content, revealing their respective strengths and limitations. We will commence here with a free-market interpretation of text summaries.

Human brains: market-based ‘meta-scopic’ interpretation

“In the human-made market-based interpretation, the discussion revolves around the critical success factors enabling regions to compete in the global marketplace while ensuring social inclusion and sustainability. It identifies six types of territorial capital, emphasizing the challenges related to institutional and X-factor capital. The interpretation underscores the importance of

Machine-made: market-based ‘meta-scopic’ interpretation

“The machine-generated market-based interpretation emphasizes economic freedom within the multiregional space-economy, advocating for liberal market principles to drive efficiency-oriented growth. It suggests that adhering to these principles fosters socio-economic well-being and ensures equitable resource distribution, thereby enhancing resilience and stability. Furthermore, it

nurturing creative and charismatic leaders supported by growth-friendly institutions. Additionally, it highlights the role of geography and efficiency-enhancing competition in mobilizing territorial capital, along with the significance of embracing new digital technologies for regional development.”

proposes that embracing market-based mechanisms unlocks growth potential and facilitates balanced resource distribution, leading to sustainable development across diverse regions. The interpretation posits that policies rooted in market principles can effectively navigate the complexities of regional economies, fostering growth while maintaining fair resource allocation and promoting overall prosperity.”

It is noteworthy that both interpretations effectively address the importance of market principles in driving regional development, aligning with the methodological perspective and normative framing adopted in the experiment. The human-made interpretation provides a detailed analysis of critical success factors, challenges, and strategies for leveraging territorial capital, including the role of leadership and digital technology. Conversely, the machine-generated interpretation offers a broader perspective on the benefits of market-based mechanisms in fostering socio-economic well-being and resource distribution. Overall, both interpretations contribute valuable insights to the discourse on market-oriented regional development strategies, with the human-made interpretation offering more nuanced details and the machine-generated interpretation providing a comprehensive overview. Next, we move to a policy orientation.

Human brains: policy-control ‘meta-scopie’ interpretation

“In the human-made interpretation, the Shenzhen Conference on ‘Regional of Hope and Glory’ in 2021 is examined, focusing on building regional resilience, utilizing indigenous resources for regional competitiveness, and creating regional leadership for intelligent policy and actor-based development. Paul Romer’s reference to Shenzhen illustrates effective urban and regional governance fostering a high-talent-based sustainable regional economy. Other scholars emphasized the importance of territorial capitals, including x-factors like creative leadership, institutions, and digital technologies, in devising sustainable regional development pathways.”

Machine-made: policy-control ‘meta-scopie’ interpretation

“The machine-generated interpretation underscores the imperative of strategic policy interventions to address spatial-economic disparities and promote inclusive development. It emphasizes the role of coordinated regional-economic policies tailored to diverse challenges in ensuring equitable socio-economic progress and preventing marginalization. Effective policy control is highlighted as vital for fostering long-term growth, enhancing socio-economic resilience, and prioritizing the welfare of all regions and their inhabitants through adaptive strategies responsive to evolving economic landscapes.”

It turns out that, comparatively, both interpretations emphasize the importance of policy interventions in regional development. The human-made interpretation draws more directly from the basic essay, focusing on specific strategies and examples. In contrast, the machine-generated interpretation provides a broader

overview of policy control and its implications for socio-economic progress and resilience. Both interpretations offer valuable insights, with the human-made interpretation providing detailed examples and the machine-generated interpretation offering a more generalized perspective. Finally, we zoom in on a more ‘technocratic’ interpretation experiment.

Human brains: technocratic ‘meta-scopie’ interpretation

“The human-made technocratic interpretation focuses on the role of artificial intelligence (AI) in addressing sustainability and resilience challenges in regions. It acknowledges the potential downsides of AI, such as bias and opacity, and highlights the importance of governance to mitigate these negative implications. The interpretation emphasizes the significance of institutions in regulating AI and promoting algorithmic governance to positively influence regional trajectories. It also stresses the necessity of human oversight to ensure that AI systems are governed by the “right” rules, maintaining a balance between automation and human intervention.”

Machine-made: technocratic ‘meta-scopie’ interpretation

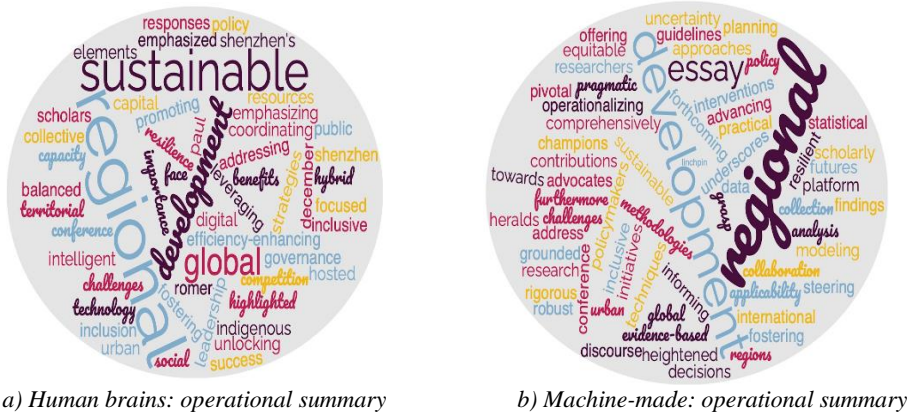
“The machine-generated technocratic interpretation emphasizes the role of advanced data analytics and modeling techniques in shaping regional-economic policy formulation and implementation. It advocates for evidence-based approaches, including spatial econometric modeling and AI-driven decision support methods, to enable effective governance of complex economic systems. The interpretation underscores the importance of leveraging these tools to ensure optimal resource allocation and sustainable growth trajectories, thereby fostering resilience and prosperity across diverse regions. It suggests that technology and data-driven insights can enhance policymakers’ ability to navigate regional economic complexities, promoting informed decision-making and facilitating balanced and inclusive development goals.”

We note here that both interpretations effectively address the role of technology and data-driven approaches in informing regional-economic policy and governance. The human-made interpretation highlights the need for governance to mitigate potential negative implications of AI, emphasizing the importance of human oversight in algorithmic governance. On the other hand, the machine-generated interpretation provides a broader overview of advanced data analytics and modeling techniques, focusing on their role in enabling effective governance and promoting sustainable growth trajectories. Overall, both interpretations contribute valuable insights to the discourse on technocratic approaches to regional development, with the human-made interpretation emphasizing governance and human oversight, while the machine-generated interpretation focuses more on the technical aspects of data analytics and modeling techniques.

In conclusion, the comparison between human-made and machine-made interpretations underscores their distinct contributions to regional development literature. Human-made interpretations offer detailed analyses and specific examples, providing nuanced insights into critical factors and challenges. Conversely, machine-made interpretations provide broader perspectives on normative principles,

made operational summary highlights discussions about advancing approaches within the context of an essay or analysis.

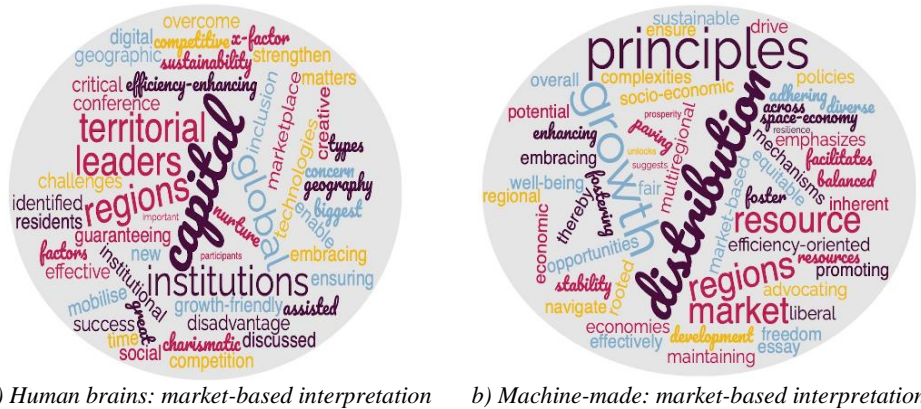
Figure 5. Content cloud results of text summaries: operational



Source: authors' representation

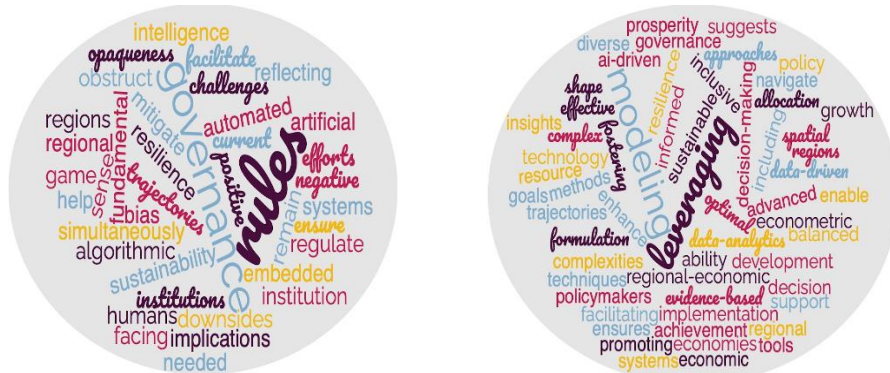
After the methodological approach, we proceed now with the normative angle, employing the three dimensions of market-based policy-control, and technocratic interpretations (see Figures 6-8, respectively).

Figure 6. Content cloud results of text summaries: market-based



Source: authors' representation

The human brains *market-based* interpretation emphasizes terms such as capital, global, institutions, leaders, and regions. These terms suggest a focus on the

Figure 8. Content cloud results of text summaries: technocratic

a) Human brains: technocratic interpretation

b) Machine-made: technocratic interpretation

Source: authors' representation

The human brains technocratic interpretation emphasizes terms such as rules, governance, algorithmic, artificial, and automated. These terms suggest a focus on the governance and implementation of algorithmic and automated systems, potentially with considerations for bias and challenges. In contrast, the machine-made technocratic interpretation features terms such as leveraging, modeling, ability, and advanced. These terms indicate discussions about leveraging models and advanced approaches, potentially within the context of AI-driven systems and complex allocation processes. Overall, while both interpretations touch upon themes related to technocratic approaches, the human brains interpretation appears to focus more on governance and algorithmic systems, while the machine-made interpretation emphasizes leveraging models and advanced approaches within complex systems.

In conclusion, the content-cloud and frequency analysis of human-made versus machine-made summaries across various thematic lenses shed light on their distinctive interpretations of textual content. While both approaches capture key themes related to development, regions, and policy, they exhibit nuanced differences in emphasis and focus. Human-made summaries tend to highlight specific aspects such as balanced development goals, sustainable leadership roles, and governance considerations, whereas machine-made summaries offer broader perspectives on global insights, distribution principles, and adaptive strategies. These findings underscore the complementary nature of human and AI interpretations, contributing to our understanding of cognitive science and AI's role in textual comprehension and analysis.

6. A systematic expert panel assessment

In this section, we present a systematic expert panel assessment of the findings from the human-made and machine-made summaries of our experiment, employing predefined judgment criteria. The panel comprised of three experts in the regional development area, based in different parts of the world. The evaluation aims to compare the effectiveness and quality of text summaries generated by both human experts and AI-powered language models. Each summary is systematically assessed across various dimensions, including systematic organization, clarity of writing style, originality of insights, and compliance with prior instructions. The scores, on a Likert scale ranging from 1 to 5, reflect the panel's assessment of each criterion for both human-made and machine-made summaries. These expert findings are contained in Table 1. Additionally, detailed observations and conclusions are provided, highlighting key differences between the two approaches, especially concerning methodological and normative aspects. Through this assessment, we seek to shed light on the strengths and limitations of both human and machine-generated summaries in the context of regional development literature analysis.

Table 1. Expert evaluation of human-made and machine-made summaries (generated by AI-powered language models) based on six judgment criteria for the quality of text summaries

Judgement criterion	Neutral		Methodological						Normative					
	Human	Machine	Contextual		Conceptual		Operational		Market		Policy		Technocratic	
			Human	Machine	Human	Machine	Human	Machine	Human	Machine	Human	Machine	Human	Machine
1. Systematic organization/ conclusion of text summary	3.67	3.00	3.67	4.33	4.00	3.67	4.67	3.67	4.67	3.00	3.67	2.67	3.67	3.67
2. Balance between broad coverage and clear focus	4.00	3.00	3.33	4.00	3.67	3.33	4.33	3.67	4.33	3.00	3.67	2.67	3.67	3.00
3. New insights/ originality of summary	4.67	2.67	4.00	4.00	4.00	3.33	4.00	3.67	4.33	2.67	4.00	2.67	3.67	2.33
4. Lessons for regional policy	4.33	2.33	4.00	3.00	4.33	4.00	3.67	4.33	4.67	3.00	4.00	2.67	2.67	3.67

5. Clarity of writing style	4.00	4.00	3.00	4.67	3.67	4.00	5.00	3.67	4.67	3.67	4.00	3.67	4.00	3.67
6. Compliance with prior instructions	4.33	3.33	3.33	4.67	4.00	3.33	5.00	3.67	4.67	3.33	4.00	3.00	3.33	3.33

Source: authors' representation

The scores in Table 1 represent the evaluation of the human-made and machine-made summaries using the six pre-defined judgment criteria. This information overview provides further insight into the observations and conclusions from comparing machine-made summaries with human-made text experiments, informed by the assigned scores, while it offers also additional perspectives on the methodological and normative dimensions:

- *Systematic organization/conclusion of text summary*: both human-made and machine-made summaries demonstrate a systematic organization, with human-made summaries potentially offering clearer conclusions due to their ability to synthesize information more cohesively. Machine-made summaries also show a systematic organization, but their performance is closer to that of human-made summaries than previously noted;
- *Balance between broad coverage and clear focus*: human-made summaries strike a better balance between broad coverage and clear focus compared to machine-made summaries, potentially due to their integration of normative frameworks or ethical considerations. However, machine-made summaries also show an equal text performance in this area, thus reflecting a reasonable balance;
- *New insights/originality of summary*: human-made summaries excel in offering original insights through scholarly reasoning and methodological innovations, potentially presenting more unique insights based on subjective framing. Machine-made summaries appear to show slightly less originality, reflecting a more standardized approach;
- *Lessons for regional policy*: human-made summaries provide nuanced policy recommendations informed by normative considerations, ensuring alignment with broader ethical frameworks, while machine-made summaries may prioritize data-driven analysis without considering normative implications. Machine-made summaries also show a reasonable performance in offering lessons for regional policy, though potentially less nuanced;
- *Clarity of writing style*: both human-made and machine-made summaries exhibit clarity in writing style, but human-made summaries tend to provide clearer explanations, especially in technical discussions. Machine-made summaries also demonstrate good clarity, showing similar effectiveness in writing style;

- Compliance with prior instructions: human-made summaries demonstrate better compliance with prior instructions, potentially aligning more closely with methodological guidelines and intended normative perspectives compared to machine-made summaries. Machine-made summaries also show a high level of compliance, comparable to human-made summaries.

Additional observations regarding methodological and normative aspects are:

- Human-made summaries tend to integrate methodological rigor and scholarly reasoning more effectively, resulting in clearer conclusions and more original insights. Machine-made summaries also meet basic standards of rigor, but might lack some depth in originality;
- Normative considerations are more prominently reflected in human-made summaries, ensuring that ethical considerations are communicated effectively and policy recommendations are aligned with broader ethical frameworks. Machine-made summaries seem to meet basic normative considerations, though perhaps less prominently;
- Both human-made and machine-made summaries likely met basic standards of coherence, relevance, and accuracy, as evident from the scores ranging from 3 to 5. This suggests that the summaries were generally well-structured, informative, and aligned with the provided instructions. Machine-made summaries also meet these standards rather well;
- The judgment criteria may have been designed in a way that inherently favors higher scores, emphasizing aspects such as systematic organization, clarity of writing style, and compliance with instructions, which are more likely to be met by competent summaries. Both human-made and machine-made summaries performed well across these criteria, reflecting their quality.

Overall, while machine-made summaries comprise efficiency and data-driven analysis, they also show strong performance in several areas previously noted as exclusive strengths of human-made summaries. Human-made summaries excel in providing nuanced interpretations, integrating methodological rigor, and considering normative implications for regional policy-making.

Conclusion

There is no doubt that AI will become an important game changer in all sciences, including regional science. The information handling capacity of AI tools such as ChatGPT is formidable and will deeply affect scientific practice, in particular the empirical application side of research. The unprecedented synthetic and information functions of AI lead of course to a question on the accountability of research findings for regional analysis and policy-making, in particular against the backdrop of data quality, big data systems, and information verifiability. This has provoked a new debate on Garbage-in, Garbage-out principles and objective or value-free research.

Another important scientific issue is the question on the intelligence of AI tools, such as machine learning or deep learning. In our study we have designed a test system in which human-made text interpretations are confronted with machine-made text interpretations, using the same basic and simple scientific text on regional development. Our research has followed three steps in interpreting this text: (i) a comparison of a human-made versus machine-made ‘*neutral*’ (objective) summary of the original paper; a ‘*methodological*’ interpretation angle, by making a distinction into three scientific perspectives, viz: *contextual*, *conceptual* and *operational*; (iii) a ‘*normative*’ (subjective) approach, by interpreting and summarizing the original paper from three value-based viewpoints, viz.: *market-based*, *policy-controlled* and *technocratic*. All these summaries were next pairwise confronted with each other, using both human brains and AI text interpretation tools.

The advantage of this approach is that both objective and subjective factors can be included in a human-machine confrontation of summarized knowledge from a given scientific text, so that a higher degree of transparency can be ensured, in terms of theory, methodology and political framing of research.

The findings from our simple experiment highlight that significant differences in scientific content, focal points of research findings, policy conclusions, as well as in writing style can be observed. This was also confirmed by a consultation on the outcomes with an expert panel. On the other hand, despite the variability in outcomes of human-made and machine-made text summaries, no obvious errors could be identified. And therefore, we may conclude that both human-made and machine-made research tools may be seen as mutually complementary research vehicles that need to be used with great caution, but are by no means each other’s enemies. Given the infant stage of AI in regional science, it seems plausible that the research landscape of regional science will exhibit drastic changes in the near future.

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