

SOCIAL ACCEPTANCE OF NANOTECHNOLOGIES IN OLD INDUSTRIAL REGIONS

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Abstract

The main aim of this paper is to identify factors that affect social acceptance of nanotechnologies at two distinct levels: individual and regional. Focusing on the context of old industrial regions (OIRs), key barriers of effective diffusion of nanotechnologies and path upgrading will be listed and discussed. At the individual level, the role of cognitive, affective and sociocultural factors together with moderating variables (sociodemographic, geographic and contextual) is outlined. At the regional level, adoption of nanotechnologies in OIRs is shaped by institutional path dependence, lock-in, and inherited industrial cultures that often favor continuity over radical change. While the application of nanotechnologies can foster modernization based on related diversification, efforts to foster unrelated diversification require targeted policies, strong institutional support and intensive public–private collaboration. Societal willingness to accept new directions of development paths in OIRs depends on the nature and thickness of industrial culture – the degree of community identification with various industrial attributes.

Keywords: Nanotechnologies, Technology Acceptance, Old Industrial Regions, Industrial Path Development

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Introduction

Although nanotechnologies may initially appear to be associated exclusively with highly specialized research, their application potential is remarkably broad. These technologies fundamentally redefine industrial processes and contribute significantly to their modernization and upgrading (Bozeman, Laredo and Mangematin, 2007). According to Babatunde *et al.* (2020), Cunningham (2012), and Liberty (2024), nanotechnology is a scientific and technological field focused on understanding, manipulating, organizing, engineering, and controlling matter at the molecular and atomic levels within the nanometer scale. As a result, such materials exhibit exceptional properties, including high strength and extraordinary conductivity. Nanotechnologies can be applied in a wide range of fields, including agriculture, environmental protection, transportation, industry, biofuel production, energy, electronics, and healthcare, where they contribute to improving efficiency, sustainability, and overall quality of life (Babatunde *et al.*, 2020; Liberty *et al.*, 2024). However, their greatest potential lies in sectors where the physical and chemical properties of materials are critical to the performance and efficiency of final products. Their integration into these industries is expected to generate significant economic opportunities and competitive advantages (Liberty *et al.*, 2024).

Despite their considerable potential, nanotechnologies face numerous practical obstacles, particularly in the early stages of implementation. Key barriers include techno-economic challenges, regulatory uncertainties, limited public trust, and low institutional acceptance (Babatunde *et al.*, 2020; Liberty *et al.*, 2024). The rate of social acceptance is a critical factor in their applicability (Gupta, Fischer and Frewer, 2011; 2015), together with the demand and regulatory frameworks that directly affect the commercialization of innovative products (Gupta, Fischer and Frewer, 2011; Babatunde *et al.*, 2020; Quatraro and Scandura, 2024). Therefore, it is essential not only to consider the technological benefits but also to thoroughly analyse the factors that influence the acceptance of these innovations at the level of individuals, firms, public institutions, and regions, while simultaneously fostering their systematic interconnection (Babatunde *et al.*, 2020; Liberty *et al.*, 2024).

The acceptance of nanotechnologies is shaped by a range of interrelated factors, the significance of which varies depending on the economic, cultural, and institutional context of a given region. Key determinants of public acceptance include perceived benefits and risks, experience and empirical knowledge about new technologies and their applications, trust in scientific and regulatory institutions, religious beliefs, media

representation, environmental and health-related concerns, fear and anxiety associated with the unknown, as well as ethical considerations (Lee, Rhee and Dunham, 2009; Gupta, Fischer and Frewer, 2015; Rathore and Mahesh, 2021). Numerous empirical studies focused on public perceptions of nanotechnologies across different application domains indicate that the degree of acceptance is also influenced by demographic characteristics such as age, gender, income level, education, and overall awareness (e.g., Babatunde *et al.*, 2020; Rathore and Mahesh, 2021).

In contrast to individuals, the adoption of nanotechnologies at the institutional level (firms, public institutions, regional institutions) is primarily affected by structural factors. Cunningham and Werker (2012) emphasize the importance of technological, geographical, and organizational proximity. Technological proximity fosters collaboration between partners with complementary knowledge bases; geographical proximity facilitates knowledge sharing and reduces transaction costs; while organizational proximity plays a more indirect role, particularly through differences between academic and non-academic entities. Nevertheless, tight proximity and long-term collaborative and supplier relationships may lead to the lock-in effect (Grabher, 1993), where regions remain entrenched in their historical specializations and exhibit strong resistance to fundamental structural change. These areas typically prioritize the technological modernization of existing industrial structures over the development of new sectors (Chou and Liou, 2023). This tendency is further reinforced by established economic linkages, political interests and pressures (Boschma and Martin, 2010; Newey and Coenen, 2022), as well as by localized tacit knowledge deeply embedded in the local economic and social environment (Maskell and Malmberg, 2007).

Various types of lock-in are typical for old industrial regions, which can be characterized as regions whose long-term development was shaped by the presence of a dominant industrial sector (Hassink, Isaksen and Trippel, 2019). This sector initially served as the main engine of economic prosperity but has, over time, become one of the key barriers to further development (Benneworth and Hospers, 2007). The transformation of old industrial regions generally occurs as a result of significant shocks, such as economic crises (Friedman, 2009). Although these regions often lack the capacity to effectively mobilize their internal resources, transformation can be achieved through a combination of external inputs – knowledge, institutions, or finance – and region-specific assets (Frenken, Van Oort and Verburg, 2007).

Nanotechnologies emerge in this context as strategic tools for the socio-economic revitalization of old industrial regions, enabling a transition from traditional manufacturing sectors to innovation-driven activities based on science and research. However, successful implementation in these regions requires not only investment in research and technical infrastructure but also active support for inter-organizational collaboration and the creation of a supportive institutional environment. The effective application of advanced materials and nanotechnologies depends on the systematic engagement of all key stakeholders – firms, research institutions, local governments, and civil society – (Cunningham and Werker, 2012; Liberty *et al.*, 2024).

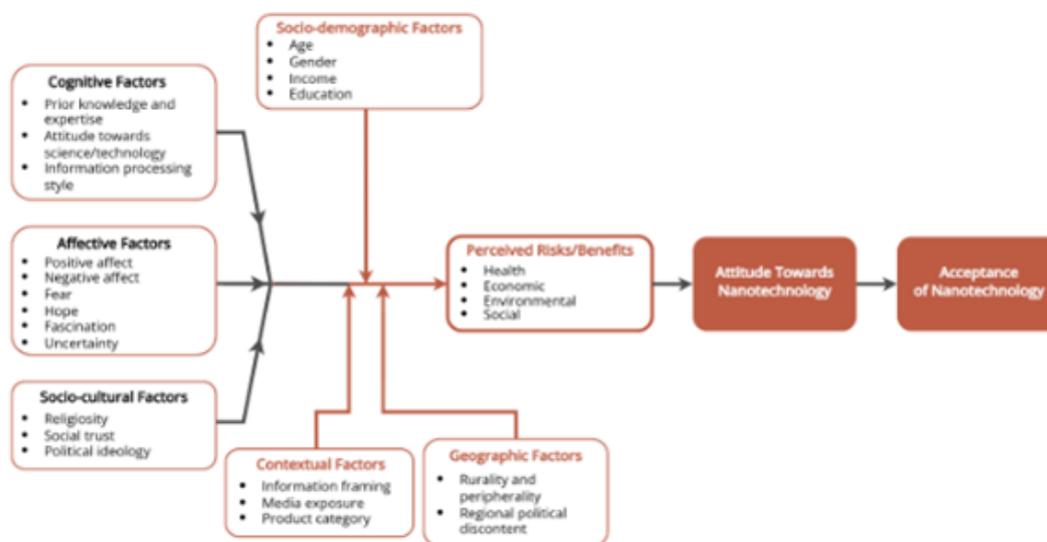
The main aim of this paper is to identify factors that affect the acceptance of advanced materials and nanotechnologies at the individual and regional level. More specifically, various barriers to the effective diffusion of innovation and path upgrading will be discussed. In the next section, factors of acceptance at the individual level will be discussed. The third section frames social acceptance at the regional level. The fourth section interlinks factors at the individual and regional level, and draws conclusions and policy implications.

Social Acceptance of Nanotechnologies at Individual Level

Given the diversity of factors affecting the acceptance of new technologies at the individual level, it is essential to employ appropriate theoretical models to better understand and analyse this complexity. The Technology Acceptance Model (TAM, see Davis *et al.*, 1989; Davis and Venkatesh, 2000; Venkatesh *et al.*, 2003) emphasizes the importance of perceived usefulness and ease of use as key determinants of technology adoption, while also considering individual and organizational characteristics such as the work environment, attitude toward change, and stress levels (Lee, Rhee and Dunham, 2009). A more comprehensive framework is offered by the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT incorporates a broader set of factors, including performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh *et al.*, 2003).

These determinants are further shaped by age, gender, experience, and voluntariness of use, enabling a more nuanced understanding of decision-making across different social and professional contexts. UTAUT and its modification UTAUT2 thus provide an integrated framework for analysing technology acceptance – including nanotechnologies at both individual and systemic levels (Venkatesh *et al.*, 2003; Venkatesh, Thong and Xu, 2012; 2016). Technology acceptance increases with higher education and declines with growing age (Venkatesh *et al.*, 2003). Young men are assumed to be the fastest adopters of a new technology, while with increasing age this gender difference is reversed (Venkatesh *et al.*, 2012) and becomes more distinctive (Morris, Venkatesh and Ackerman, 2005). Women (older) value technical support and ease of use, while (younger) men focus more on performance expectancy (Venkatesh, Thong and Xu, 2012; Hwang *et al.*, 2016; Ženka *et al.*, 2021).

Pillai and Bezbaruah (2017) argued that these models do not capture all factors of technology acceptance and are not necessarily optimal for the evaluation of advanced materials and nanotechnologies. Most importantly, the public's perception of risks and benefits associated with advanced materials and nanotechnologies has the greatest effect on their attitude and acceptance (Gupta, Fischer and Frewer, 2011), considering that the factual public knowledge about these technologies is generally low (Cobb and Macoubrie, 2004; Scheufele *et al.*, 2009). Therefore, Pillai and Bezbaruah (2017) proposed antecedent factors of the risks/benefits perception – cognitive, affective and sociocultural factors – and two groups of moderators: sociodemographic and contextual factors. In this paper, we develop this comprehensive conceptual framework of nanotechnology acceptance at the individual level by adding a new group of previously omitted moderating variables: geographic factors (Fig. 1). Unless stated otherwise, the below-discussed individual-level factors of nanotechnology acceptance are thus based on our elaboration of the model proposed by Pillai and Bezbaruah (2017).



1: Factors of nanotechnologies acceptance at individual level
Source: own elaboration based on Pillai and Bezbaruah 2017

Antecedent Conditions: Cognitive, Affective and Sociocultural Factors

In accordance with the assumptions of the UTAUT framework, people with higher factual knowledge about nanotechnologies are generally expected to perceive nanotechnologies more positively and to be more willing to accept and actually use them (Gupta *et al.*, 2013; Pillai and Bezbaruah, 2017). Experts perceive nanotechnologies as more beneficial and less risky, being more aware of a broad variety of applications. Further, nanotechnology acceptance is higher among people with a positive attitude toward and engagement with science and technology (Besley, Kramer and Priest, 2008), who gain information from multiple sources (Ho, Scheufele and Corley, 2010). Religious beliefs show negative effects on the perception of and attitudes toward nanotechnologies (Scheufele *et al.*, 2009), while Vandermoere *et al.* (2010) found weak effects of individual religiosity and no effects of church membership.

However, positive attitudes towards nanotechnologies are supported not only by factual knowledge, but also by affective factors such as hope and fascination (Gupta, Fischer and Frewer, 2011), which interact with cognitive factors (Lee, Scheufele and Lewenstein, 2005). Nevertheless, affective factors may also influence the perception of nanotechnologies negatively – vague fears are primary drivers of risk perceptions of nanotechnologies (Simons *et al.*, 2009).

Besides, political ideology and cultural standards also matter. Liberals are more likely to view nanotechnologies positively than conservatives (Cacciatore, Scheufele and Corley, 2011). People with individualistic values and a hierarchical view of the world perceive nanotechnologies more positively compared to egalitarians (Kahan *et al.*, 2013). Correspondingly, a low level of social trust in government and business leaders may have adverse effects on nanotechnology acceptance (MacOubrie, 2006), while people who trust scientists should value their benefits (Ho, Scheufele and Corley, 2011). As Pillai and Bezbaruah (2017, p. 8) conclude, “there is great agreement that social trust in critical actors (e.g., scientists, governments, business, and religious leaders) is a major factor in developing people's perception of risks and benefits of nanotechnology.” Importantly, sociocultural factors are expected to interact with sociodemographic factors: gender, age, education, and income.

Moderating Variables: Sociodemographic, Geographic and Contextual Factors

Drawing on the results of George *et al.* (2014) or Senocak (2014), males, younger and more educated respondents showed higher understanding of nanotechnologies and products containing nanotechnologies compared to females, older and less educated respondents. The authors also reported a positive effect of higher income or the promise of higher income (e.g., university students) on the ability to grasp the usefulness of nanotechnologies. Females, on the other hand, were more sensitive in the perception of risks associated with nanotechnologies (Ho, Scheufele and Corley, 2011); this finding was valid for the general public, not for experts. Perception of nanotechnologies also varies substantially according to the specific application (Gupta, Fischer and Frewer, 2015). The public is more sensitive to risks associated with nanotechnology use in medicine and agriculture than in electronics (George *et al.*, 2014).

Apart from the regional-level factors that shape technology acceptance at institutional level discussed in Section 4, geographic contexts affect individual-level factors as well. Senocak (2014) reported that people in urban regions are assumed to display more positive attitudes toward nanotechnologies than their rural counterparts. Senocak (2014) offered two possible explanations: i) urban residents are more familiar with nanotechnologies, and ii) urban residents may use nanotechnology products more than people living in rural areas. Another possible explanation related to limited factual knowledge is the core–periphery polarity. The periphery is characterized by geographical remoteness, loose connection with the core (Borgatti and Everett, 1999), and weak internal cohesion and interrelations between local actors, firms and institutions compared to the high internal density of the core (Glückler, Shearmur and Martinus, 2023, pp. 238–240). Larger distance to the agents developing and using nanotechnologies (universities, research centres, innovative firms) and limited “local buzz” might constrain social trust and appreciation of nanotechnology benefits.

Even more importantly, social trust might be seriously challenged by regional political discontent (McKay, Jennings and Stoker, 2024). While no systematic empirical evidence is available, nanotechnology acceptance is likely to be lower in peripheral, old industrial and other economically lagging, “left-behind” (Fiorentino *et al.*, 2024; MacKinnon, Béal and Leibert, 2024) or trapped regions (Rodríguez-Pose, Dijkstra and Poelman, 2024). People in those regions often distrust elites, established institutions and political parties, express dissatisfaction with the “system,” vote for antisystem political parties, make decisions based on disinformation, and “are ill at ease with a changing world they consider threatens their identity and security” (Rodríguez-Pose, Dijkstra and Poelman, 2024, p. 3). Therefore, their perception of risks associated with nanotechnologies is expected to be significantly higher, similarly to the phenomenon of antivaccination movements.

Contextual factors are represented by three variables: information framing, media exposure and product category. Framing refers to the way information is presented to influence opinion and decision-making (Schütz and Wiedemann, 2008). Presentation of nanotechnologies may highlight either benefits or risks, the social context (e.g., impact on large or small firms, metropolitan or peripheral regions), or issues such as environmental or health impacts (Cobb, 2005). According to the focus and way of presentation, framing may substantially affect perceptions of nanotechnology benefits and risks (Cobb, 2005; Schütz and Wiedemann, 2008). Correspondingly, the amount of media exposure should increase public awareness and a positive attitude toward nanotechnologies (Pillai and Bezbaruah, 2017). Nevertheless, the type of media matters. Scientific content (even science fiction) displays a positive effect on the perception of nanotechnologies in contrast with religious content (Nisbet and Goidel, 2007). Exposure to scientific media content interacts with education and information processing (a cognitive factor) to increase familiarity with nanotechnologies (Lee and Ho, 2015). Perception of risks and benefits also depends on the application of nanotechnologies (Gupta, Fischer and Frewer, 2015): the greatest concerns are associated with medical and agricultural applications, and least concern with electronic items (George *et al.*, 2014). While individual-level factors provide a detailed understanding of personal perceptions and attitudes toward nanotechnologies, they also shape perceptions and acceptance at the organizational level: both in firms and in public institutions, which are introduced in the next section.

Social Acceptance of Nanotechnologies at Regional Level

According to Grabher (1993, p. 256), OIRs “can be regarded as the industrial districts of the past – their industrial atmosphere, highly developed and specialized infrastructure, the close interfirm linkages, and strong political support by regional institutions – turned into stubborn obstacles to innovation.” The decline triggered by the loss of competitiveness of traditional sectors, resulting in serious socio-economic, environmental and spatial consequences (summarised by Píša 2023), is caused by institutional specificities described as path dependence and lock-in (e.g. Boschma and Martin, 2010). Path dependence describes how past decisions influence the future direction of economic and regional development (Martin and Sunley, 2006), whereas lock-in refers to the set of constraints resulting from long-term specialisation in resource-intensive industries, which are usually dominated by a single firm (functional lock-in). This setting forms a specific mindset that favours old industries and hinders consideration of new directions for

regional development and industrial innovation (cognitive lock-in), as well as political protection (political lock-in) of existing industries (Hassink, 2010). These mechanisms limit the potential exploitation of the specific features of OIRs (a high concentration of relatively large settlements and population, extensive technical infrastructure, and large firms), the number of technology-intensive enterprises, and the intensity of innovative activities that could contribute to the economic diversity and growth of OIRs (Tödtling *et al.*, 2013), including nanotechnologies (Mangematin and Errabi, 2012).

Importance of Unrelated Diversification

During an economic transition, OIRs tend to favour related diversification to maintain continuity with the original industry, rather than creating unrelated development paths (Saviotti and Frenken, 2008; Coenen, Moodysson and Martin, 2015). This could also be the case with nanotechnologies, which can foster upgrading in existing industries (Palmberg, Nikulainen and Tuomo, 2006; Romig *et al.*, 2007). On the other hand, while considering positions in global production chains and the structural challenges OIRs face, some scholars advocate alternative development strategies, including a focus on the foundational economy and social innovation. These approaches—which aim to ensure a high quality of life and well-being—are based on the idea of development beyond growth (Pike, Rodríguez-Pose and Tomaney, 2007), which seems to be more suitable than growth-oriented efforts to introduce R & D and high-tech sectors (MacKinnon *et al.*, 2022). However, both approaches can be closely linked, as seen in the example of nanotechnologies, which may combine science-based sectors with mature industries such as textiles, food, energy, automotive or engineering (Kant, 2017).

In contrast, several case studies demonstrate the establishment of unrelated, knowledge-intensive industries in declining regions. These industries typically combine local and external knowledge (Nilsen, Grillitsch and Hauge, 2023), which is often the result of the arrival of highly skilled and entrepreneurial individuals, or of extra-regional or foreign firms utilising competencies and networks from other regions and industries alongside local resources (Cortinovis *et al.*, 2017; Neffke *et al.*, 2018; Hassink, Isaksen and Trippel, 2019). The impact on the region's overall development depends on the extent to which these activities become embedded and whether those new industries avoid creating new excessive dependencies, such as in many cases of FDI (MacKinnon, 2012).

Thus, although switching to entirely new sectors appears to be more challenging and less feasible than branching out from existing industries, it is less vulnerable to path exhaustion and lock-in (Isaksen, 2014). Furthermore, Evangelista *et al.* (2018) reported a positive correlation between regional specialisation in nanotechnology and other key enabling technologies, and GDP growth, even in lagging regions. In general terms, high value-added export-oriented industries supported by higher-level institutions form an important part of municipal tax revenues, which are the main source of funding for community and foundational economy strategies (Butzin and Flögel, 2024).

Introducing Knowledge- and Technology-Intensive Industries

Alongside the diversity of change agency (Grillitsch and Sotarauta, 2019), actors, and the resources they utilise, such as motivation, knowledge and finances (Piša, 2023), the implementation of innovation requires these actors to operate within an appropriately structured institutional framework comprising networks, norms and formal institutions (Stam and van de Ven, 2021). However, the level of this varies considerably across OIRs, depending on the broader geographical and historical conditions of the country (Tödtling *et al.*, 2013) and the region itself (Simone, 2023). Especially for more lagging OIRs, establishing such an ecosystem is particularly challenging (Simone, 2023); therefore, it is crucial for them to start with institutional entrepreneurship, initiated by the regional public administration in cooperation with other intra- and extra-regional actors (Isenberg, 2011).

In terms of knowledge production in the field of nanotechnology, a key role is played by universities and other R&D organisations. If they are sufficiently supported in applied research and collaboration with firms, they can capture global knowledge utilised through a specific constellation of individual interests, tacit knowledge and effective cooperation of actors involved at the regional level (Robinson, Rip and Delemarle, 2016). This naturally presupposes the existence of a small number of application partners (Benneworth and Hospers, 2007) – in the case of nanotechnology, innovative firms and organisations that support knowledge and technology transfer between the public and private sectors and potentially across regions (Palmberg, Nikulainen and Tuomo, 2006). For organisations whose competence and knowledge are limited by specific technologies and industries in OIRs, institutionalised and policy-powered research cooperation with partners from highly innovative nanotech cores seems to be the most beneficial approach (Calignano and Nordli, 2024).

New, unrelated industries may emerge as a result of public-sector policies implemented at the supra-regional level, which rather focus on diversifying existing sectors by linking technology-development support programmes with regional technology bases (Foray, David and Hall, 2011). This strategy, however,

usually overlooks the lack of endogenous potential and innovative actors who could contribute to the branching of existing sectors into innovative, knowledge-intensive industries (Simone, 2023). For example, policy efforts to introduce nanotechnologies in less developed regions of the EU and Italy have been unable to bridge the gap between knowledge-intensive nanotechnologies and traditional industries, despite the potential for combining the two (Calignano and Quarta, 2015; Calignano and Nordli, 2024).

Therefore, such attempts often, paradoxically, contribute to widening regional disparities rather than convergence (Capello and Lenzi, 2021), and excessive pressure toward unrelated diversification beyond a region's existing knowledge and R&D capacity is unlikely to succeed (Nuur and Laestadius, 2010). When searching for new development paths, public support must be tailored to the specific conditions of an OIR and consider the existing spectrum of assets and actors (Calignano and Nordli, 2024). After all, in some cases, the beginning of new and technologically unrelated development trajectories lies in the bottom-up agency of individuals (e.g. entrepreneurs or scientists), later accelerated by the financial and coordinating assistance of state and private supporting agencies or local governments (Nuur and Laestadius, 2010; Butzin and Flögel, 2024).

The development of innovative industries can improve the regional image (otherwise perceived as peripheral) and strengthen local identity (Butzin and Flögel, 2024), if the nanotechnology or other industry in question is viewed positively by the public and promoted in the media (Rathore and Mahesh, 2021). Although this topic remains under-researched, case studies show that societal willingness to accept new directions of development paths in OIRs depends on the nature and thickness of industrial culture – the degree of community identification with various industrial attributes (material heritage, tacit knowledge, working-class values, shared experiences and stories) (Bole, 2021). Stihl (2024) found that in regions dependent on large employers, industrial culture was relatively weak, meaning society was more likely to accept unrelated diversification, driven more by individual agency. By contrast, OIRs with a long tradition of small-scale entrepreneurship demonstrate a higher level of community engagement, which can contribute to changes in development paths but favours related diversification (Bole, Goluža and Kozina, 2024). If communities in an OIR are sufficiently cohesive, they produce shared narratives that influence the acceptance of development policies (Görmar, 2024). Top-down policies that are consistent with regional narratives are enforced more easily; however, if the situation is reversed, policies face considerable social resistance (Norris *et al.*, 2024).

Discussion and Conclusions

Nanotechnologies acceptance cannot be understood in isolation. It is necessary to understand their relationships and interactions at various scales, especially in OIRs with limited possibilities for new development trajectories. This section summarizes the main factors of technology acceptance at individual and regional level and explains how these interactions affect the perception and attitudes toward nanotechnologies. The acceptance of nanotechnology at the individual level is based on existing theoretical models (TAM, UTAUT), which consider the perception of risks and benefits to be the key determinants of nanotechnology acceptance. These factors are shaped by the interaction of factual knowledge and emotional attitudes of individuals, including the sociocultural environment reflecting their ideological and value beliefs. Nanotechnology acceptance of individuals is shaped by antecedent conditions (cognitive, affective and sociocultural factors) that are moderated by sociodemographic variables (age, gender, education, income) and contextual factors. The latter influence not only the level of awareness but also how potential risks and benefits are interpreted, and by broader contextual factors that modulate the perception of nanotechnology through media presentation and its applications across disciplines.

We propose to extend the list of individual factors to include geographical variables, which, regarding the perception of benefits and risks, highlight the importance of the influence of the environment in which people's attitudes develop. These variables capture differences in awareness and willingness to accept technologies between urban and rural areas, and especially between the core and the periphery, which, in addition to spatial remoteness, experience lower social and institutional connectivity and thus limited social trust. In OIRs, this effect is further exacerbated by regional political dissatisfaction, which weakens trust in key actors, a crucial factor in the acceptance of new technologies. The acceptance of nanotechnologies and their applications at the individual level is thus the result of a combination of perceptions of benefits and risks reflected in the personality factors of individuals and broader social, cultural and geographical contexts that shape overall attitudes toward new technologies.

The inherited industrial structures and institutional frameworks in OIRs significantly influence the potential for developing new technologies, including nanotechnologies. The nature and strength of industrial culture, which shape local attitudes toward change and new directions in development, also play a role in this process. The literature distinguishes between two main diversification

strategies: diversification into related and unrelated industries. In the former case, which is more realistic in OIRs, the application of nanotechnologies may spur innovation in traditional (medium-) low-tech industries. This type of development is more common in regions with a higher proportion of smaller companies and a stronger community identity. In contrast, diversification into unrelated industries tends to be more effective in regions with dominant companies, but requires a more demanding combination of local and external knowledge, as well as stronger institutional support. A key prerequisite for such a development trajectory is the presence of motivated individuals who can initiate new directions of development in cooperation with partners outside the region. Acceptance of nanotechnologies in OIRs requires a functional innovation ecosystem based on collaboration between research institutions, businesses and public administration.

Acceptance of nanotechnologies is thus a result of a dynamic interaction between individual perceptions of risks and benefits and the broader regional socio-cultural and institutional environment. Weakened trust in key actors affects how risks and benefits are interpreted and directly influences the willingness to accept new technologies. A key prerequisite is the creation of a targeted and context-sensitive regional strategy, based on a detailed analysis of stakeholders and their involvement in governance. Another aspect of successful technology adoption is the emphasis on education and building trust in new technologies among the general public and workers in dominant industries. In this process, it is necessary to consider the role of public institutions, which function not only as regulators of change but also as key recipients and co-creators of new technologies. At the same time, it is necessary to actively support bottom-up approaches that can become the basis for new development trajectories. Therefore, systemic conditions and local human capital must be taken into account when designing support instruments. Diversification policies that do not respect local capacities and contexts often fail and can lead to a deepening of regional disparities.

Finally, OIRs and other 'left-behind places' can be characterized by generally lower social trust in elites and overestimation of risks associated with new technologies: symptoms of regional political discontent. This can be translated not only into possibly lower demand for final products using nanotechnologies, but also into lower willingness of organizations (firms, public institutions, regional administration and government) to accept nanotechnologies that may foster firm and regional competitiveness or reduce negative environmental externalities of local production. Systematic education and popularization of nanotechnologies in OIRs is thus of particular importance, targeting the final consumers, managers of manufacturing companies and public institutions, including the regional governmental bodies.

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