

Article

Data-Driven Labor Market Governance in Smart Cities: Developing the Urban Workforce Readiness Framework (UWRF)

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Abstract

The accelerating digital transformation of urban economies is reshaping labor markets at unprecedented speed, generating skills mismatches, employment volatility, and widening inclusion gaps that current smart city governance frameworks are insufficiently equipped to address. While the smart city literature has advanced substantially in the areas of digital infrastructure, mobility, and e-government services, the governance of labor market transitions in data-driven urban environments remains conceptually underdeveloped. In particular, no integrated analytical framework currently links smart city governance, labor market intelligence, and workforce resilience into a coherent tool for assessing urban preparedness for technology-driven employment change. This study addresses that gap by developing the Urban Workforce Readiness Framework (UWRF)—an integrated conceptual model designed to evaluate how prepared urban labor markets are for accelerating digital and technological transformation. Methodologically, the framework is constructed through a structured synthesis of peer-reviewed scholarship published between 2015 and 2025 across five domains—smart city governance, labor market regulation, human capital development, workforce resilience, and data-driven public administration—complemented by a thematic review of policy documents issued by the OECD, ILO, European Commission, and World Bank. On this basis, the UWRF identifies five interdependent dimensions of urban workforce readiness: (i) digital infrastructure capacity, (ii) labor market intelligence and analytics, (iii) workforce skills adaptability, (iv) institutional governance capacity, and (v) social inclusion mechanisms. A multi-criteria operationalization is proposed, enabling comparative diagnostic assessment across cities and supporting evidence-based prioritization of policy interventions. The analysis demonstrates that institutional governance capacity and real-time labor market intelligence function as critical mediators within the system: in their absence, even substantial investments in digital infrastructure fail to produce resilient, inclusive, or sustainable labor market outcomes. Theoretically, the study extends data-driven governance scholarship beyond service delivery into the domain of workforce management, thereby integrating three traditionally separate research streams—smart city studies, labor market governance, and digital public administration—under a single analytical architecture. Practically, the UWRF provides policymakers, municipal authorities, labor market institutions, and urban planners with a structured diagnostic instrument for aligning digital transformation strategies with sustainable and equitable employment outcomes, and offers a replicable foundation for future empirical validation across diverse urban contexts.



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Keywords: smart cities; labor market governance; data-driven governance; urban workforce readiness framework (UWRF); digital transformation; human capital development; workforce resilience; sustainable urban development

1. Introduction

The accelerating digitalization of contemporary urban economies is producing structural transformations that extend far beyond technological modernization. Advances in artificial intelligence, big data analytics, cloud computing, the Internet of Things, and algorithmic platforms are reconfiguring how cities are governed, how public services are delivered, and how economic activity is organized [1–3]. Within this transformation, the smart city has emerged as a dominant paradigm of sustainable urban development, framing data and digital infrastructure as strategic instruments for enhancing governance effectiveness, service quality, and citizen well-being [4,5]. Yet, as smart city research has evolved, scholars have increasingly recognized that sustainable urbanization cannot be reduced to physical or digital infrastructure alone; it depends equally on the human dimensions of the city, including education systems, labor market institutions, workforce adaptability, and social inclusion [6–8].

Nowhere is this tension between technological progress and human adaptation more acute than in urban labor markets. Automation, algorithmic management, platform-based employment models, and machine-learning-enabled work organization are simultaneously creating new occupations, transforming traditional ones, and intensifying demand for advanced digital competencies [9,10]. As a result, cities worldwide are experiencing widening skills gaps, structural mismatches between labor supply and demand, and growing inequality in access to emerging economic opportunities [11,12]. These dynamics are concentrated disproportionately in urban environments, which function as the principal nodes of innovation, human capital accumulation, and economic exchange, while simultaneously exposing workers to the most acute effects of technological disruption, demographic change, and geopolitical volatility [13,14]. Municipal authorities and labor market institutions are therefore under mounting pressure to develop governance mechanisms capable of anticipating labor market transitions, supporting workforce adaptation, and safeguarding inclusive participation.

Recent international experience demonstrates that existing labor market governance mechanisms often struggle to respond effectively to the pace and complexity of digital transformation. For example, many European cities continue to experience persistent shortages of digital talent despite significant investments in digitalization and skills development programs. Similarly, OECD reports have highlighted growing mismatches between the competencies demanded by rapidly evolving labor markets and those supplied by education and training systems. The expansion of platform-based employment, artificial intelligence applications, and data-driven business models has further exposed limitations in traditional labor market monitoring and workforce planning mechanisms, which frequently lack the predictive capacity necessary to anticipate emerging skill needs and workforce transitions. These challenges underscore the practical need for integrated governance frameworks capable of assessing workforce preparedness and supporting more proactive labor market management in smart cities.

Recent quantitative evidence further reinforces these observations and illustrates the scale and urgency of workforce transformation. The World Economic Forum estimates that structural labor market transformation between 2025 and 2030 will create 170 million jobs while displacing 92 million, resulting in a net increase of 78 million jobs. The same report

indicates that 39% of workers' existing skill sets are expected to be transformed or become outdated by 2030. At the regional level, OECD evidence shows that ICT occupations experience substantially greater labor market tightness than the average occupation across almost all regions for which data are available. Selected indicators illustrating these developments are summarized in Table 1.

Table 1. Selected International Indicators of Workforce Transformation and Digital Skills Pressure.

Indicator	Statistical Evidence	Analytical Relevance to the UWRF	Source
Jobs projected to be created globally, 2025–2030	170 million	Indicates the scale of emerging employment opportunities and the need for anticipatory workforce planning	World Economic Forum (2025)
Jobs projected to be displaced globally, 2025–2030	92 million	Demonstrates the need for reskilling, transition support, and adaptive labor market policies	World Economic Forum (2025)
Existing workers' skill sets expected to change or become outdated by 2030	39%	Highlights the importance of workforce skills adaptability and lifelong learning	World Economic Forum (2025)
Relative labor market tightness of ICT occupations across OECD regions	156% more vacancies per employed person than the regional occupational average	Shows the intensity of digital talent shortages and the need for real-time labor market intelligence	OECD (2024)
OECD regions in which ICT occupations are tighter than the average occupation	97% of regions with available data	Demonstrates the widespread geographical character of digital skills shortages	OECD (2024)

Taken together, these indicators provide empirical context for understanding the governance challenges associated with workforce transformation in smart cities. The projected coexistence of large-scale job creation and displacement increases the need for labor market intelligence capable of detecting emerging occupations, declining roles, and changing skill requirements. The expected transformation of workers' skill sets highlights the importance of lifelong learning, reskilling, and institutional mechanisms that can align education and training provision with labor market demand. At the same time, the widespread shortage of ICT professionals demonstrates that investments in digital infrastructure alone do not ensure workforce preparedness. Rather, these developments substantiate the relevance of a multidimensional approach encompassing digital infrastructure capacity, labor market intelligence and analytics, workforce skills adaptability, institutional governance capacity, and social inclusion mechanisms.

Against this backdrop, recent scholarship increasingly identifies labor market resilience as a defining component of sustainable urban development [15,16]. Resilience in this context extends beyond conventional employment protection; it refers to the capacity of workers, institutions, and labor market systems to absorb disruption while preserving employment stability, productivity, and social cohesion. In smart cities, this capacity requires integrated governance approaches that combine technological innovation, institutional flexibility, continuous learning, and evidence-based policy design [17]. As cities become more dependent on digital infrastructures and real-time information systems, labor market governance must evolve from reactive interventions toward proactive, predictive, and data-driven management approaches.

Data-driven governance—the systematic use of digital information, analytics, and algorithmic tools to support public decision-making, policy design, and performance evaluation—offers substantial promise for addressing these challenges [18]. In urban

contexts, it has already produced measurable gains in transportation management, environmental monitoring, public safety, and municipal service optimization [19,20]. However, its extension to labor market governance remains conspicuously underdeveloped, despite the growing volume of employment-related data generated by digital platforms, educational databases, administrative records, workforce surveys, and real-time labor market intelligence systems [21,22]. This underutilization is not merely a technical gap but a governance gap: existing frameworks often lack the analytical architecture required to translate labor market data into coherent city-level strategic decisions.

This gap becomes even more visible when the relevant research streams are examined side by side. On the one hand, the smart city literature has produced extensive knowledge on digital infrastructure, urban innovation ecosystems, e-governance, and technology-enabled services [23–25]. On the other hand, labor economics and employment policy research have generated deep insights into workforce development, active labor market policies, employment protection, and skills formation systems [26–28]. These two literatures, however, have evolved largely in parallel. With few exceptions [29], limited attention has been given to integrated analytical frameworks that link smart city governance, labor market intelligence, and workforce resilience into a coherent tool for assessing urban preparedness for technology-driven employment change. This absence constitutes the central research gap that the present study seeks to address.

The consequences of this gap are not merely theoretical. A growing body of evidence demonstrates that technological investment alone does not guarantee successful urban transformation [30,31]. Cities can possess advanced digital infrastructures while simultaneously experiencing persistent unemployment, workforce shortages, digital exclusion, and weak institutional capacity to manage labor market transitions. Sustainable outcomes therefore depend not on technological readiness in isolation, but on the ability of governance systems to identify emerging skill requirements, coordinate cross-sectoral stakeholders, facilitate lifelong learning, and support inclusive labor market participation [32]. This suggests the need for a comprehensive, multidimensional framework capable of evaluating both technological and institutional dimensions of urban workforce preparedness.

To address this need, the present study develops the Urban Workforce Readiness Framework (UWRF), a conceptual and analytical model designed to assess the preparedness of urban labor markets for digital transformation and technology-driven economic change. The framework integrates insights from five theoretical traditions: smart city governance, labor market regulation, human capital development, workforce resilience, and data-driven public administration. On this foundation, workforce readiness is conceptualized as a multidimensional construct encompassing five interdependent dimensions: (i) digital infrastructure capacity, (ii) labor market intelligence and analytics, (iii) workforce skills adaptability, (iv) institutional governance capacity, and (v) social inclusion mechanisms. The selection of these dimensions rests on a deliberate theoretical triangulation: the smart city literature identifies infrastructure and institutional capacity as foundational enablers [4,23,24]; human capital and labor market theories emphasize skills adaptability and inclusion as determinants of long-term economic performance [26–28]; and data-driven public administration positions labor market intelligence as the essential analytical layer connecting technological capacity with policy action [18,21,22]. Together, these five dimensions capture the technological, institutional, and human-centered pillars of workforce readiness—an integration that remains largely absent from the existing literature. The selection of these dimensions was guided by their recurrent appearance across the five theoretical traditions synthesized in this study. Digital Infrastructure Capacity and Institutional Governance Capacity emerged as foundational enabling conditions within the smart city governance literature; Labor Market Intelligence and Analytics were derived primarily

from data-driven public administration research; Workforce Skills Adaptability was rooted in human capital and labor market theories; and Social Inclusion Mechanisms were incorporated to reflect insights from workforce resilience and inclusive urban development scholarship. Collectively, these dimensions were selected because they represent complementary rather than independent capacities and together provide a holistic representation of urban workforce preparedness in the digital era.

The framework is developed through a structured synthesis of peer-reviewed scholarship published between 2015 and 2025 across the five domains identified above, complemented by a thematic review of policy documents issued by the OECD, ILO, European Commission, and World Bank. This dual literature-and-policy synthesis approach is intended to ensure both scholarly rigor and practical relevance and is consistent with established methodological standards for conceptual framework development in smart city and public administration research [17,25,29].

The study offers two principal contributions. Theoretically, it extends smart city scholarship by integrating labor market governance into the analytical core of urban sustainability research, thereby bridging three traditionally separate research streams—smart city studies, labor market governance, and digital public administration—under a single conceptual architecture. Practically, it provides policymakers, municipal authorities, labor market institutions, and urban planners with a structured diagnostic instrument for evaluating workforce readiness, identifying strategic intervention priorities, and aligning digital transformation strategies with inclusive and sustainable employment outcomes. However, the proposed framework should be interpreted as a conceptual and analytical tool rather than an empirically validated model. While the UWRF identifies theoretically grounded relationships between workforce readiness and outcomes such as workforce resilience, employment stability, skills alignment, and inclusive labor market participation, these relationships remain provisional and require empirical verification. Consequently, caution should be exercised when generalizing the framework's implications across different urban contexts until future empirical studies test and validate its assumptions and operational dimensions.

Accordingly, the study pursues four specific objectives: (1) to identify the key dimensions influencing workforce preparedness in data-driven urban environments; (2) to establish a conceptual relationship between smart city governance and labor market resilience; (3) to propose a multi-criteria assessment framework capable of supporting evidence-based urban labor market policies; and (4) to contribute to the emerging discourse on human-centered approaches to sustainable urban development.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on smart city governance, labor market resilience, human capital development, and data-driven public administration, identifying the theoretical foundations of the proposed framework. Section 3 outlines the methodological approach adopted for framework development, including the criteria for literature selection and thematic synthesis. Section 4 presents the Urban Workforce Readiness Framework and elaborates its five constitutive dimensions. Section 5 discusses the multi-criteria assessment approach and its potential applications in urban policymaking. Section 6 concludes by summarizing the theoretical contributions, policy implications, limitations, and directions for future empirical validation of the UWRF across diverse urban contexts.

2. Literature Review

2.1. Smart City Governance and Data-Driven Urban Management

The smart city concept has evolved from a technology-centered model of urban modernization into a broader governance paradigm concerned with sustainability, institutional

coordination, citizen participation, and evidence-based decision-making. Early approaches to smart cities emphasized the deployment of digital infrastructure, sensor networks, intelligent transportation systems, and ICT-enabled public services [33,34]. However, more recent scholarship argues that the effectiveness of smart city initiatives depends not merely on technological sophistication but on the capacity of urban institutions to transform data into actionable policy, coordinate multiple stakeholders, and address complex socio-economic challenges [35,36].

Within this broader perspective, data-driven urban management has become a key mechanism for improving the responsiveness and efficiency of city governance. The use of big data analytics, artificial intelligence, digital platforms, and real-time monitoring systems enables municipal authorities to identify urban problems more rapidly, allocate resources more effectively, and evaluate policy outcomes with greater precision [37,38]. These tools have been widely applied in areas such as mobility, energy management, public safety, environmental monitoring, health services, and administrative modernization [39,40]. Nevertheless, the social and labor market implications of data-driven urban governance remain less systematically explored.

A growing body of literature emphasizes the need for human-centered smart city models that place people, skills, inclusion, and institutional learning at the center of urban digital transformation [41,42]. This shift is particularly important because smart city development can produce unequal outcomes when technological innovation is not accompanied by inclusive governance mechanisms. Digital exclusion, uneven access to skills, platform-based labor insecurity, and unequal participation in emerging employment opportunities may reproduce or deepen existing urban inequalities [43,44]. Therefore, smart city governance must be understood not only as the management of digital infrastructures but also as the governance of human capabilities, labor transitions, and social resilience.

2.2. Labor Market Governance and Workforce Resilience

Labor market governance refers to the institutional arrangements, regulatory frameworks, policy instruments, and coordination mechanisms through which employment systems are organized and adjusted to economic change [45]. Traditionally, this field has focused on employment protection legislation, wage-setting institutions, active labor market policies, vocational education and training systems, unemployment insurance, and social dialogue [46,47]. These mechanisms remain central to labor market stability, but digital transformation has created new governance challenges that exceed the boundaries of conventional employment policy.

The rise in automation, artificial intelligence, digital platforms, and algorithmic management has altered the organization of work and the structure of labor demand [48,49]. While technological innovation can generate new forms of employment and productivity growth, it can also displace routine occupations, intensify skills mismatches, and increase labor market polarization [50,51]. These effects are particularly visible in cities, where high concentrations of firms, workers, educational institutions, and digital infrastructure accelerate both innovation and disruption. As a result, urban labor markets require governance systems capable of anticipating change rather than merely responding to its consequences.

Workforce resilience has emerged as a useful concept for understanding labor market adaptation under conditions of uncertainty. In this context, resilience refers to the capacity of workers, institutions, and employment systems to absorb shocks, adapt to structural change, and maintain social and economic functionality [52,53]. A resilient urban workforce is not defined solely by employment stability; it also depends on skills adaptability, access to lifelong learning, institutional responsiveness, and inclusive pathways into emerging

sectors [54]. Therefore, labor market resilience should be treated as a multidimensional governance outcome rather than a narrow labor economics indicator.

2.3. Human Capital Development in the Digital Economy

Human capital theory emphasizes the role of education, skills, competencies, and learning capacity in shaping productivity and long-term economic performance [55]. In the digital economy, however, the meaning of human capital has expanded beyond formal education to include digital literacy, adaptability, creativity, problem-solving, interdisciplinary skills, and the capacity for continuous reskilling [56,57]. As technological change accelerates, workers increasingly need to update their competencies throughout their careers rather than rely on a fixed stock of knowledge acquired through initial education.

This transformation has important implications for urban governance. Cities are not only places where labor demand is concentrated; they are also ecosystems of learning, innovation, and skills formation. Universities, vocational education institutions, firms, public employment services, training providers, and municipal authorities all contribute to the development of urban human capital [58,59]. The effectiveness of this ecosystem depends on the ability of institutions to identify emerging skills needs, align education and training programs with labor market demand, and ensure that vulnerable groups are not excluded from digital employment opportunities [60].

The literature on skills mismatch highlights the growing disconnect between the competencies supplied by education and training systems and the competencies demanded by rapidly changing labor markets [61,62]. In smart cities, this mismatch may become more visible because digital transformation increases the demand for specialized technological skills while also transforming non-technical occupations. Consequently, workforce readiness requires not only investment in digital skills but also the development of broader adaptive capabilities that allow workers and institutions to respond to uncertain future labor market conditions.

2.4. Conceptual Foundations of Data-Driven Labor Market Intelligence

Labor market intelligence refers to the collection, analysis, and use of labor market data to support employment policy, workforce planning, education reform, and skills development [63]. Traditional labor market information systems have relied on surveys, administrative records, and periodic statistical reporting. While these instruments remain important, they often lack the speed, granularity, and predictive capacity required in rapidly changing urban economies [64]. The expansion of digital platforms, online job vacancies, educational databases, social insurance records, and real-time employment indicators creates new opportunities for more dynamic labor market monitoring [65].

Data-driven labor market intelligence can support urban policymakers in several ways. First, it can help identify emerging occupations and declining sectors. Second, it can reveal skills shortages and mismatches across industries and demographic groups. Third, it can improve the targeting of active labor market policies, training programs, and employment services. Fourth, it can support scenario-based planning by helping cities anticipate the effects of automation, demographic change, migration, and economic shocks [66,67]. These functions are especially relevant for smart cities, where governance increasingly depends on the ability to integrate data across sectors and institutions.

However, the use of labor market data also raises governance challenges. Data fragmentation, limited interoperability between institutions, weak analytical capacity, privacy concerns, algorithmic bias, and insufficient policy coordination can reduce the effectiveness of data-driven labor market systems [68,69]. Therefore, labor market intelligence should not be treated merely as a technical infrastructure. It requires institutional capacity, ethical

safeguards, cross-sectoral coordination, and a clear policy architecture that connects data analysis with strategic decision-making.

2.5. Research Gap and Conceptual Foundations of the UWRF

The reviewed literature demonstrates that smart city governance, labor market governance, human capital development, workforce resilience, and data-driven public administration each offer important insights into urban transformation. However, these research streams remain insufficiently integrated. Smart city studies often prioritize digital infrastructure, service optimization, and urban innovation, while labor market research tends to focus on national employment institutions, regulatory frameworks, and macroeconomic labor market outcomes [70,71]. As a result, the city-level governance of workforce readiness remains undertheorized.

This gap is particularly important because the future of work is increasingly urban. Cities concentrate technological innovation, employment opportunities, educational institutions, entrepreneurial ecosystems, and social inequalities. They are therefore not passive spaces where labor market change occurs, but active governance arenas in which workforce transformation can be anticipated, shaped, and managed [72]. Yet existing frameworks provide limited guidance on how municipalities and urban institutions can assess their readiness to govern labor market transitions in a data-driven environment.

The Urban Workforce Readiness Framework (UWRF) is developed to address this gap. It builds on five interconnected theoretical foundations. First, smart city governance highlights the importance of digital infrastructure and institutional coordination. Second, labor market governance emphasizes regulatory capacity, policy instruments, and stakeholder cooperation. Third, human capital theory explains the centrality of skills, learning, and adaptability. Fourth, workforce resilience provides a lens for understanding adaptation under uncertainty. Fifth, data-driven public administration offers tools for evidence-based decision-making and performance assessment [73–75].

On this basis, workforce readiness is conceptualized as a multidimensional urban governance capacity. It refers to the ability of a city to use digital infrastructure, labor market intelligence, institutional coordination, skills development systems, and inclusion mechanisms to prepare workers and institutions for technology-driven economic transformation. This conceptualization moves beyond narrow measures of employment performance and instead frames workforce readiness as a strategic condition for sustainable, inclusive, and resilient smart city development.

As summarized in Table 2, the proposed UWRF integrates five complementary theoretical traditions that collectively explain the technological, institutional, analytical, and human-centered dimensions of workforce readiness. This conceptual triangulation provides the theoretical basis for the framework's operational structure and guides the selection of assessment dimensions presented in the following section.

Table 2. Theoretical Foundations of the Urban Workforce Readiness Framework (UWRF), Their Conceptual Contributions, and Operational Indicators.

#	Theoretical Tradition	Key Scholars & Anchor References	Core Concepts	Contribution to UWRF	Corresponding UWRF Dimension	Expected Indicators
1	Smart City Governance	Kitchin [19]; Meijer & Bolívar [5]; Nam & Pardo [25]	Digital infrastructure; sensor-based urban management; e-governance; institutional coordination; citizen-centric governance	Establishes the digital-institutional foundation of urban transformation; frames the city as an integrated governance ecosystem in which technology enables—but does not determine—policy outcomes	D1. Digital Infrastructure Capacity	Broadband penetration; digital public service availability; smart city platform integration; open-data infrastructure; ICT investment per capita
2	Data-Driven Public Administration	Kitchin [19]; Jassen, van der Voort et al. [17] Meijer & Bolívar [5];	Big data analytics; algorithmic governance; evidence-based policymaking; predictive public management; data assemblages	Provides the analytical layer through which labor market data are transformed into strategic municipal decisions; introduces predictive and real-time governance logic	D2. Labor Market Intelligence and Analytics	Labor market information systems; real-time vacancy databases; predictive analytics tools; frequency of labor market monitoring; data interoperability across institutions
3	Human Capital Theory & Skills Development	Becker [26]; Schultz [27]; Mincer [28]; Autor [9]; McGuinness et al. [62]	Human capital as investment; lifelong learning; skills adaptability; skills mismatch; digital competencies	Explains why skills adaptability and continuous reskilling are strategic assets in digitalizing economies; supplies the theoretical basis for measuring workforce transformation capacity	D3. Workforce Skills Adaptability	Participation in lifelong learning; digital skills levels; reskilling and upskilling rates; tertiary education attainment; workforce training participation
4	Labor Market Governance & Employment Regulation	Freeman [33]; Cardullo et al. [6]; Ross et al. [76]	Employment protection; active labor market policies; social dialogue; institutional coordination; stakeholder engagement	Emphasizes the regulatory, institutional, and coordination mechanisms needed to translate labor market data into inclusive employment policy	D4. Institutional Governance Capacity	Active labor market policy expenditure; employment service effectiveness; interagency coordination mechanisms; stakeholder participation; policy responsiveness indicators
5	Workforce Resilience & Inclusive Urban Development	Martin [15]; Boschma [16]; Florida [13]; Moretti [14]; Cardullo et al. [62]	Evolutionary resilience; adaptive capacity; digital inclusion; equitable participation; human-centered smart urbanism	Positions workforce readiness as a multidimensional resilience outcome and safeguards against reproducing digital-era inequalities; ensures that social equity remains a structural dimension of the framework	D5. Social Inclusion Mechanisms	Labor force participation of vulnerable groups; digital inclusion index; youth employment rate; gender employment gap; accessibility of training opportunities

Note: The five theoretical traditions are treated as complementary rather than competing. Together, they provide the conceptual triangulation upon which the Urban Workforce Readiness Framework (UWRF) operationalizes urban workforce readiness across technological, institutional, and human-centered dimensions. The proposed indicators are illustrative and serve as a basis for future empirical operationalization and validation of the framework. # denotes the sequential number of each entry.

3. Methodology

3.1. Research Design

This study adopts a conceptual framework development approach aimed at constructing an integrated model for assessing workforce readiness in smart cities under conditions of accelerating digital transformation. Unlike empirical studies that primarily seek to test causal relationships, conceptual research focuses on synthesizing existing knowledge, identifying theoretical gaps, and developing new analytical structures capable of advancing scholarly understanding and supporting policy practice [77].

The development of the Urban Workforce Readiness Framework (UWRF) follows a structured conceptualization process that combines theoretical integration with policy-oriented analysis. The methodological approach is grounded in the assumption that workforce readiness in smart cities represents a multidimensional phenomenon that cannot be adequately explained through a single theoretical perspective. Consequently, the framework is developed through the systematic integration of insights from five complementary research domains: smart city governance, data-driven public administration, labor market governance, human capital development, and workforce resilience.

The study therefore employs a qualitative research design based on structured literature synthesis and thematic policy analysis. This approach is consistent with established methodological practices for conceptual framework development in public administration, urban studies, and governance research and is particularly suitable for emerging interdisciplinary fields where theoretical integration remains limited [78,79].

3.2. Literature Selection and Review Procedure

The literature review process was conducted in a systematic and transparent manner to ensure conceptual rigor and analytical consistency. Peer-reviewed academic publications indexed in major scientific databases, including Scopus and Web of Science, were examined. The review focused primarily on studies published between 2015 and 2025 in order to capture recent developments associated with digital transformation, artificial intelligence, smart city governance, and the future of work.

The literature search employed combinations of keywords such as “smart city governance”, “data-driven governance”, “urban labor markets”, “labor market resilience”, “human capital development”, “workforce adaptability”, “digital transformation”, “future of work”, “algorithmic governance”, and “urban sustainability”. Additional studies were identified through backward and forward citation tracking of highly cited publications.

The inclusion criteria required publications to satisfy at least one of the following conditions: (i) provide theoretical contributions relevant to smart city governance; (ii) examine labor market adaptation to technological change; (iii) address workforce resilience or human capital development; (iv) investigate data-driven public administration; or (v) propose governance mechanisms applicable to urban transformation. Studies lacking a clear connection to workforce preparedness, urban governance, or digital transformation were excluded from the final analytical sample. Following the application of these inclusion criteria, a total of 115 academic and policy sources were retained for detailed review and analysis. The final sample included peer-reviewed journal articles, scholarly books and book chapters, as well as policy reports and strategic documents published by leading international organizations, including the OECD, ILO, European Commission, and World Bank. The objective was not only to ensure broad coverage of the relevant literature but also to identify recurring concepts, governance mechanisms, and workforce-related themes that could inform the development of an integrated framework for assessing urban workforce readiness.

3.3. Policy Document Analysis

To complement the academic literature, the study incorporates a thematic review of policy documents published by leading international organizations. These include reports, strategic frameworks, and analytical publications issued by the Organisation for Economic Co-operation and Development (OECD), the International Labour Organization (ILO), the European Commission, the World Bank, and other relevant institutions.

The inclusion of policy documents serves two purposes. First, it allows the framework to reflect contemporary policy priorities associated with digital labor markets, workforce development, and urban sustainability. Second, it strengthens the practical relevance of the proposed model by linking theoretical constructs with governance challenges encountered by policymakers and municipal authorities.

The policy analysis focused on recurring themes related to labor market intelligence systems, digital skills development, workforce resilience, inclusive employment, institutional capacity, and evidence-based governance. These themes were subsequently compared and integrated with findings derived from the academic literature.

3.4. Framework Development Process

The Urban Workforce Readiness Framework was developed through an iterative process of conceptual synthesis and thematic categorization. Initially, key concepts, variables, governance mechanisms, and workforce-related factors identified in the reviewed literature were extracted and systematically categorized according to their theoretical relevance. Subsequently, an iterative thematic coding process was employed to identify recurring patterns, relationships, and areas of conceptual convergence across the literature. Through multiple rounds of comparison and refinement, common themes associated with workforce preparedness in digitally transforming urban environments were identified and consolidated into broader analytical categories. To determine whether a theme should be retained as a standalone dimension in the final framework, three selection criteria were applied: (i) consistent theoretical support across more than one of the reviewed research streams; (ii) direct relevance to workforce preparedness under conditions of urban digital transformation; and (iii) applicability to city-level governance, policy intervention, and future empirical measurement. Potentially relevant factors that appeared only within a narrowly defined disciplinary perspective, lacked a direct relationship with workforce readiness, or could not be meaningfully assessed at the urban level were not retained as separate dimensions. Where appropriate, such factors were incorporated as indicators, subcomponents, or contextual influences within one of the five broader UWRF dimensions. This process resulted in the identification of five interrelated dimensions:

- Digital Infrastructure Capacity;
- Labor Market Intelligence and Analytics;
- Workforce Skills Adaptability;
- Institutional Governance Capacity;
- Social Inclusion Mechanisms.

The selection of these dimensions reflects the convergence of technological, institutional, analytical, and human-centered perspectives identified throughout the literature review. The dimensions are also conceptually interconnected. Digital Infrastructure Capacity provides the technological foundation for data collection, information exchange, and digital service delivery. Labor Market Intelligence and Analytics transform these data into actionable insights that support workforce planning and policy formulation. Workforce Skills Adaptability reflects the capacity of individuals and institutions to respond to the information generated by these systems. Institutional Governance Capacity functions as the coordinating mechanism that aligns stakeholders, policies, and resources across the

workforce ecosystem. Finally, Social Inclusion Mechanisms ensure that the benefits of workforce transformation are distributed equitably across different population groups. Thus, the framework should be understood as an integrated and mutually reinforcing system rather than a collection of independent dimensions.

Where competing or partially divergent perspectives were identified, an integrative synthesis approach was adopted. Rather than privileging a single theoretical tradition, the framework was designed to incorporate complementary insights from smart city governance, labor market studies, human capital theory, workforce resilience research, and data-driven public administration. Concepts that appeared consistently across multiple research streams were given greater analytical weight, while discipline-specific perspectives were incorporated where they contributed to a more comprehensive understanding of workforce readiness. This approach helped ensure that the framework reflected the multidimensional nature of workforce transformation while minimizing theoretical bias toward any single disciplinary perspective.

3.5. Analytical Logic of the UWRF

The analytical logic underlying the UWRF assumes that workforce readiness emerges from the interaction of technological capabilities, institutional arrangements, human capital resources, and social inclusion mechanisms. Rather than treating these elements as independent variables, the framework conceptualizes them as mutually reinforcing components of an adaptive urban governance system.

Accordingly, the UWRF is designed as a multidimensional assessment framework that may serve as a foundation for future empirical applications, comparative city-level analyses, indicator development, and multi-criteria evaluation models. To facilitate future empirical evaluation, each UWRF dimension can be linked to potential indicators and corresponding data sources. Digital Infrastructure Capacity may be assessed through broadband penetration, internet affordability, ICT investment, digital public service availability, and municipal information-system interoperability, using telecommunications statistics, municipal administrative records, open-data portals, and national statistical databases. Labor Market Intelligence and Analytics may be evaluated through the availability and maturity of labor market information systems, the coverage of real-time vacancy data, the frequency of workforce monitoring, predictive analytics capacity, and institutional data interoperability, drawing on public employment service records, online vacancy platforms, administrative databases, and municipal labor market observatories. Workforce Skills Adaptability may be assessed through digital skills proficiency, participation in lifelong learning, reskilling and upskilling rates, employer-sponsored training, and the alignment between education provision and labor demand, using labor force surveys, educational statistics, employer surveys, and training-provider records. Institutional Governance Capacity may be evaluated through interagency coordination mechanisms, stakeholder participation, policy responsiveness, implementation effectiveness, and regulatory adaptability, based on municipal policy documents, institutional surveys, administrative performance reports, and stakeholder assessments. Social Inclusion Mechanisms may be measured through the labor force participation of vulnerable groups, youth employment, gender employment gaps, digital inclusion, and equitable access to training and employment services, using disaggregated labor statistics, household surveys, social protection records, and program-level administrative data. These indicators and sources are illustrative rather than definitive and require context-sensitive refinement and empirical validation before comparative application. While the present study focuses on conceptual development, the framework is intentionally structured to facilitate subsequent operationalization and empirical validation across diverse urban contexts.

Figure 1 illustrates the overall architecture of the Urban Workforce Readiness Framework and the relationships among its five constitutive dimensions.

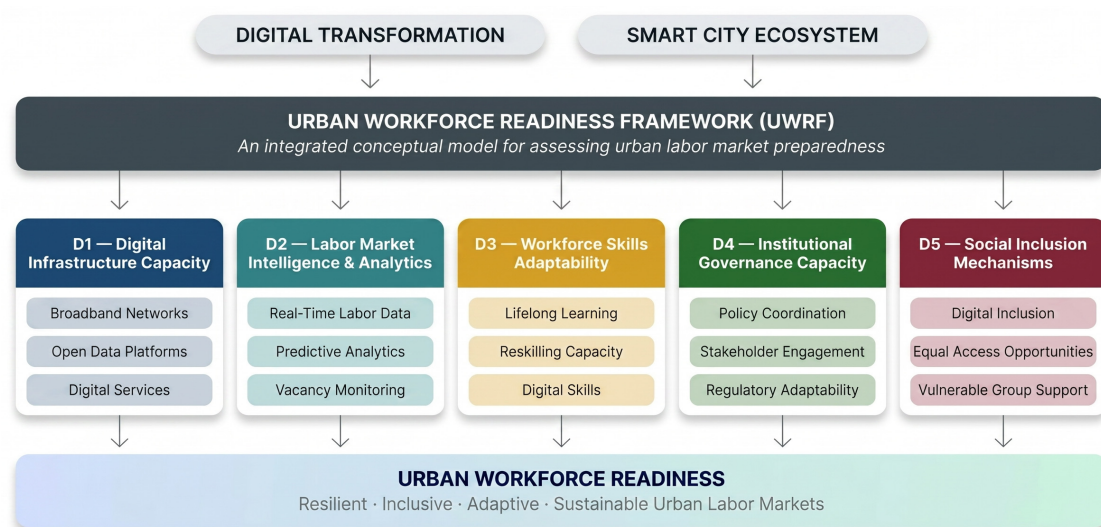


Figure 1. Urban Workforce Readiness Framework (UWRF).

4. Results: The Urban Workforce Readiness Framework (UWRF)

4.1. Conceptual Structure of the UWRF

The Urban Workforce Readiness Framework (UWRF) represents the principal outcome of this study. Developed through the synthesis of smart city governance, labor market regulation, human capital theory, workforce resilience, and data-driven public administration, the framework provides an integrated approach for assessing the preparedness of urban labor markets for digital transformation.

As illustrated in Figure 1, the framework conceptualizes workforce readiness as a multidimensional governance capacity emerging from the interaction of five interdependent dimensions: Digital Infrastructure Capacity, Labor Market Intelligence and Analytics, Workforce Skills Adaptability, Institutional Governance Capacity, and Social Inclusion Mechanisms. Together, these dimensions capture the technological, analytical, institutional, and human-centered foundations required for sustainable labor market adaptation in smart cities.

Unlike traditional labor market assessment approaches that focus primarily on employment outcomes, the UWRF emphasizes the enabling conditions that allow cities to anticipate labor market transitions, support workforce adaptation, and ensure inclusive participation in emerging economic opportunities. Consequently, workforce readiness is treated not as a static condition but as a dynamic governance capability shaped by continuous interactions among technological systems, public institutions, labor market actors, and human capital resources.

The five dimensions of the framework are discussed below.

4.2. Dimension 1: Digital Infrastructure Capacity

Digital Infrastructure Capacity constitutes the foundational dimension of the Urban Workforce Readiness Framework (UWRF). It refers to the technological and digital environment that enables cities to collect, process, exchange, and utilize information necessary for effective labor market governance. In the context of smart cities, digital infrastructure extends beyond physical connectivity and encompasses the institutional and technological systems that facilitate data-driven decision-making, public service delivery, and workforce development [77,78].

The importance of digital infrastructure has increased substantially as labor markets become increasingly dependent on digital technologies, online platforms, and data-intensive economic activities. Modern employment systems rely on broadband connectivity, cloud-based services, digital public administration platforms, labor market information systems, online recruitment channels, and digital learning environments [79]. Consequently, deficiencies in digital infrastructure may constrain the ability of cities to anticipate labor market changes, monitor workforce dynamics, and provide accessible employment-related services.

Within the UWRF, digital infrastructure is conceptualized as an enabling condition rather than an outcome. It does not directly determine labor market performance; instead, it provides the technological foundation upon which other dimensions of workforce readiness operate. Labor market intelligence systems cannot function effectively without reliable digital data infrastructures, while workforce reskilling initiatives increasingly depend on digital learning ecosystems and online training platforms. Similarly, institutional coordination and social inclusion policies require interoperable digital systems capable of connecting diverse stakeholders across urban governance networks.

The literature identifies several components that collectively determine digital infrastructure capacity. First, broadband connectivity remains a fundamental prerequisite for participation in the digital economy. Access to reliable and affordable internet services influences both individual employment opportunities and organizational productivity [80]. Second, digital public service platforms facilitate interaction between citizens, employers, educational institutions, and government agencies, reducing administrative barriers and improving service accessibility [81]. Third, open-data ecosystems enhance transparency and support evidence-based governance by enabling public institutions to share and utilize labor market information more effectively [82].

A further component involves the integration of smart city technologies and digital governance architectures. Sensor networks, cloud-based data management systems, artificial intelligence applications, and digital identity solutions increasingly contribute to urban management capabilities [83]. Although many of these technologies are traditionally associated with transportation, energy, and public service delivery, they also influence labor market governance by improving information availability, facilitating policy coordination, and enabling more responsive public administration.

From the perspective of workforce readiness, digital infrastructure performs three critical functions. First, it creates the technological conditions necessary for labor market intelligence and analytics. Second, it expands access to digital employment opportunities, training resources, and lifelong learning systems. Third, it reduces informational asymmetries between labor market actors by improving the availability and accessibility of employment-related information. Through these mechanisms, digital infrastructure contributes to the adaptability and resilience of urban labor markets under conditions of technological change.

The UWRF therefore treats Digital Infrastructure Capacity as the first and foundational dimension of workforce readiness. Cities characterized by robust digital infrastructures are better positioned to support evidence-based labor market governance, facilitate workforce adaptation, and promote inclusive participation in the digital economy. Conversely, weaknesses in digital infrastructure may generate systemic constraints that undermine the effectiveness of workforce development policies and limit the capacity of urban institutions to respond to emerging labor market challenges.

For analytical purposes, Digital Infrastructure Capacity may be assessed through indicators such as broadband penetration rates, digital public service availability, open-data platform maturity, interoperability of municipal information systems, and levels of ICT

investment. Collectively, these indicators provide insight into the technological readiness of cities to support data-driven labor market governance and workforce transformation.

4.3. Dimension 2: Labor Market Intelligence and Analytics

Labor Market Intelligence and Analytics represents the analytical core of the Urban Workforce Readiness Framework (UWRF). While digital infrastructure provides the technological foundation for data collection and information exchange, labor market intelligence transforms raw data into actionable knowledge capable of supporting strategic decision-making. In the context of smart cities, this dimension reflects the capacity of urban institutions to monitor labor market developments, identify emerging trends, forecast future workforce needs, and design evidence-based employment policies [84,85].

The growing complexity of urban labor markets has significantly increased the importance of labor market intelligence systems. Traditional labor market monitoring approaches, largely based on periodic surveys and administrative reporting, often struggle to capture the speed and scale of technological change. Digital transformation continuously reshapes occupational structures, skills requirements, employment relationships, and workforce mobility patterns. As a result, policymakers require more dynamic and predictive analytical tools capable of identifying labor market shifts before they become structural challenges [86].

Recent advances in big data analytics, machine learning, and artificial intelligence have expanded the possibilities of labor market intelligence. Online vacancy databases, digital employment platforms, educational records, social insurance systems, and real-time labor market information sources generate unprecedented volumes of workforce-related data [87]. When integrated effectively, these data sources enable governments and municipal authorities to identify emerging occupations, detect skills shortages, monitor workforce participation patterns, and forecast future labor market developments with greater precision.

Within the UWRF, labor market intelligence serves as the connecting mechanism between information and policy action. Its primary function is not merely descriptive but strategic. Effective labor market intelligence systems support the transition from reactive governance toward anticipatory governance by enabling policymakers to identify risks, opportunities, and workforce development priorities before labor market disruptions occur [88].

The literature identifies several core functions of labor market intelligence systems. First, they facilitate continuous monitoring of employment trends across sectors and demographic groups. Second, they support forecasting and scenario analysis concerning technological change, demographic transitions, migration flows, and economic restructuring. Third, they improve the targeting and effectiveness of active labor market policies, training programs, and workforce development initiatives. Fourth, they contribute to policy evaluation by generating evidence regarding the outcomes of labor market interventions [89,90].

A critical challenge concerns the transformation of data availability into institutional intelligence. Many cities possess significant volumes of labor market data but lack analytical capacity, interagency coordination, or governance mechanisms capable of converting information into strategic policy decisions. Consequently, labor market intelligence should be understood as an institutional capability rather than merely a technological resource [91].

From the perspective of workforce readiness, labor market intelligence contributes to resilience by reducing uncertainty and improving adaptive capacity. Cities capable of identifying future skills requirements, forecasting labor market disruptions, and responding proactively to emerging workforce challenges are more likely to achieve sustainable and inclusive labor market outcomes. Conversely, the absence of reliable intelligence systems

may increase policy fragmentation, delay institutional responses, and exacerbate labor market mismatches.

Within the UWRF, Labor Market Intelligence and Analytics is therefore conceptualized as the analytical engine of workforce readiness. It provides the information infrastructure necessary for evidence-based governance and enables the continuous alignment of workforce development policies with evolving labor market conditions. Potential indicators associated with this dimension include labor market information system maturity, frequency of labor market monitoring, predictive analytics capabilities, data interoperability across institutions, and utilization of labor market intelligence in policy formulation.

Table 3 summarizes the core functions of labor market intelligence systems and their contribution to evidence-based urban workforce governance.

Table 3. Core Functions of Labor Market Intelligence Systems in Smart Cities.

Function	Description	Governance Value
Monitoring	Continuous observation of labor market developments	Early identification of labor market imbalances
Forecasting	Prediction of future workforce demand and supply	Strategic workforce planning
Skills Intelligence	Identification of skills shortages and emerging competencies	Alignment of education and labor market systems
Policy Evaluation	Assessment of employment program effectiveness	Evidence-based policymaking
Scenario Analysis	Evaluation of alternative labor market futures	Increased institutional preparedness

Source: Developed by the authors based on the reviewed literature.

Figure 2 illustrates the proposed data-driven labor market intelligence cycle and its role in supporting evidence-based workforce governance.

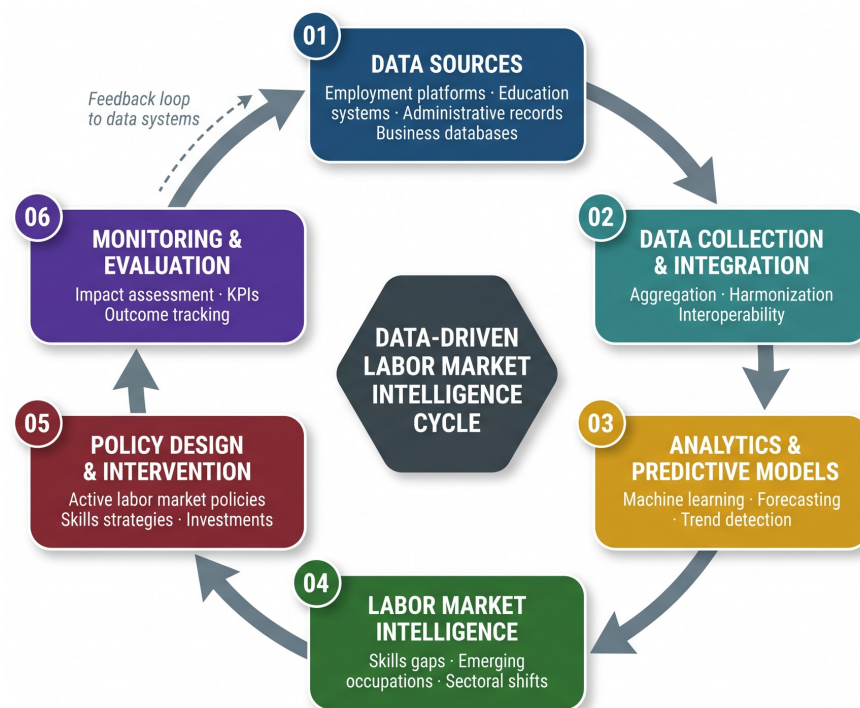


Figure 2. Data-Driven Labor Market Intelligence Cycle.

The framework conceptualizes urban labor market governance as a continuous six-stage cycle in which employment-related data are systematically transformed into strategic

policy interventions and, through evaluation and feedback, feed back into the data ecosystem. This closed-loop architecture enables municipal authorities to shift from reactive labor market management toward proactive, evidence-based, and adaptive governance in the smart city context.

4.4. Dimension 3: Workforce Skills Adaptability

Workforce Skills Adaptability represents the human capital dimension of the Urban Workforce Readiness Framework (UWRF). It reflects the capacity of individuals, organizations, and urban labor market systems to acquire, update, and apply competencies required in rapidly changing technological and economic environments. In the context of smart cities, workforce adaptability has become a critical determinant of sustainable development because technological progress generates value only when workers possess the skills necessary to participate effectively in emerging economic activities [92,93].

The acceleration of digital transformation has fundamentally altered the nature of workforce preparedness. Traditional models of human capital development were largely based on the assumption that formal education provided a stable foundation for long-term employment. However, the emergence of artificial intelligence, automation, digital platforms, and data-intensive business models has challenged this assumption. Skills acquired at the beginning of a career may become obsolete within relatively short periods, increasing the importance of lifelong learning and continuous reskilling [94].

Contemporary labor markets increasingly reward adaptability rather than static qualifications. Employers seek workers capable of learning new technologies, integrating interdisciplinary knowledge, solving complex problems, and responding to changing organizational requirements [95]. Consequently, workforce readiness must be understood not simply as the possession of skills but as the capacity to continuously acquire and renew them throughout an individual's professional life.

Human capital theory provides the principal theoretical foundation for this dimension. Classical contributions emphasize that investments in education and skills contribute directly to productivity and economic growth [96]. More recent research extends this perspective by highlighting the importance of digital competencies, technological literacy, creativity, critical thinking, and adaptive learning capabilities in knowledge-based economies [97]. These competencies are increasingly recognized as prerequisites for workforce resilience in technologically dynamic environments.

In smart cities, workforce adaptability is shaped by the interaction of multiple actors, including educational institutions, employers, public authorities, training providers, and workers themselves. Universities and vocational education systems play a crucial role in preparing future workers, while employers contribute through workplace learning and professional development initiatives. Municipal authorities, meanwhile, influence workforce adaptability through labor market policies, skills development programs, and strategic investments in educational infrastructure [98].

A recurring theme in the literature concerns the challenge of skills mismatch. Technological change often creates a gap between the competencies demanded by employers and those supplied by education and training systems [76]. Such mismatches can reduce productivity, increase structural unemployment, and slow the adoption of innovation. Effective workforce adaptability therefore requires mechanisms capable of continuously aligning educational outputs with labor market needs.

The digital economy further amplifies the importance of reskilling and upskilling initiatives. Reskilling involves the acquisition of new competencies that enable workers to transition into different occupations, while upskilling focuses on enhancing existing competencies to meet evolving job requirements [99]. Both processes contribute to labor

market resilience by reducing vulnerability to technological displacement and increasing opportunities for participation in emerging sectors.

Within the UWRF, Workforce Skills Adaptability is conceptualized as a strategic capability that enables workers and institutions to respond proactively to technological transformation. Rather than measuring educational attainment alone, this dimension captures the dynamic capacity of urban labor markets to generate, update, and mobilize relevant skills over time. Cities characterized by strong adaptability are better positioned to absorb technological shocks, support workforce mobility, and maintain economic competitiveness.

Potential indicators associated with this dimension include participation in lifelong learning programs, digital skills proficiency levels, workforce training rates, reskilling and upskilling participation, tertiary education attainment, and employer investment in workforce development. Collectively, these indicators provide insight into the adaptive capacity of urban labor markets and their readiness for future technological change.

The key components of workforce skills adaptability and their strategic importance are presented in Table 4.

Figure 3 illustrates the proposed workforce adaptation pathway in the digital economy and the progression of workforce capabilities in response to technological change.

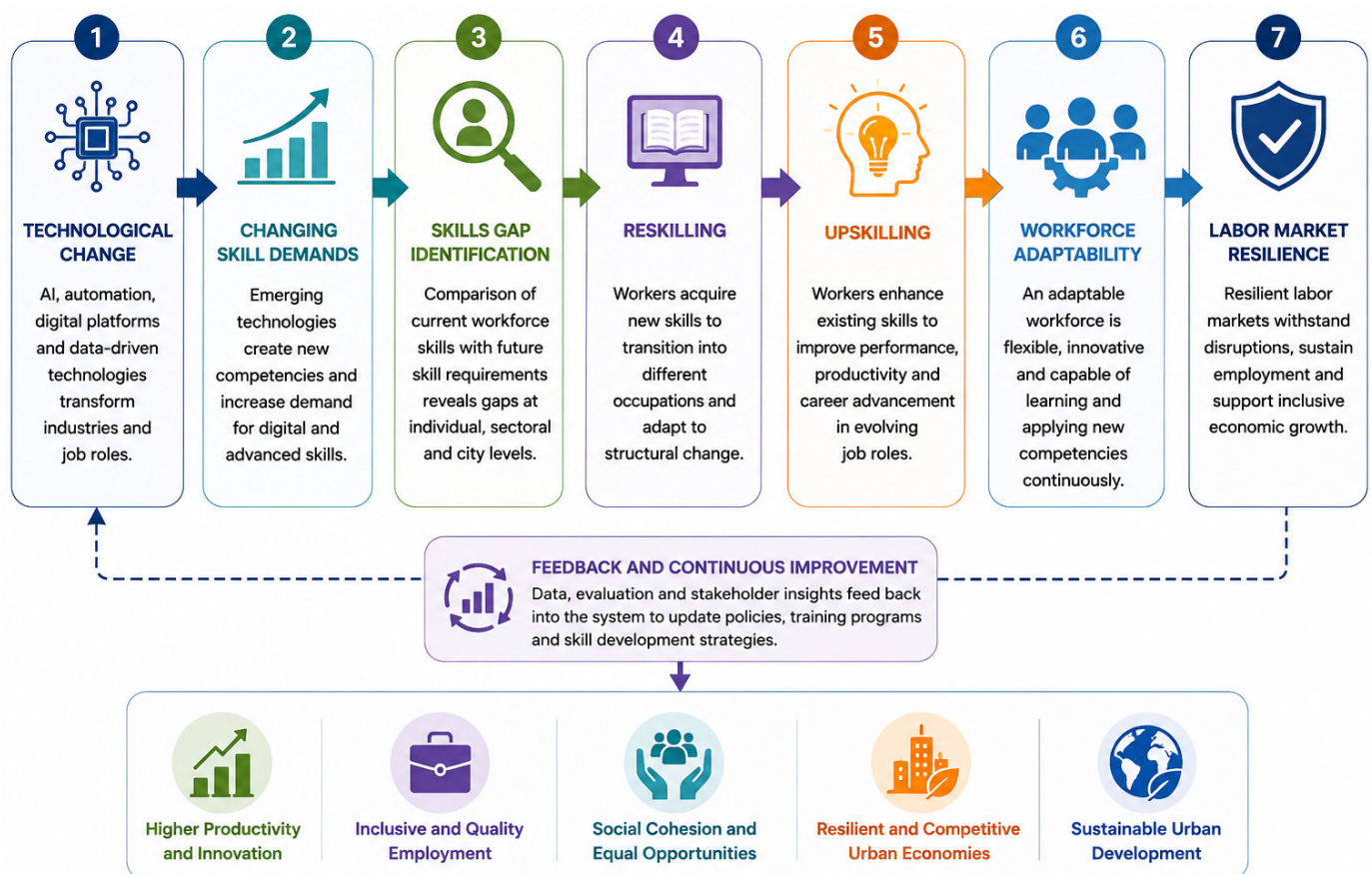


Figure 3. Workforce Adaptation Pathway in the Digital Economy.

Table 4. Components of Workforce Skills Adaptability.

Component	Description	Strategic Importance
Digital Skills	Ability to use digital technologies effectively	Foundation for participation in the digital economy

Table 4. *Cont.*

Component	Description	Strategic Importance
Lifelong Learning	Continuous acquisition of knowledge and competencies	Supports long-term employability
Reskilling Capacity	Ability to transition into new occupations	Reduces vulnerability to automation
Upskilling Capacity	Enhancement of existing competencies	Increases productivity and career mobility
Adaptive Learning	Ability to learn and apply new knowledge rapidly	Strengthens workforce resilience
Skills Alignment	Correspondence between labor demand and labor supply	Reduces structural mismatches

Source: Developed by the authors based on the reviewed literature.

4.5. Dimension 4: Institutional Governance Capacity

Institutional Governance Capacity represents the ability of urban institutions to design, coordinate, implement, and continuously adapt labor market policies in response to technological, economic, and social change. Within the Urban Workforce Readiness Framework (UWRF), this dimension serves as the principal governance mechanism through which information, resources, and policy instruments are transformed into workforce development outcomes [100,101].

The increasing complexity of contemporary labor markets has elevated the importance of institutional capacity as a determinant of workforce resilience. Rapid technological innovation, demographic transitions, platform-based employment, and evolving skills requirements create governance challenges that cannot be addressed solely through market mechanisms. Effective adaptation requires public institutions capable of coordinating stakeholders, aligning policy objectives, and responding proactively to emerging labor market developments [102].

The literature on governance emphasizes that institutional effectiveness depends not only on formal regulatory structures but also on organizational flexibility, administrative competence, interagency coordination, and stakeholder engagement [103]. In smart cities, governance systems increasingly operate within interconnected digital ecosystems involving municipal authorities, educational institutions, employers, workforce development agencies, labor organizations, and technology providers. Consequently, workforce readiness becomes a collective governance outcome rather than the responsibility of a single institution.

A key function of institutional governance capacity is strategic coordination. Labor market challenges frequently span multiple policy domains, including education, employment, economic development, innovation policy, social protection, and digital transformation. Fragmented governance structures often result in duplicated efforts, inconsistent policies, and inefficient resource allocation [104]. Strong institutional capacity therefore requires mechanisms that facilitate cooperation across organizational and sectoral boundaries.

Stakeholder engagement represents another critical component of workforce governance. Effective labor market adaptation depends on the participation of employers, educational institutions, workers, civil society organizations, and government agencies. Such collaboration improves information sharing, enhances policy legitimacy, and supports the alignment of workforce development initiatives with actual labor market needs [105].

Institutional adaptability is equally important. Digital transformation generates uncertainty regarding future skills requirements, employment structures, and occupational demand. Governance systems must therefore possess the capacity to revise policies, adjust programs, and respond rapidly to new information [106]. Cities characterized by adaptive

institutions are better positioned to anticipate labor market disruptions and implement timely interventions that support workforce resilience.

Within the UWRF, Institutional Governance Capacity is conceptualized as the coordinating dimension that connects technological infrastructure, labor market intelligence, workforce skills development, and social inclusion policies. Without effective governance mechanisms, investments in digital infrastructure or workforce training may fail to produce meaningful labor market outcomes. Institutional capacity therefore acts as the integrative force that aligns the framework's various dimensions into a coherent workforce readiness strategy.

Potential indicators associated with this dimension include policy coordination mechanisms, interagency collaboration capacity, stakeholder participation structures, responsiveness of labor market policies, regulatory adaptability, implementation effectiveness, and institutional innovation capability. Together, these indicators provide insight into the governance readiness of cities to manage workforce transformation in the digital era. The key components of institutional governance capacity are summarized in Table 5.

Figure 4 illustrates the institutional governance ecosystem that supports workforce readiness through coordinated interactions among key stakeholders and governance mechanisms.

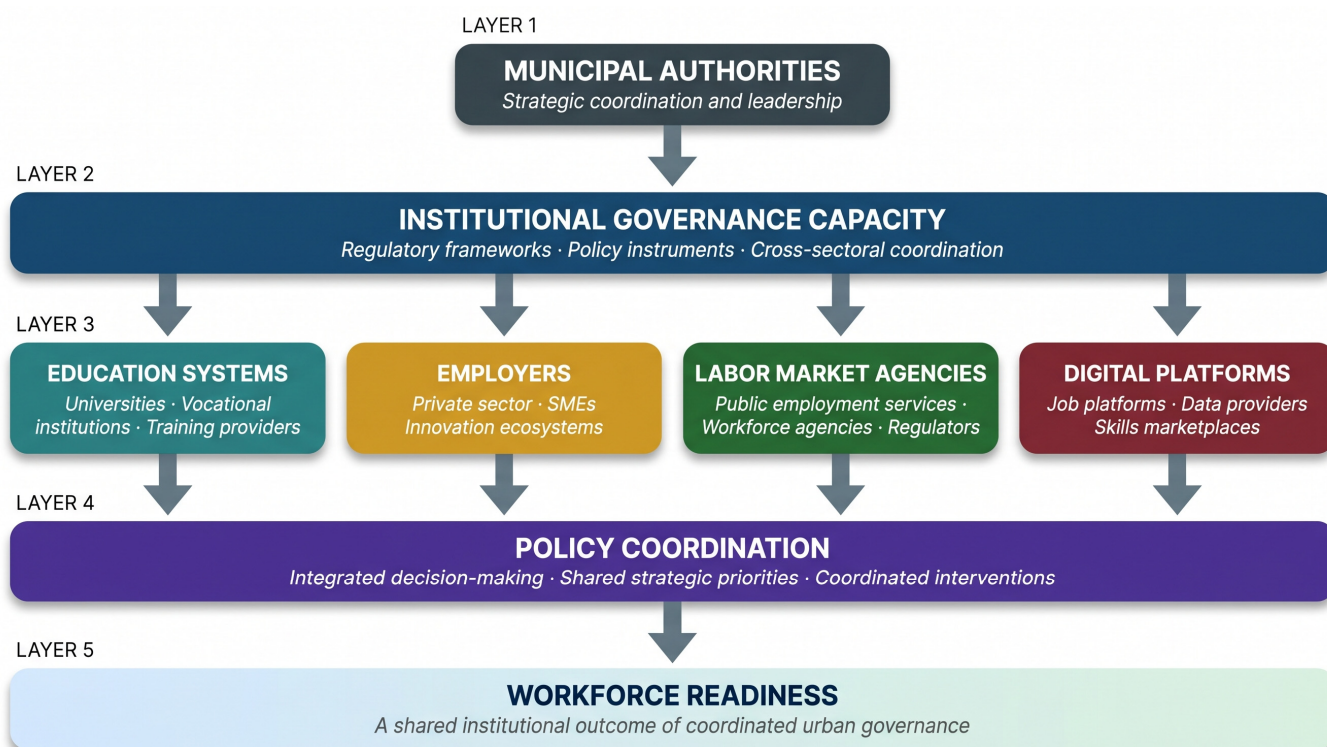


Figure 4. Institutional Governance Ecosystem for Workforce Readiness.

Table 5. Key Components of Institutional Governance Capacity.

Component	Description	Strategic Function
Policy Coordination	Alignment of workforce-related policies across sectors	Reduces fragmentation and improves policy coherence
Stakeholder Engagement	Participation of employers, educational institutions, workers, and public agencies	Enhances policy legitimacy and responsiveness
Regulatory Adaptability	Ability to revise regulations in response to technological change	Supports labor market flexibility

Table 5. *Cont.*

Component	Description	Strategic Function
Institutional Learning	Capacity to incorporate feedback and evidence into decision-making	Improves long-term governance performance
Implementation Effectiveness	Ability to translate policy objectives into measurable outcomes	Enhances workforce development results
Innovation Capacity	Institutional ability to experiment with new governance solutions	Supports adaptation to emerging challenges

Source: Developed by the authors based on the reviewed literature.

Municipal authorities orchestrate the institutional governance capacity that mobilizes four categories of urban stakeholders—education systems, employers, labor market agencies, and digital platforms—around a shared framework of policy coordination. Workforce readiness thereby emerges not as a sectoral output but as a systemic institutional outcome produced through coordinated multi-actor governance within the smart city context.

4.6. Dimension 5: Social Inclusion Mechanisms

Social Inclusion Mechanisms constitute the human-centered and equity-oriented dimension of the Urban Workforce Readiness Framework (UWRF). While digital infrastructure, labor market intelligence, workforce adaptability, and institutional governance collectively strengthen a city's capacity to manage labor market transformation, sustainable workforce readiness cannot be achieved unless the benefits of technological progress are distributed broadly across society. Consequently, social inclusion serves as a critical safeguard against the emergence of new forms of labor market inequality associated with digital transformation [107,108].

The literature on sustainable urban development increasingly emphasizes that technological innovation does not automatically generate inclusive outcomes. Although digitalization creates new employment opportunities and productivity gains, it may simultaneously produce unequal access to jobs, skills, information, and economic resources [109]. Certain population groups—including low-skilled workers, older individuals, migrants, persons with disabilities, women in underrepresented sectors, and economically disadvantaged communities—often face greater barriers to participation in the digital economy [110].

Within smart cities, these inequalities may become particularly visible. The concentration of technological innovation in urban centers often generates substantial economic opportunities while simultaneously increasing disparities in workforce participation and access to skills development. As a result, workforce readiness should not be evaluated solely in terms of aggregate economic performance but also through the extent to which all population groups are able to participate in and benefit from labor market transformation [111].

Social inclusion mechanisms therefore play a dual role within the UWRF. First, they enhance workforce participation by reducing structural barriers that limit access to education, training, employment services, and digital resources. Second, they contribute to labor market resilience by ensuring that workforce adaptation processes are socially sustainable and politically legitimate [112]. Inclusive labor markets are generally characterized by higher participation rates, stronger social cohesion, lower levels of exclusion, and greater capacity to absorb economic shocks.

Digital inclusion represents one of the most important components of this dimension. As employment opportunities, training programs, and labor market services become increasingly digitalized, unequal access to technology can generate new forms of exclusion. Digital inclusion policies seek to ensure that individuals possess both the technological resources and the competencies necessary to participate effectively in the digital econ-

omy [113]. These policies may include broadband accessibility initiatives, digital literacy programs, assistive technologies, and targeted support for vulnerable populations.

Another critical component concerns equitable access to workforce development opportunities. Lifelong learning, reskilling programs, vocational education, and digital skills initiatives are often concentrated among individuals who already possess relatively strong educational backgrounds. Without targeted intervention, workforce development policies may inadvertently reinforce existing inequalities [114]. Consequently, inclusive workforce governance requires mechanisms that ensure broad participation in learning opportunities across different demographic and socioeconomic groups.

The literature further highlights the importance of social cohesion as a strategic outcome of inclusive labor market governance. Rapid technological change can generate uncertainty, employment displacement, and perceptions of inequality. Inclusive governance mechanisms help mitigate these risks by strengthening trust, supporting social mobility, and promoting equitable participation in economic transformation [115]. In this sense, social inclusion is not merely a social policy objective but a fundamental component of long-term workforce resilience and urban sustainability.

Within the UWRF, Social Inclusion Mechanisms are conceptualized as the dimension that ensures workforce readiness remains aligned with broader objectives of sustainable and equitable urban development. By embedding inclusion directly within the framework rather than treating it as a secondary consideration, the UWRF recognizes that successful workforce transformation depends not only on technological and institutional capacity but also on the ability of cities to ensure that no groups are systematically excluded from emerging opportunities.

Potential indicators associated with this dimension include labor force participation among vulnerable groups, digital inclusion indices, gender employment equality measures, youth employment rates, accessibility of workforce development programs, and participation rates in reskilling initiatives across different demographic categories. Together, these indicators provide insight into the inclusiveness and social sustainability of urban workforce governance systems. The core components of social inclusion mechanisms are presented in Table 6.

Table 6. Core Components of Social Inclusion Mechanisms.

Component	Description	Strategic Contribution
Digital Inclusion	Access to digital technologies and competencies	Expands participation in the digital economy
Equal Opportunity Access	Fair access to employment and training opportunities	Reduces labor market inequality
Support for Vulnerable Groups	Targeted measures for disadvantaged populations	Strengthens social cohesion
Inclusive Skills Development	Broad participation in reskilling and upskilling programs	Enhances workforce adaptability
Gender and Youth Inclusion	Promotion of equitable workforce participation	Improves labor market diversity
Social Mobility Support	Mechanisms facilitating upward economic mobility	Increases long-term workforce resilience

Source: Developed by the authors based on the reviewed literature.

Figure 5 illustrates the social inclusion pathways that contribute to workforce readiness by promoting equitable participation in the labor market.

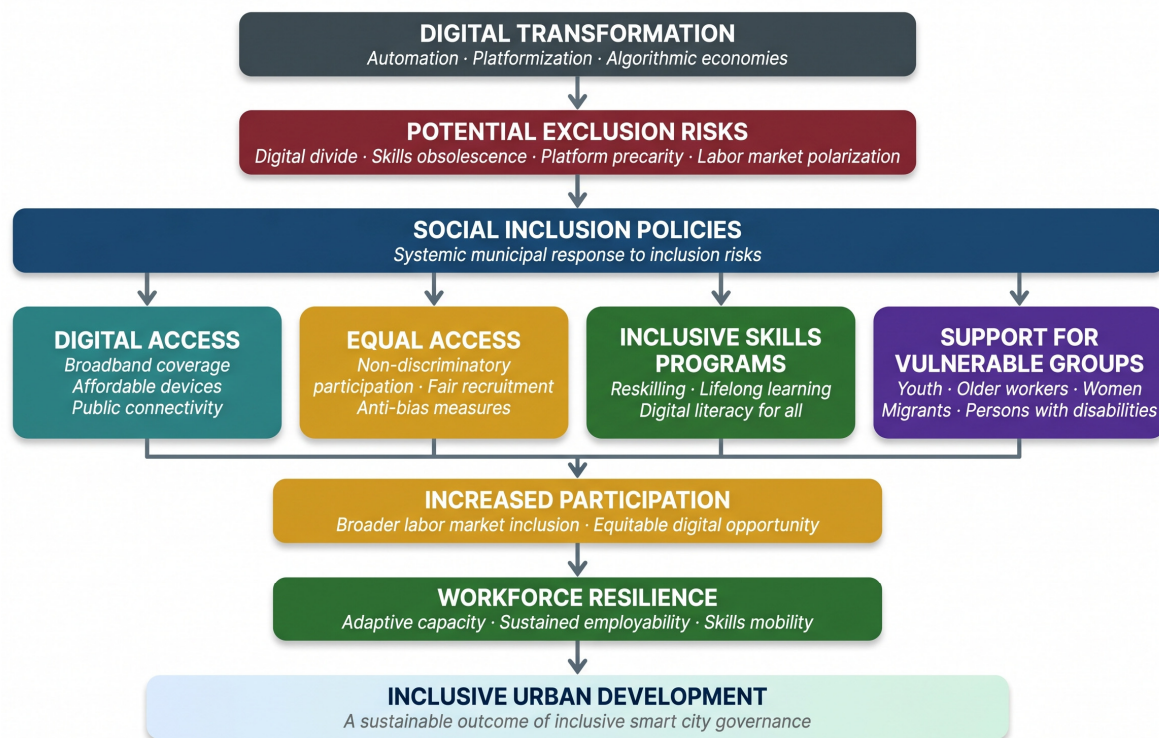


Figure 5. Social Inclusion Pathways in Workforce Readiness.

Social inclusion pathway toward inclusive urban development. Municipal social inclusion policies mediate exclusion risks through four interdependent pillars, producing increased participation, workforce resilience, and, ultimately, inclusive urban development.

In practical terms, social inclusion may be supported through a range of policy instruments, including subsidized digital skills training, targeted employment programs for vulnerable groups, community-based digital literacy initiatives, accessible e-government services, and public–private partnerships aimed at expanding access to digital technologies. International experience demonstrates the effectiveness of such measures. For example, Singapore’s Digital for Life initiative promotes digital literacy among older adults and disadvantaged groups, while Barcelona has implemented a variety of digital inclusion programs designed to improve access to digital services, training opportunities, and labor market participation among socially vulnerable populations. These examples illustrate how inclusion-oriented policies can strengthen workforce readiness while reducing the risk of exclusion associated with digital transformation.

At the same time, digital transformation may generate new forms of inequality that undermine workforce readiness. Algorithmic decision-making systems can unintentionally reproduce existing labor market biases, while unequal access to digital infrastructure, digital skills, and emerging technologies may widen socio-economic disparities. The persistence of digital divides across income groups, age cohorts, educational backgrounds, and geographic areas may limit participation in workforce development opportunities and reduce the effectiveness of digital labor market policies. Consequently, workforce readiness strategies should incorporate safeguards that promote transparency, fairness, accessibility, and equal opportunity within digitally enabled labor market systems.

4.7. Framework Integration and System Logic

The Urban Workforce Readiness Framework (UWRF) is based on the premise that workforce preparedness in smart cities emerges from the dynamic interaction of technological, analytical, institutional, and social capacities rather than from any single factor

operating independently. Accordingly, the framework conceptualizes workforce readiness as a systemic governance capability that reflects the ability of urban institutions, labor market actors, and citizens to anticipate, adapt to, and shape technological and economic transformation.

The integrated logic of the UWRF is illustrated through the interdependence of its five dimensions. Digital Infrastructure Capacity (D1) provides the technological foundation that enables the collection, transmission, and utilization of labor market information. Building upon this foundation, Labor Market Intelligence and Analytics (D2) transforms data into actionable knowledge, allowing policymakers and stakeholders to identify trends, forecast future workforce requirements, and support evidence-based decision-making.

Workforce Skills Adaptability (D3) represents the human capital response to these insights. Through lifelong learning, reskilling, and upskilling mechanisms, workers acquire the competencies necessary to participate effectively in evolving labor markets. However, neither digital infrastructure nor workforce adaptability alone is sufficient to ensure successful labor market transformation. Institutional Governance Capacity (D4) plays a coordinating role by aligning policies, stakeholders, and resources across different sectors and governance levels. It ensures that information generated through labor market intelligence is translated into coherent policy interventions and workforce development strategies.

Social Inclusion Mechanisms (D5) provide the normative and sustainability-oriented dimension of the framework. By promoting equitable access to employment opportunities, skills development programs, and digital resources, inclusion mechanisms ensure that workforce transformation benefits broad segments of society rather than a limited group of highly skilled individuals. In this way, social inclusion strengthens both the legitimacy and long-term resilience of labor market governance.

The interaction among these dimensions generates a cumulative effect that enhances overall workforce readiness. Weaknesses in any individual dimension may reduce the effectiveness of the entire system. For example, advanced labor market analytics may produce limited benefits in the absence of institutional capacity to act upon the resulting information. Similarly, investments in digital infrastructure may fail to generate meaningful outcomes if significant portions of the population remain excluded from workforce development opportunities. Consequently, workforce readiness should be understood as a multidimensional governance outcome requiring balanced development across all five dimensions.

From a policy perspective, the framework highlights the importance of integrated governance approaches that simultaneously address technological modernization, human capital development, institutional effectiveness, and social equity. Rather than viewing these objectives as separate policy domains, the UWRF demonstrates that they constitute mutually reinforcing components of sustainable urban labor market governance.

The framework therefore advances a holistic understanding of workforce preparedness in smart cities. It positions workforce readiness not merely as an employment policy objective but as a strategic capability that supports urban resilience, economic competitiveness, social cohesion, and sustainable development. By integrating technological, institutional, and human-centered perspectives within a single analytical structure, the UWRF provides a comprehensive basis for future empirical assessment and comparative evaluation of workforce governance across diverse urban contexts.

Compared with existing smart city maturity, digital government, and workforce readiness frameworks, the UWRF adopts a more explicitly workforce-centered perspective. Many established smart city assessment models primarily evaluate technological infrastructure, digital service delivery, sustainability, urban mobility, environmental performance, or institutional digitalization. Workforce-oriented approaches, in contrast, typically focus on

skills development, employability, and labor market adaptation without fully incorporating governance, data intelligence, and social inclusion dimensions. The UWRF integrates these traditionally separate perspectives into a single analytical architecture that links technological capacity, labor market intelligence, workforce adaptability, governance effectiveness, and inclusion mechanisms. Its distinctive contribution therefore lies not in introducing entirely new dimensions, but in systematically combining them around the specific challenge of urban workforce preparedness in the context of digital transformation. Table 7 compares the Urban Workforce Readiness Framework (UWRF) with existing workforce governance frameworks and highlights its distinctive conceptual contributions.

Table 7. Comparative Positioning of the UWRF.

Framework Type	Primary Focus	Limitation	UWRF Contribution
Smart City Maturity Models	Digital infrastructure, smart services, sustainability	Limited focus on workforce governance	Integrates labor market preparedness into smart city assessment
Digital Government Frameworks	Administrative digitalization and data use	Limited attention to workforce adaptation	Links data-driven governance with workforce transformation
Workforce Readiness Models	Skills development and employability	Limited integration with urban governance systems	Connects skills, governance, infrastructure, and inclusion
UWRF	Workforce preparedness for digital transformation	Requires future empirical validation	Provides integrated workforce governance architecture

Figure 6 presents the integrated logic of the Urban Workforce Readiness Framework (UWRF), illustrating the relationships among its core dimensions and governance processes.

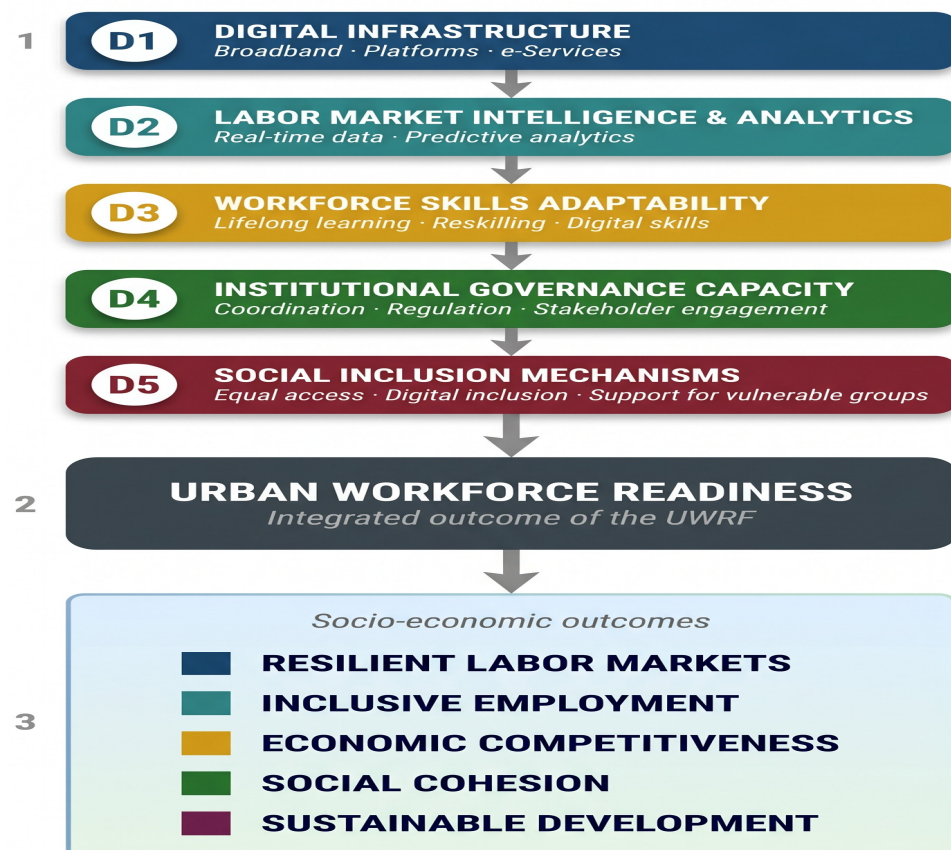


Figure 6. Integrated Logic of the Urban Workforce Readiness Framework (UWRF).

5. Discussion and Policy Implications

5.1. Theoretical Implications

The findings of this study contribute to the growing body of research at the intersection of smart city governance, labor market transformation, and data-driven public administration. While existing studies have generated substantial knowledge regarding digital infrastructure, urban innovation, workforce development, and employment policy, these domains have frequently been examined in isolation. The Urban Workforce Readiness Framework (UWRF) addresses this fragmentation by integrating technological, institutional, analytical, and social dimensions within a single conceptual architecture.

A primary theoretical contribution of the framework lies in its reconceptualization of workforce readiness as a governance capability rather than solely a labor market outcome. Traditional approaches often evaluate workforce preparedness through indicators such as employment rates, educational attainment, or labor force participation. Although these indicators remain important, they primarily measure the consequences of workforce development rather than the underlying capacities that enable cities to anticipate and manage labor market transformation. The UWRF shifts attention toward the enabling conditions that support adaptive and resilient workforce systems.

The framework also extends smart city scholarship by positioning labor market governance as a central component of urban sustainability. Existing smart city research has historically concentrated on technological infrastructure, digital services, mobility systems, and environmental management. Comparatively less attention has been devoted to workforce transformation and labor market adaptation, despite their growing importance in the context of digitalization and artificial intelligence. By explicitly incorporating workforce governance into the smart city agenda, the UWRF broadens the analytical scope of urban transformation research.

A further contribution concerns the integration of data-driven governance into labor market analysis. Previous studies have emphasized the role of big data, predictive analytics, and digital platforms in improving public administration. However, relatively few conceptual models have examined how these tools can support workforce planning, skills forecasting, and labor market resilience. The UWRF demonstrates that labor market intelligence should be understood not merely as a technical function but as a strategic governance capability that connects information systems with policy action.

The framework additionally contributes to human capital and workforce resilience literature by emphasizing the interaction between skills adaptability and institutional capacity. Workforce preparedness is often examined at the individual level through education, training, or competency development. The UWRF highlights that individual adaptability alone cannot ensure successful labor market transformation. Institutional coordination, policy responsiveness, and inclusive governance mechanisms are equally important determinants of workforce resilience in digitally transforming urban economies.

Finally, the framework advances a multidimensional understanding of workforce readiness by integrating social inclusion directly into its conceptual structure. Rather than treating inclusion as a secondary outcome of economic growth, the UWRF identifies equitable participation as a foundational component of sustainable workforce governance. This perspective aligns with contemporary discussions regarding human-centered smart cities and inclusive digital transformation.

5.2. Policy Implications

The practical significance of the UWRF lies in its potential to support evidence-based labor market governance in smart cities. As urban economies experience accelerating technological change, policymakers increasingly require tools capable of identifying work-

force vulnerabilities, anticipating future skills needs, and coordinating adaptive policy responses. The framework provides a structured approach for assessing these capacities and identifying areas requiring strategic intervention.

First, the framework highlights the importance of investing in digital infrastructure as a prerequisite for effective workforce governance. Reliable broadband networks, interoperable digital platforms, and open-data ecosystems create the technological foundation necessary for labor market intelligence and evidence-based decision-making. Cities that lack adequate digital infrastructure may face significant limitations in their ability to monitor workforce dynamics and deliver accessible employment-related services.

Second, the findings underscore the strategic value of labor market intelligence systems. Municipal authorities should strengthen their capacity to collect, integrate, and analyze workforce-related data from diverse sources, including employment platforms, educational institutions, business registries, and administrative databases. Such systems can support more accurate forecasting of labor demand, identification of skills shortages, and evaluation of workforce development programs.

Third, policymakers should prioritize lifelong learning, reskilling, and upskilling initiatives as central components of urban workforce strategies. Rapid technological change requires continuous adaptation rather than one-time educational investments. Consequently, workforce development policies should promote flexible learning pathways that enable workers to acquire new competencies throughout their careers. International experience demonstrates the practical relevance of this approach. Singapore's SkillsFuture initiative has become one of the most frequently cited examples of a national workforce adaptation strategy that combines lifelong learning, skills intelligence, employer engagement, and targeted reskilling programs. By continuously aligning training provision with evolving labor market demand, the initiative has strengthened workforce adaptability and supported the transition toward a knowledge-intensive digital economy.

Fourth, the framework emphasizes the necessity of institutional coordination. Workforce transformation spans multiple policy domains, including education, employment, economic development, innovation, and social protection. Effective governance therefore requires collaboration among municipal authorities, educational institutions, employers, labor market agencies, and civil society organizations. Cities characterized by fragmented governance structures may encounter difficulties in translating labor market intelligence into coherent policy interventions. A complementary example can be observed in Barcelona, where Barcelona Activa serves as an institutional platform connecting municipal authorities, employers, educational institutions, and workforce development initiatives. Through integrated employment services, digital skills programs, entrepreneurship support, and labor market intelligence activities, the city has strengthened its capacity to coordinate workforce transformation policies and respond more effectively to changing economic conditions.

Finally, the UWRF highlights the importance of inclusive workforce policies. Technological progress can generate substantial economic opportunities, but these benefits may be distributed unevenly across population groups. Policymakers should therefore ensure that workforce development initiatives are accessible to vulnerable and underrepresented groups, including low-skilled workers, women, youth, migrants, older workers, and persons with disabilities. Inclusive participation is essential not only for social equity but also for long-term labor market resilience and urban sustainability.

From an operational perspective, the UWRF may also serve as a comparative assessment instrument for evaluating workforce readiness across cities. Each of the five dimensions can be measured through a set of standardized indicators, such as broadband penetration and ICT investment for Digital Infrastructure Capacity, participation in lifelong learning and digital skills attainment for Workforce Skills Adaptability, or labor force par-

ticipation rates of vulnerable groups for Social Inclusion Mechanisms. By normalizing and aggregating such indicators into dimension-specific scores, cities could benchmark their performance, identify relative strengths and weaknesses, and prioritize policy interventions more effectively. While the present study does not prescribe a definitive measurement methodology, the proposed dimensions provide a foundation for future indicator development, weighting procedures, and comparative urban workforce readiness assessments.

Taken together, these implications suggest that successful workforce transformation requires an integrated governance approach that simultaneously addresses technological readiness, analytical capacity, skills development, institutional effectiveness, and social inclusion. The UWRF provides a strategic framework through which cities can evaluate these capacities and align workforce policies with broader objectives of sustainable urban development.

An important practical feature of the UWRF is its potential to support continuous feedback between workforce assessment and policy formation. Assessment results may help policymakers identify capacity gaps, prioritize strategic interventions, allocate resources more effectively, and monitor the outcomes of workforce development initiatives over time. Periodic reassessment of the framework's dimensions can generate updated evidence regarding changing workforce conditions, enabling institutions to revise policies, adjust training programs, and respond proactively to emerging labor market challenges. In this way, the UWRF can function not only as a diagnostic instrument but also as a mechanism supporting adaptive and evidence-based workforce governance.

6. Conclusions

The accelerating digital transformation of urban economies is fundamentally reshaping labor market structures, workforce requirements, and governance practices. Advances in artificial intelligence, automation, digital platforms, and data-driven decision-making are generating new opportunities for economic growth while simultaneously creating significant challenges related to workforce adaptability, skills development, institutional responsiveness, and social inclusion. These developments have intensified the need for governance frameworks capable of supporting labor market resilience and sustainable workforce transformation within smart city environments.

This study addressed this challenge by developing the Urban Workforce Readiness Framework (UWRF), a multidimensional conceptual model designed to assess the preparedness of urban labor markets for technology-driven economic change. Building upon insights from smart city governance, data-driven public administration, labor market governance, human capital development, and workforce resilience research, the framework integrates technological, analytical, institutional, and social perspectives within a single analytical structure.

The proposed framework conceptualizes workforce readiness as a governance capability rather than merely an employment outcome. In contrast to traditional approaches that focus primarily on labor market performance indicators, the UWRF emphasizes the underlying capacities that enable cities to anticipate, manage, and adapt to labor market transformation. This perspective recognizes that successful workforce development depends not only on the skills and competencies of individual workers but also on the broader institutional and technological environments within which labor market adaptation occurs.

The framework identifies five interrelated dimensions that collectively shape urban workforce readiness. Digital Infrastructure Capacity provides the technological foundation required for data collection, connectivity, and service delivery. Labor Market Intelligence and Analytics transform information into actionable knowledge that supports evidence-based policymaking. Workforce Skills Adaptability reflects the ability of workers and

institutions to acquire and renew competencies in response to changing labor market demands. Institutional Governance Capacity coordinates policies, stakeholders, and resources across multiple sectors. Social Inclusion Mechanisms ensure that the benefits of workforce transformation are distributed equitably and contribute to broader goals of social sustainability.

Taken together, these dimensions demonstrate that workforce readiness is not determined by any single factor but emerges from the interaction of technological systems, governance institutions, human capital resources, and inclusion policies. The framework therefore advances a systemic understanding of labor market preparedness and highlights the importance of integrated governance approaches in smart cities.

From a theoretical perspective, the study contributes to the literature in three important ways. First, it expands smart city research by positioning workforce governance as a central component of sustainable urban development. Second, it bridges previously disconnected research streams related to labor market governance, digital transformation, and data-driven public administration. Third, it introduces a multidimensional conceptualization of workforce readiness that incorporates technological, institutional, analytical, and social dimensions within a unified framework.

From a practical perspective, the UWRF offers policymakers, municipal authorities, labor market institutions, educational organizations, and urban planners a structured tool for evaluating workforce preparedness and identifying strategic priorities. The framework may support the design of labor market intelligence systems, workforce development programs, digital inclusion initiatives, and governance reforms aimed at enhancing urban resilience in the face of technological disruption.

Despite its contributions, the study is subject to several limitations. First, the framework remains conceptual and has not yet been empirically validated across specific urban contexts. Consequently, the relationships among the proposed dimensions and their influence on workforce readiness should be interpreted as theoretically grounded propositions rather than empirically verified causal relationships. Second, the proposed dimensions and indicators are derived primarily from the theoretical and policy-oriented literature and may require adaptation to local institutional conditions. Third, the framework does not currently specify standardized weighting coefficients or a composite workforce readiness index, as such elements require empirical testing and validation. Finally, the framework does not account for all contextual factors that may influence workforce readiness, including cultural, political, and macroeconomic variations across cities and regions.

These limitations create important opportunities for future research. Subsequent studies may empirically test the framework using comparative city-level data, develop composite indices for measuring workforce readiness, and apply multi-criteria decision-making techniques to evaluate the relative importance of individual dimensions. Future empirical applications could utilize internationally comparable datasets provided by organizations such as the OECD, ILO, World Bank, Eurostat, and national statistical agencies to operationalize the framework and conduct comparative assessments across different urban contexts. Such efforts would contribute to validating, refining, and strengthening the practical applicability of the UWRF. Future research may also explore regional differences in workforce preparedness, examine the relationship between workforce readiness and urban competitiveness, and investigate how emerging technologies such as generative artificial intelligence influence labor market governance.

In conclusion, the Urban Workforce Readiness Framework provides a comprehensive foundation for understanding and assessing workforce preparedness in smart cities. By integrating technological readiness, labor market intelligence, workforce adaptability, institutional capacity, and social inclusion within a single analytical architecture, the framework

contributes to a more holistic understanding of urban labor market transformation. As cities continue to navigate the opportunities and challenges of digitalization, the UWRF offers a promising foundation for both scholarly inquiry and evidence-based policymaking aimed at building resilient, inclusive, and sustainable urban labor markets.

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References

1. Vial, G. Understanding digital transformation: A review and a research agenda. *J. Strateg. Inf. Syst.* **2019**, *28*, 118–144. [[CrossRef](#)]
2. Mergel, I.; Edelmann, N.; Haug, N. Defining digital transformation: Results from expert interviews. *Gov. Inf. Q.* **2019**, *36*, 101385. [[CrossRef](#)]
3. Kankanhalli, A.; Charalabidis, Y.; Mellouli, S. IoT and AI for smart government: A research agenda. *Gov. Inf. Q.* **2019**, *36*, 304–309. [[CrossRef](#)]
4. Anthopoulos, L. *Smart City Emergence: Cases, Strategies and Perspectives*; Elsevier: London, UK, 2017.
5. Meijer, A.; Bolívar, M.P.R. Governing the smart city: A review of the literature on smart urban governance. *Int. Rev. Adm. Sci.* **2016**, *82*, 392–408. [[CrossRef](#)]
6. Cardullo, P.; Kitchin, R. Being a ‘citizen’ in the smart city: Up and down the scaffold of smart citizen participation in Dublin, Ireland. *Geojournal* **2019**, *84*, 1–13. [[CrossRef](#)]
7. UN-Habitat. *World Cities Report 2022: Envisaging the Future of Cities*; United Nations Human Settlements Programme: Nairobi, Kenya, 2022.
8. OECD. *OECD Urban Studies: The Metropolitan Century: Understanding Urbanisation and Its Consequences*; OECD Publishing: Paris, France, 2015. [[CrossRef](#)]
9. Autor, D.H. Why are there still so many jobs? The history and future of workplace automation. *J. Econ. Perspect.* **2015**, *29*, 3–30. [[CrossRef](#)]
10. Acemoglu, D.; Restrepo, P. Artificial intelligence, automation and work. In *The Economics of Artificial Intelligence: An Agenda*; Agrawal, A., Gans, J., Goldfarb, A., Eds.; University of Chicago Press: Chicago, IL, USA, 2019; pp. 197–236.
11. OECD. *Skills Outlook 2023: Skills for a Resilient Green and Digital Transition*; OECD Publishing: Paris, France, 2023.
12. European Commission. *Employment and Social Developments in Europe 2024*; Publications Office of the European Union: Luxembourg, 2024.
13. Florida, R. *The Rise of the Creative Class*, Revised ed.; Basic Books: New York, NY, USA, 2014.
14. Moretti, E. *The New Geography of Jobs*; Houghton Mifflin Harcourt: Boston, MA, USA, 2012.
15. Martin, R. Regional economic resilience, hysteresis and recessionary shocks. *J. Econ. Geogr.* **2012**, *12*, 1–32. [[CrossRef](#)]
16. Boschma, R. Towards an evolutionary perspective on regional resilience. *Reg. Stud.* **2015**, *49*, 733–751. [[CrossRef](#)]
17. Janssen, M.; van der Voort, H. Agile and adaptive governance in crisis response: Lessons from the COVID-19 pandemic. *Int. J. Inf. Manag.* **2020**, *55*, 102180. [[CrossRef](#)] [[PubMed](#)]

18. Janssen, M.; Estevez, E. Lean government and platform-based governance—Doing more with less. *Gov. Inf. Q.* **2013**, *30*, S1–S8. [\[CrossRef\]](#)
19. Kitchin, R. The real-time city? Big data and smart urbanism. *GeoJournal* **2014**, *79*, 1–14. [\[CrossRef\]](#)
20. Batty, M.; Axhausen, K.W.; Giannotti, F.; Pozdnoukhov, A.; Bazzani, A.; Wachowicz, M.; Ouzounis, G.; Portugali, Y. Smart cities of the future. *Eur. Phys. J. Spec. Top.* **2012**, *214*, 481–518. [\[CrossRef\]](#)
21. International Labour Organization (ILO). *World Employment and Social Outlook: Trends 2025*; ILO: Geneva, Switzerland, 2025.
22. European Commission. *Labour Market and Wage Developments in Europe 2024*; Publications Office of the European Union: Luxembourg, 2024.
23. Anthopoulos, L.G.; Reddick, C.G. Smart city and smart government: Synonymous or complementary? In Proceedings of the 25th International Conference Companion on World Wide Web (WWW '16 Companion), Montréal, QC, Canada, 11–15 April 2016; pp. 351–355. [\[CrossRef\]](#)
24. Gil-Garcia, J.R.; Dawes, S.S.; Pardo, T.A. Digital government and public management research: Finding the crossroads. *Public Manag. Rev.* **2018**, *20*, 633–646. [\[CrossRef\]](#)
25. Nam, T.; Pardo, T.A. Conceptualizing smart city with dimensions of technology, people, and institutions. In Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, College Park, MD, USA, 12–15 June 2011; pp. 282–291. [\[CrossRef\]](#)
26. Becker, G.S. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, 3rd ed.; University of Chicago Press: Chicago, IL, USA, 1993.
27. Schultz, T.W. Investment in human capital. *Am. Econ. Rev.* **1961**, *51*, 1–17.
28. Mincer, J. *Schooling, Experience, and Earnings*; Columbia University Press: New York, NY, USA, 1974.
29. OECD. *OECD Skills Strategy 2019: Skills to Shape a Better Future*; OECD Publishing: Paris, France, 2019. [\[CrossRef\]](#)
30. European Commission. *European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience*; COM(2020) 274 Final; European Commission: Brussels, Belgium, 2020.
31. World Bank. *World Development Report 2019: The Changing Nature of Work*; World Bank: Washington, DC, USA, 2019. [\[CrossRef\]](#)
32. International Labour Organization (ILO). *Global Employment Trends for Youth 2024*; ILO: Geneva, Switzerland, 2024.
33. Freeman, R.B. Labour market institutions without blinders: The debate over flexibility and labour market performance. *Int. Econ. J.* **2005**, *19*, 129–145. [\[CrossRef\]](#)
34. Betcherman, G. *Labor Market Institutions: A Review of the Literature*; World Bank Policy Research Working Paper 2012, No. 6276; World Bank: Washington, DC, USA, 2012. [\[CrossRef\]](#)
35. OECD. *OECD Employment Outlook 2024: The Net-Zero Transition and the Labour Market*; OECD Publishing: Paris, France, 2024. [\[CrossRef\]](#)
36. Acemoglu, D.; Autor, D. Skills, tasks and technologies: Implications for employment and earnings. In *Handbook of Labor Economics*; Ashenfelter, O., Card, D., Eds.; Elsevier: Amsterdam, The Netherlands, 2011; Volume 4B, pp. 1043–1171. [\[CrossRef\]](#)
37. Brynjolfsson, E.; McAfee, A. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*; W.W. Norton & Company: New York, NY, USA, 2014.
38. Frey, C.B.; Osborne, M.A. The future of employment: How susceptible are jobs to computerisation? *Technol. Forecast. Soc. Change* **2017**, *114*, 254–280. [\[CrossRef\]](#)
39. Arntz, M.; Gregory, T.; Zierahn, U. *The Risk of Automation for Jobs in OECD Countries*; OECD Social, Employment and Migration Working Papers 2016, No. 189; OECD Publishing: Paris, France, 2016. [\[CrossRef\]](#)
40. Manyika, J.; Lund, S.; Chui, M.; Bughin, J.; Woetzel, J.; Batra, P.; Ko, R.; Sanghvi, S. *Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation*; McKinsey Global Institute: New York, NY, USA, 2017.
41. Yigitcanlar, T.; Kamruzzaman, M.; Foth, M.; Sabatini-Marques, J.; da Costa, E.; Ioppolo, G. Can Cities Become Smart Without Being Sustainable? A Systematic Review of the Literature. *Sustain. Cities Soc.* **2019**, *45*, 348–365. [\[CrossRef\]](#)
42. OECD. *The Future of Work: OECD Employment Outlook 2023*; OECD Publishing: Paris, France, 2023.
43. Autor, D.; Salomons, A. Is automation labor-displacing? Productivity growth, employment, and the labor share. *Brook. Pap. Econ. Act.* **2018**, *2018*, 1–87. [\[CrossRef\]](#)
44. OECD. *Bridging Digital Divides in G20 Countries*; OECD Publishing: Paris, France, 2021. [\[CrossRef\]](#)
45. World Economic Forum. *Reskilling Revolution: Preparing 1 Billion People for Tomorrow's Economy*; WEF: Geneva, Switzerland, 2020.
46. Bessen, J. *AI and Jobs: The Role of Demand*; NBER Working Paper No. 24235; National Bureau of Economic Research: Cambridge, MA, USA, 2018. [\[CrossRef\]](#)
47. Susskind, D. *A World Without Work: Technology, Automation, and How We Should Respond*; Allen Lane: London, UK, 2020.
48. OECD. *Job Creation and Local Economic Development 2024*; OECD Publishing: Paris, France, 2024.
49. European Training Foundation. *Changing Skills for a Changing World*; ETF: Turin, Italy, 2022.
50. World Bank. *Digital Development Overview 2023: Expanding Opportunities in the Digital Economy*; World Bank: Washington, DC, USA, 2023.

51. Goos, M.; Manning, A.; Salomons, A. Job polarization in Europe. *Am. Econ. Rev.* **2009**, *99*, 58–63. [\[CrossRef\]](#)
52. Martin, R.; Sunley, P. On the notion of regional economic resilience: Conceptualization and explanation. *J. Econ. Geogr.* **2015**, *15*, 1–42. [\[CrossRef\]](#)
53. Simmie, J.; Martin, R. The economic resilience of regions: Towards an evolutionary approach. *Camb. J. Reg. Econ. Soc.* **2010**, *3*, 27–43. [\[CrossRef\]](#)
54. OECD. *OECD Skills Outlook 2021: Learning for Life*; OECD Publishing: Paris, France, 2021. [\[CrossRef\]](#)
55. Becker, G.S. Human capital and the economy. *Proc. Am. Philos. Soc.* **1992**, *136*, 85–92.
56. van Laar, E.; van Deursen, A.J.A.M.; van Dijk, J.A.G.M.; de Haan, J. The relation between 21st-century skills and digital skills: A systematic literature review. *Comput. Hum. Behav.* **2017**, *72*, 577–588. [\[CrossRef\]](#)
57. Redecker, C. *European Framework for the Digital Competence of Educators (DigCompEdu)*; Publications Office of the European Union: Luxembourg, 2017. [\[CrossRef\]](#)
58. OECD. *OECD Employment Outlook 2023: Artificial Intelligence and the Labour Market*; OECD Publishing: Paris, France, 2023. [\[CrossRef\]](#)
59. UNESCO. *Reimagining Our Futures Together: A New Social Contract for Education*; UNESCO: Paris, France, 2021.
60. Cedefop. *Skills Forecast 2025*; №41; European Centre for the Development of Vocational Training: Luxembourg, 2025.
61. OECD. *Getting Skills Right: Assessing and Anticipating Changing Skill Needs*; OECD Publishing: Paris, France, 2016. [\[CrossRef\]](#)
62. McGuinness, S.; Pouliakas, K.; Redmond, P. Skills mismatch: Concepts, measurement and policy approaches. *J. Econ. Surv.* **2018**, *32*, 985–1015. [\[CrossRef\]](#)
63. OECD. *Labour Market Intelligence: Building Better Labour Market Information Systems*; OECD Publishing: Paris, France, 2022.
64. International Labour Organization (ILO). *Labour Market Information Systems and Labour Market Analysis*; ILO: Geneva, Switzerland, 2021.
65. Kureková, L.M.; Beblavý, M.; Thum-Thysen, A. Using online vacancies and web surveys to analyse the labour market: A methodological inquiry. *IZA J. Labor Econ.* **2015**, *4*, 18. [\[CrossRef\]](#)
66. Engin, Z.; van Dijk, J.; Lan, T.; Longley, P.A.; Treleven, P.; Batty, M.; Penn, A. Data-Driven Urban Management: Mapping the Landscape. *J. Urban Manag.* **2020**, *9*, 140–150. [\[CrossRef\]](#)
67. OECD. *OECD Employment Outlook 2025: Can We Get Through the Demographic Crunch?* OECD Publishing: Paris, France, 2025. [\[CrossRef\]](#)
68. Zuiderwijk, A.; Chen, Y.C.; Salem, F. Implications of the use of artificial intelligence in public governance. *Gov. Inf. Q.* **2021**, *38*, 101577. [\[CrossRef\]](#)
69. Sun, T.Q.; Medaglia, R. Mapping the challenges of Artificial Intelligence in the public sector: Evidence from public healthcare. *Gov. Inf. Q.* **2019**, *36*, 368–383. [\[CrossRef\]](#)
70. Caragliu, A.; Del Bo, C.; Nijkamp, P. Smart cities in Europe. *J. Urban Technol.* **2011**, *18*, 65–82. [\[CrossRef\]](#)
71. Anthopoulos, L. *Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick?* Springer: Cham, Switzerland, 2017. [\[CrossRef\]](#)
72. Florida, R. *The New Urban Crisis*; Basic Books: New York, NY, USA, 2017.
73. Gil-Garcia, J.R.; Pardo, T.A.; Nam, T. What makes a city smart? Identifying core components and proposing an integrative framework. *Inf. Polity* **2015**, *20*, 61–87. [\[CrossRef\]](#)
74. Hollands, R.G. Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City* **2008**, *12*, 303–320. [\[CrossRef\]](#)
75. Cordella, A.; Tempini, N. E-government and organizational change: Reappraising the role of ICT and bureaucracy in public service delivery. *Gov. Inf. Q.* **2015**, *32*, 279–286. [\[CrossRef\]](#)
76. Ross, A.G.; McGregor, P.G.; Swales, J.K. Labour Market Dynamics in the Era of Technological Advancements: The System-Wide Impacts of Labour Augmenting Technological Change. *Technol. Soc.* **2024**, *77*, 102539. [\[CrossRef\]](#)
77. Jabareen, Y. Building a conceptual framework: Philosophy, definitions, and procedure. *Int. J. Qual. Methods* **2009**, *8*, 49–62. [\[CrossRef\]](#)
78. Torraco, R.J. Writing integrative literature reviews: Guidelines and examples. *Hum. Resour. Dev. Rev.* **2005**, *4*, 356–367. [\[CrossRef\]](#)
79. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [\[CrossRef\]](#)
80. World Bank. *Digital Progress and Trends Report 2023*; World Bank: Washington, DC, USA, 2024.
81. United Nations. *E-Government Survey 2024: Accelerating Digital Transformation for Sustainable Development*; United Nations: New York, NY, USA, 2024.
82. OECD. *Open Government Data Report: Enhancing Policy Maturity for Sustainable Impact*; OECD Publishing: Paris, France, 2023.
83. Bibri, S.E.; Krogstie, J. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustain. Cities Soc.* **2017**, *31*, 183–212. [\[CrossRef\]](#)
84. International Labour Organization (ILO). *Labour Market Information Systems: Maximizing the Potential of Labour Market Data and Analysis for Effective Policymaking*; ILO: Geneva, Switzerland, 2023.

85. Cedefop. *Skills Intelligence and Labour Market Information: Supporting Evidence-Based Policy Making*; European Centre for the Development of Vocational Training: Luxembourg, 2023.
86. World Economic Forum. *The Future of Jobs Report 2025*; World Economic Forum: Geneva, Switzerland, 2025. Available online: <https://www.weforum.org/publications/the-future-of-jobs-report-2025/> (accessed on 2 July 2026).
87. Deming, D.J.; Noray, K. Earnings dynamics, changing job skills, and STEM careers. *Q. J. Econ.* **2020**, *135*, 1965–2005. [\[CrossRef\]](#)
88. Torfing, J.; Ansell, C. Strengthening political leadership and policy innovation through the expansion of collaborative forms of governance. *Public Manag. Rev.* **2016**, *19*, 37–54. [\[CrossRef\]](#)
89. OECD. *OECD Employment Outlook 2022: Building Back More Inclusive Labour Markets*; OECD Publishing: Paris, France, 2022. [\[CrossRef\]](#)
90. de Paz, C.; Rutkowski, J.; Levin, V. *Labor Market Observatories: Critical Success Factors*; Jobs Group Note, No. 4; World Bank: Washington, DC, USA, 2018. Available online: <https://openknowledge.worldbank.org/handle/10986/29594> (accessed on 2 July 2026).
91. Mergel, I. Social Affordances of Agile Governance. *Public Adm. Rev.* **2024**, *84*, 932–947. [\[CrossRef\]](#)
92. van Laar, E.; van Deursen, A.J.A.M.; van Dijk, J.A.G.M.; de Haan, J. Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *Sage Open* **2020**, *10*, 2158244019900176. [\[CrossRef\]](#)
93. World Bank. *The Human Capital Index 2024 Update: Building Skills for Future Growth*; World Bank: Washington, DC, USA, 2024.
94. Liu, J.; Chen, K.; Lyu, W. Embracing artificial intelligence in the labour market: The case of statistics. *Humanit. Soc. Sci. Commun.* **2024**, *11*, 1112. [\[CrossRef\]](#)
95. Deming, D.J. The growing importance of social skills in the labor market. *Q. J. Econ.* **2017**, *132*, 1593–1640. [\[CrossRef\]](#)
96. Hanushek, E.A.; Woessmann, L. *The Knowledge Capital of Nations: Education and the Economics of Growth*; MIT Press: Cambridge, MA, USA, 2015.
97. Carretero, S.; Vuorikari, R.; Punie, Y. *DigComp 2.1: The Digital Competence Framework for Citizens with Eight Proficiency Levels and Examples of Use*; Publications Office of the European Union: Luxembourg, 2017. [\[CrossRef\]](#) [\[PubMed\]](#)
98. Wall, T.; Ngo, N.T.H.; Luong, P.M.; Ho, T.T.H.; Hindley, A. ‘Decent Work’ as a Higher Education Policy Myopia: An Ecosystem Framework for Policy-Making. *Stud. High. Educ.* **2024**, *49*, 2396–2410. [\[CrossRef\]](#)
99. Cordella, A.; Gualdi, F.; van de Laar, M. Digital Skills within the Public Sector: A Missing Link to Achieve the Sustainable Development Goals (SDGs). *Inf. Polity* **2024**, *29*, 1–18. [\[CrossRef\]](#)
100. Peters, B.G. *The Politics of Bureaucracy*, 7th ed.; Routledge: London, UK, 2018.
101. Osborne, S.P. *The New Public Governance? Emerging Perspectives on the Theory and Practice of Public Governance*; Routledge: London, UK, 2010.
102. OECD. *Public Governance Review 2023*; OECD Publishing: Paris, France, 2023.
103. Christensen, T.; Lægreid, P. *The Ashgate Research Companion to New Public Management*; Ashgate: Farnham, UK, 2011.
104. Bouckaert, G.; Peters, B.G.; Verhoest, K. *The Coordination of Public Sector Organizations*; Palgrave Macmillan: London, UK, 2010.
105. Ansell, C.; Gash, A. Collaborative governance in theory and practice. *J. Public Adm. Res. Theory* **2008**, *18*, 543–571. [\[CrossRef\]](#)
106. OECD. *Global Trends in Government Innovation 2024: Fostering Human-Centred Public Services*; OECD Publishing: Paris, France, 2024. [\[CrossRef\]](#)
107. United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*; United Nations: New York, NY, USA, 2015.
108. UNDP. *Human Development Report 2025: People and Possibilities in the Age of Artificial Intelligence*; United Nations Development Programme: New York, NY, USA, 2025.
109. World Bank. *World Development Report 2016: Digital Dividends*; World Bank: Washington, DC, USA, 2016. [\[CrossRef\]](#)
110. International Telecommunication Union (ITU). *Measuring Digital Development: Facts and Figures 2023*; ITU: Geneva, Switzerland, 2023.
111. OECD. *Making Cities Work for All: Data and Actions for Inclusive Growth*; OECD Publishing: Paris, France, 2016.
112. ILO. *World Social Protection Report 2024–26: Universal Social Protection for Climate Action and a Just Transition*; International Labour Organization: Geneva, Switzerland, 2024.
113. van Dijk, J. *The Digital Divide*; Polity Press: Cambridge, UK, 2020.
114. OECD. *Getting Skills Right: Future-Ready Adult Learning Systems*; OECD Publishing: Paris, France, 2019. [\[CrossRef\]](#)
115. Wilkinson, R.; Pickett, K. *The Spirit Level: Why More Equal Societies Almost Always Do Better*; Penguin Books: London, UK, 2010.

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