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Characteristics of the Labour Market and Innovations in the Digital Economy: Exploring Their Relationship in OECD Countries

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ABSTRACT

Objective: This paper examines the relationship between labour market characteristics and innovations in the OECD countries. Specifically, this study adopts a quantitative approach, primarily focused on employing correlation analysis to explore the relationship between labour market institutions, labour market outcomes, and indicators measuring innovations in the OECD countries.
Research Design & Methods: The study uses data from a diverse range of OECD countries to analyse the relationship between institutional frameworks, labour market outcomes and various dimensions of innovation. Through a correlation analysis of key indicators such as innovation and technological adoption rates, employment and participation patterns, and labour market institutions, the study highlights various ways in which labour markets respond to the demands of an increasingly digitised economy.
Findings: The results indicate that investments in information and communication technology in the OECD countries are positively associated with public spending on labour market policies.

Additionally, the empirical analysis indicates a positive relationship between people employed in high-skill occupations and indicators measuring innovation. In contrast, the relationship between people employed in low and medium-skill occupations and indicators measuring innovation was negative. Furthermore, stricter employment protection legislation is usually associated with lower values in indicators measuring innovation in the OECD countries. The results also indicate that the relationship between indicators measuring innovation and employment can vary across different sectors.
Implications/Recommendations: The findings underline the critical importance of institutional dynamics in fostering digital progress and provide essential insights for researchers, policymakers, and others interested in the labour markets in the digital age.
Contribution: The originality of the study lies in its extensive discussion of the impact of innovation and new technologies on labour markets in the digital economy, as well as its analysis of relationships between labour market outcomes, labour market institutions and indicators measuring innovation.

Article type: original article.

Keywords: digital economy, Industry 4.0, innovation, labour market, labour market institutions.

JEL Classification: J08, J88.

1. Introduction

The functioning of labour markets has consistently been a concern for OECD policymakers. It is also a central focus of the OECD Jobs Strategy (OECD, 2022). Therefore, labour market policy remains one of the most critical policy areas, and its significance has further increased during the COVID-19 pandemic (Costa Dias *et al*., 2020) because both employees and employers anticipated support from the state. Moreover, recent technological advances, often referred to as Industry 4.0 or the fourth industrial revolution, have led to many fundamental changes in the labour market. New technologies and innovations are reshaping labour markets, affecting labour supply and demand, wages, working conditions, and organisational structures. On one hand, these innovations can create job opportunities and new forms of work. On the other hand, they can lead to job displacement or even the replacement of human workers by automation and robots. Consequently, innovation in the economy may influence various labour market outcomes, including employment rates, labour force participation rates, and wage levels.

What is more, it is generally held that flexible labour markets can facilitate the rapid adjustment of employees to changes, including technological advancements. Additionally, they enable employees to respond quickly to technological changes. Therefore, in countries with more flexible labour markets, there may be a greater willingness to invest in innovation. Furthermore, labour market institutions that support training and education programmes can positively influence digitalisation by nurturing employees with relevant digital skills.

Thus, the study aims to assess the relationship between labour market characteristics and innovation in the OECD countries. More specifically, this study adopts a quantitative approach, primarily focused on employing correlation analysis to explore the relationship between labour market institutions, labour market outcomes, and indicators measuring innovations in the OECD countries. The empirical analysis was conducted for the period 2011–2021 and was based on the data collected from the OECD database.

This paper contributes to the debate on the labour market in the digital economy through an empirical analysis of the relationship between labour market characteristics and variables measuring innovation in the OECD countries. In particular, the originality of the study lies in its extensive discussion of the impact of innovation on labour markets in the digital economy, as well as its analysis of relationships between labour market outcomes, labour market institutions and indicators measuring innovation. Additionally, the study will assist labour market stakeholders, scholars, policymakers, and others in more efficiently addressing the challenges posed by the fourth industrial revolution.

The paper is organised as follows: The first section is the introduction. The second section discusses the impact of innovations on the labour market and approaches and indicators measuring innovation in the digital economy. The third section presents the methodology of the empirical research, while the fourth section provides the results of the empirical analysis, examining the relationship between labour market characteristics and variables measuring innovation in the OECD countries. Finally, the last section concludes the paper.

2. Innovations and the Labour Market in the Digital Economy: Approaches, Measures and Implications

The fourth industrial revolution, known as Industry 4.0[1], drives many significant changes in the economy. Specifically, innovations and new technologies influence many aspects of labour markets, such as working conditions, wages and work environment, creating both opportunities and challenges for employees and employers (Rotar, 2022). The digital transformation may have a positive impact on economic growth and labour markets through the implementation of innovative technologies and productivity improvements (Acemoglu & Restrepo, 2020). Innovations and new technologies also contribute to the creation of new jobs and increase competitive-

[1] Industry 4.0 is used to express the ongoing advances in the following fields, artificial intelligence, innovations, robotics, the Internet of Things, 3-D printing, autonomous vehicles, nanotechnology, biotechnology, energy storage, materials science, and quantum computing (Schwab, 2015).

ness (OECD, 2016). Existing studies also indicate that innovations will increase the demand for employees who perform innovative and creative tasks (Schroeder, Greef & Schreiter, 2017).

Conversely, innovations and new technologies can displace employees in some occupations, exacerbating existing labour market disparities, increasing inequality, and creating digital divides (OECD, 2016). One of the main challenges of the new labour market is also technological unemployment. Frey and Osborne (2017) indicate that approximately 47% of jobs in the USA are at risk of computerisation and automation in the next decade or two. Similarly, Arntz, Gregory and Zierahn (2016) estimate that 9% of jobs in 21 OECD countries can be automated. Additionally, Acemoglu and Restrepo (2020) state that industrial robots negatively impact wages, despite leading to higher productivity. Studies also indicate that routine tasks are most at risk of being replaced by machines and robots (Agolla, 2018).

What is more, labour market institutions will play an important role in shaping the benefits and addressing the challenges of these innovations and new technologies. The literature indicates that flexible labour markets positively influence labour market outcomes (Kryńska, 2004). Moreover, labour market regulations regarding part-time or temporary employees might impact how organisations engage with remote work, the gig economy and digital platforms (Braesemann *et al.*, 2022; Wojtkowiak, 2023). Additionally, the involvement of trade unions in negotiations regarding the use of innovations and new technologies in the workplace may lead to significant changes in labour markets, particularly in aspects such as remote work and data privacy (Pilc *et al.*, 2022). Therefore, labour market institutions that provide employees with relatively high benefits may allocate more funds for training to improve digital skills, consequently supporting them in adapting to new market requirements. However, results may vary depending on the influence of collective bargaining (Corrocher *et al.*, 2023).

The role of innovation in the labour market is significant and may result in both positive and negative impacts. However, how innovations and new technologies will shape the labour market in the digital economy is also determined by labour market institutions. Various approaches to measuring individual aspects of the digital economy have been presented so far. The demand for new indicators that measure the digital economy is particularly crucial due to the growing impact of new technologies and digitalisation on economies, especially their potential to transform labour markets. Measuring innovations and the digital economy primarily relies on creating rankings that incorporate indicators predominantly assessing the use of digital technologies across various economic sectors. These rankings are typically developed by international organisations, such as the European Union (EU), the Organisation for Economic Co-operation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD) etc. As early as 2004, the G20 Roadmap for Digitalisation and the G20 Toolkit for Measuring the Digital Economy were developed. These indicators can be used to monitor the digital transformation, identify critical gaps, and address challenges that G20 countries face. The G20 Toolkit for Measuring the Digital Economy focuses on different indicators, and includes the following sources: the Organisation for Economic Co-operation and Development, the International Labour Organization, the European Union, the World Bank, the United Nations Conference on Trade and Development, the International Monetary Fund, and the International Telecommunication Union (OECD, 2018).

Another approach was adopted by the European Commission, which has devised the Digital Economy and Society Index (DESI), which includes relevant indicators to assess the digital performance of EU countries and track their progress in digital competitiveness, along with the implementation of the Digital Single Market strategy. DESI encompasses four main policy areas, overall 32 indicators, including connectivity (such as mobile broadband and its characteristics), human capital, integration of digital technology and digital public services (European Commission, 2022a, 2022b). On the other hand, the United Nations Conference on Trade and Development, within the Working Group on Measuring E-Commerce and the Digital Economy, developed information economy indicators focused especially on information and communication technology (ICT) use in business and ICT trade (UNCTAD, 2024). Similarly, the OECD has been working on the measurement of innovations and the digital economy since the late 1990s. In 2017, the OECD initiated the Going Digital: Making the Transformation Work for Growth and Well-being project, aimed at understanding the digital transformation and implementing policies to foster a beneficial digital economy and society. This project includes the following areas: innovation, access, use, society, trust, jobs, and market openness (OECD, 2018, 2024d).

However, the main issue with particular rankings is that the indicators and measures used are not based on a precise definition of the digital economy and often employ different methodologies. The need for the development of a generally agreed-upon and actionable definition of the digital economy was expressed by the International Monetary Fund, which indicated that the lack of this definition is a hurdle to measuring the digital transformation of an economy (IMF, 2018). So far, the most progress in defining the digital economy has been made by the OECD which developed this definition on the basis of the survey among countries participating in the Digital Economy Task Force (DETF). According to the OECD, the digital economy is defined through the following tiers (OECD, 2020):

– the core measure of the digital economy covers activity from producers of ICT goods and information and ICT services,

– the narrow measure involves the core sector and economic activity of firms involved in and reliant on digital inputs,

– the broad measure includes both the core and narrow sectors, as well as economic activity of firms enhanced by the use of inputs.

Based on a framework including the core, narrow, and broad tiers of the digital economy, OECD developed the following definition, which was also adopted in this paper: the digital economy includes all economic activity reliant on, or significantly enhanced by the use of digital inputs, involving digital technologies, digital services, digital data and digital infrastructure. The main argument in favour of adopting this definition is the fact that this definition of the digital economy also encompasses the flexible approach developed by UNCTAD and the work of Bukht and Heeks (2017) and was recognized to be most useful to both economists and policy makers (OECD, 2020). Based on these implications and considering the geographical scope of this study, the empirical analysis used the OECDs' approach and measures in the area of innovation provided within the Going Digital Toolkit project[2].

Spending on research and development (R&D) is a key driver of digital innovation and a large share of the spending is contributed by the private sector (OECD, 2019). What is more, increasing national investment in research and development requires the combination of efforts of public and business sectors. In more developed countries, the business sector plays a crucial role in R&D work, by developing new products and business processes that develop existing knowledge and create new knowledge. Furthermore, sectors such as ICT equipment and information services emerge as particularly intensive in R&D efforts due to the fact that investment in information and communications technologies (ICTs) is a crucial condition for businesses to use digital technologies (OECD, 2018, 2024e). Based on these circumstances, the empirical analysis includes the following measures: ICT investment and business R&D expenditure in information industries (all these indicators are measured as a share of GDP).

Another innovation indicator in the digital economy is the share of start-up firms (up to 2 years old) in information industries as a share of all businesses. This indicator is relevant for several reasons. First of all, relatively young companies enhance productivity as resources flow from less efficient firms to smaller and more dynamic businesses. Secondly, start-up firms drive innovation because they play a significant role in commercialising new technologies. Finally, this indicator is also used as a measure of business dynamism (OECD, 2024g). What is more, access to finance for innovative and new businesses includes both debt and equity finance. An important source of equity funding, especially for young and technology-based firms, is venture capital (VC). Therefore, this analysis also includes venture capital

[2] The paper does not include the following areas of the Going Digital Toolkit project: access, use, society, trust, and jobs because of the fact that the digital society is a broader term than the digital economy and includes digitalised interactions not involved in the GDP production boundary (e.g. the use of free digital platforms) (OECD, 2020).

investment in the ICT sector, measured as a share of GDP. This indicator provides an indication of the venture capital support directed to young businesses in the ICT sector (OECD, 2024i).

Finally, patents, software and organisational capital, especially in information and communication technologies (ICT) are also factors which significantly promote and contribute to the development of digital innovations (OECD, 2024f). Competing globally in ICT markets requires technological and innovative developments and attractive designs, while enabling consumers to use the new products on offer. Patents are also important because they protect technological inventions, such as products or processes providing, e.g. new technological solutions to problems (OECD, 2018, 2020). Therefore, the analysis also includes patents, measured as a country's share in "tradic" patent families, which are sets of patents registered in different national patent offices to protect the same invention. Moreover, another one of the indicators used to measure innovations is the top 10% most-cited documents in computer science, measured as a share of the top 10% ranked documents in all fields, which informs us about OECD countries relative contribution to advancing the state of knowledge in innovation (OECD, 2020, 2024h).

3. Data and Methodology

This paper examines the relationship between labour market characteristics and innovations in the OECD countries. Specifically, this study adopts a quantitative approach, primarily focused on employing correlation analysis to explore the relationship between labour market institutions, labour market outcomes, and indicators measuring innovations in the OECD countries. The geographical scope of the research covers countries that belong to the Organisation for Economic Cooperation and Development. Firstly, based on the literature review, the following research questions were formulated:

RQ1: What is the role of labour market institutions in new, digital labour markets?

RQ2: To what extent do labour market institutions correlate with innovation in the OECD countries?

RQ3: To what degree and direction are labour market outcomes associated with innovation in the OECD countries?

Then, the following hypotheses were formulated:

H1: There is a positive relationship between indicators measuring innovation and active labour market policies in the OECD countries.

H2: A higher level of unionisation in the OECD countries is positively correlated with investments in R&D activities.

H3: In the OECD countries with more flexible labour markets, there is a greater willingness to invest in R&D.

H4: The occupations that are least at risk from automation and robotisation are those that are highly skilled.

H5: The relationship between indicators measuring innovation and employment vary across sectors in the OECD countries.

Secondly, a set of indicators that measure innovations, labour market institutions, and labour market outcomes were collected (Table 1). The primary sources of data were the data published by the OECD. The selection of indicators was based on the availability of statistical data and substantive considerations. This ensured the comparability of the collected data and the consistency of the analysis.

The analysis covers the period from 2011 to 2021. The starting point for the analysis is the year 2011 when Industry 4.0 strategic initiative was implemented by the German government and consequently, the term "Industry 4.0" was made public (Rojko, 2017). However, the study employed the most recent data to capture the latest relationships between labour market characteristics and indicators measuring innovation in the OECD countries.

Table 1. Description of the Used Variables

Variable	Description	Source
Labour market outcomes variables		
Employment by education level		
Empl_bel	Employment rate of people with education below the upper secondary level (% of persons aged 25–64)	OECD (2024c)
Empl_sec	Employment rate of people with upper secondary, non-tertiary education (% of persons aged 25–64)	
Empl_tert	Employment rate of people with tertiary education (% of persons aged 25–64)	
Employment by occupation		
Empl_low	People aged 15–64 and employed in low (level 1) skilled occupation (% of total employment)	ILOSTAT (2024)
Empl_med	People aged 15–64 and employed in medium (level 2) skilled occupation (% of total employment)	
Empl_high	People aged 15–64 and employed in high (level 3 and 4) skilled occupation (% of total employment)	
Employment by activity		
Empl_agr	Employment in agriculture (% of total employment)	OECD (2024b)
Empl_ind	Employment in construction (% of total employment)	
Empl_man	Employment in manufacturing (% of total employment)	
Empl_ser	Employment in services (% of total employment)	

Table 1 cnt'd

Variable	Description	Source
Labour market institutions variables		
LMP	Public spending on labour market (% of GDP)	OECD (2023)
ALMP	Public spending on active labour market (% of GDP)	
PLMP	Public spending on passive labour market (% of GDP)	
Training	Public spending on training (as a percentage of GDP)	
Strictness_r[a]	Strictness of employment protection – individual dismissals (regular contracts)	OECD.Stat (2023b)
Strictness_t	Strictness of employment protection – temporary contracts	OECD.Stat (2023c)
Union	Trade union density (as a percentage of employees)	OECD.Stat (2023d)
Innovations variables		
B_G_ICT	Business R&D expenditure information industries (ISIC 26 + 58 – 63) (% of GDP)	OECD (2024a)
ICT_invest	ICT investment (total; as a share of GDP)	OECD (2024e)
VC_invest	Venture capital investment in the ICT sector (as a share of GDP)	OECD (2024i)
Start-up	Share of start-up firms (up to 2 years old) in the business population (information industries (ISIC 26 + 58 – 63))	OECD (2024g)
S_patent	share of countries in "triadic" patent families	OECD.Stat (2023a)
Top_doc	Top 10% most-cited documents in computer science (as a share of the top 10% ranked documents in all fields)	OECD (2024h)

[a] According to the OECD's recommendations, version 3 of the indicator that measures employment protection was applied in the empirical analysis.

Source: the author.

In the third step, the descriptive statistics of the indicators were calculated (Table 2). The main statistical tool employed in this study was the correlation analysis that allows for an in-depth examination of the strength and nature of relationships between labour market characteristics and various dimensions of innovation. Subsequently, in the fourth step of the analysis, the correlation between labour market characteristics (labour market institutions and labour market outcomes) and indicators that measure innovations in the OECD countries was estimated. Finally, the results were discussed, and concluding remarks were presented.

4. Results

Table 2 presents the descriptive statistics of the analysed indicators, while Table 3 presents the matrix correlation of labour market policies and variables measuring innovations in the OECD countries. In the descriptive statistics, panel data from 2011 to 2021 for OECD countries was considered while in the correlation analysis, cross-sectional data in 2021 for OECD countries were considered. The data indicate that the OECD countries exhibited diversity in terms of labour market institutions and outcomes, as well as in terms of variables measuring innovations (Table 2).

Table 2. Descriptive Statistics of the Variables

Variable	Min	Q_1	Q_2	M	Q_3	Max	SD	Number of Countries	Number of Observations
Empl_bel	29.78	49.83	55.48	55.43	61.95	72.89	8.65	31	335
Empl_sec	54.07	70.93	74.30	74.73	79.91	86.61	5.84	31	335
Empl_tert	68.54	82.39	85.38	84.66	87.69	91.26	4.06	31	335
Empl_low	2.14	6.63	8.52	8.84	10.13	24.29	3.38	31	332
Empl_med	14.03	43.51	47.60	47.90	52.60	68.87	7.42	31	331
Empl_high	8.74	36.33	42.85	41.57	46.82	63.61	8.38	31	331
Empl_agr	0.76	1.84	3.09	4.70	4.90	40.12	6.36	31	336
Empl_ind	8.05	17.01	18.98	20.66	22.86	71.48	7.11	31	329
Empl_man	3.08	9.30	11.30	14.25	15.77	66.32	10.00	31	340
Empl_serv	46.19	58.37	66.14	63.94	70.87	87.81	8.98	31	325
LMP	0.24	0.66	1.18	1.47	2.15	4.8	0.97	31	335
ALMP	0.08	0.24	0.49	0.57	0.76	4.14	0.48	31	336
PLMP	0.12	0.37	0.62	0.89	1.35	3.36	0.67	31	336
Training	0.00	0.04	0.08	0.13	0.16	0.64	0.14	30	338
Strictness_r	0.09	1.64	2.33	2.15	2.55	4.13	0.73	25	276
Strictness_t	0.21	1.58	2.13	2.08	2.54	3.83	0.83	25	275
Union	4.50	13.20	17.85	26.12	32.55	69.60	18.46	21	237
B_G_ICT	0.01	0.13	0.26	0.40	0.39	2.71	0.48	32	279
ICT_invest	0.73	1.82	2.45	2.60	3.23	8.69	1.06	31	310
VC_invest	0.00	0.02	0.03	0.09	0.07	2.27	0.23	31	336
Start-up	8.50	24.8	30.2	30.10	35.05	60.3	8.46	29	248
S_patent	0.00	0.04	0.51	2.81	1.54	35.56	6.91	32	320
Top_doc	2.45	6.23	7.91	8.50	9.50	27.40	3.61	32	352

Notes: The table includes the values of selected indicators based on panel data from 2011 to 2021 for OECD countries.

Source: the author's calculations, based on the data collected from the sources listed in Table 1.

A positive and statistically significant relationship was observed between public spending on labour market policy (LMP, ALMP) and ICT investment (ICT_invest) (Table 3). Furthermore, a positive and statistically significant association was observed between public spending on training (Training) and the variable which measures the top 10% most-cited documents in computer science (Top_doc) which confirms the first hypothesis. As pointed out, investment in ICT and advances in scientific knowledge are key to developing new digital technologies. First, investments in ICT can enhance the effectiveness of public spending on labour market policies, by facilitating better data management or developing more effective labour market programmes. Second, investments in ICT can improve job matching (e.g. through use of special online job platforms) and the organisation of online training. Finally, states may invest in ICT to promote innovation and create new jobs in the digital economy. Furthermore, the results suggest that ICT investments create online training programmes, which are often provided and supported for employees to acquire new skills through public spending on labour market policies. What is more, increasing investments in ICT promotes digital skills, which are crucial in the new labour market of the digital economy.

Table 3. Matrix Correlation of Labour Market Policies and Innovations

Variable	LMP	ALMP	PLMP	Training	B_G_ ICT	ICT_ invest	VC_ invest	Start-up	S_patent	Top_ doc
LMP	1									
ALMP	0.68*	1								
PLMP	–0.34	–0.07	1							
Training	0.67*	0.61*	–0.18	1						
B_G_ICT	–0.08	–0.04	–0.09	0.04	1					
ICT_invest	0.15*	0.14*	0.11	0.05	0.16*	1				
VC_invest	–0.11*	–0.12*	–0.10	–0.09	0.69*	0.10	1			
Start-up	–0.17*	–0.005	–0.25*	–0.05	0.09	–0.14*	0.06	1		
S_patent	–0.21*	–0.15*	–0.19*	–0.17*	0.25*	0.18*	0.12*	–0.06	1	
Top_doc	–0.01	–0.03	0.01	0.16*	0.31*	–0.20*	0.19*	0.06	–0.08	1

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD (2023, 2024a, 2024e, 2024f, 2024g, 2024h, 2024i), OECD.Stat (2023a).

However, a negative relationship was observed between public spending on labour market policy (LMP and ALMP) and venture capital investment in the ICT (VC_invest), as well as between labour market policies (LMP, PLMP, ALMP, Training) and share of countries in "triadic" patent families (S_patent). This may be due to the fact that start-ups in the ICT sector often rely more on private financing and venture capital, which is consistent with the implications of international organisations working on this phenomenon (OECD, 2024i). High public spending on LMP may indicate more demanding market conditions or high unemployment rates, which could reduce the willingness to start new businesses, particularly in the ICT sector or to develop patents. Apart from these, LMP expenditure may focus on unemployment support programmes and training that are not directly related to promoting innovation. These results can be also related to market conditions, especially during periods of economic decline when states typically spend more on labour market policies. During such times venture investors may be less likely to invest in start-ups, particularly those in the ICT sector. Relatively high expenditure on the labour market can also be a signal of a more interventionist governmental approach, which can potentially lead to the crowding out of private investments.

Table 4. Matrix Correlation of Labour Market Institutions and Innovations

Variable	Strict-ness_t	Strict-ness_r	Union	B_G_ICT	ICT_invest	VC_invest	Start-up	S_patent	Top_doc
Strictness_t	1								
Strictness_r	0.52*	1							
Union	0.10	0.13	1						
B_G_ICT	–0.22*	–0.14*	0.15*	1					
ICT_invest	–0.31*	–0.08	0.03	0.16*	1				
VC_invest	–0.27*	–0.18*	–0.07	0.69*	0.10	1			
Start-up	0.14*	0.17*	–0.20*	0.09	–0.14*	0.06	1		
S_patent	–0.37*	–0.44*	–0.21*	0.25*	0.18*	0.12*	–0.06	1	
Top_doc	0.25*	–0.03	0.10	0.31*	–0.20*	0.19*	0.06	–0.08	1

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD.Stat (2023a, 2023b, 2023c, 2023d), OECD (2024a, 2024e, 2024f, 2024g, 2024h, 2024i).

Table 4 displays the matrix correlation of labour market institutions and variables measuring innovations in the OECD countries. The results indicate a positive relationship between trade union membership and business R&D expenditure in information industries (B_G_ICT), which partially supports the second hypothesis, while there are negative relationships between trade union density and both the share of start-up firms in the business population and the share of countries in "triadic" patent families. Generally, these results suggest that, in the digital economy, trade unions may intensify their efforts to ensure that employees have access to the training necessary to keep up with technological advancements. In this new working environment, the involvement of trade unions may influence negotiations related to new technologies and innovation, ensuring that adopted changes are beneficial for employees (e.g. Pilc *et al*., 2022). Generally, the activities of trade unions may exert pressure on the state and organisations to create an innovative working environment, resulting in increased spending on R&D in economies.

On the other hand, the negative relationship between trade union density and the share of start-up firms in the business population, as well as the share of countries in "triadic" patent families may be related to the fact that start-ups are usually involved in high levels of innovation (including patents) and therefore typically require a more flexible labour force to quickly adapt to the demands of the digital economy. Thus, high union density may impose various constraints on hiring practices, reducing the flexibility needed in the digital economy and the new world of work. Stricter employment protection legislation (for both regular and temporary contracts) is usually associated with lower values in indicators measuring innovations in the OECD countries, which partially supports the third hypothesis (Fig. 1–3). However, in the case of start-up firms, this relationship indicates that strict employment protection may create an environment that is supportive of new business activities in some cases. This relationship needs further research, but it can be supposed that labour market stability resulting from strict employment protection encourages employers to start businesses because they feel more secure in a changing labour market. Additionally, as previously mentioned, the impact of innovation and new technologies on the labour market is considered complex, and as a result, outcomes might also vary depending on factors such as e.g. collective bargaining in wage determination (Corrocher *et al*., 2023).

Finally, Table 5 presents the matrix correlation of labour market outcomes, including the employment rate of people with education below the upper secondary level, with upper secondary, non-tertiary education and with tertiary education, people aged 15–64 and employed in low (level 1), medium (level 2) and high (level 3 and 4) skilled occupations, as well as employment in agriculture, construction, manufacturing and services, along with variables measuring innovations in the OECD countries.

Regarding employment by education level, the findings show a positive relationship between almost all indicators measuring innovation in OECD countries and the employment rate of people with varying levels of education (Table 5, Fig. 4–5). First of all, expenditure on R&D, ICT investment, etc., can lead to the creation of new jobs and positions. This job creation is not limited to high-skill occupations but also involves opportunities for individuals with mid-level or even lower educational levels. Additionally, businesses operating in sectors focused on innovation and new technologies can stimulate growth in other sectors, resulting in new job opportunities for people with different educational qualifications.

Table 5. Matrix Correlation of Labour Market Outcomes and Innovations

Variable	Empl_ bel	Empl_ sec	Empl_ tert	Empl_ low	Empl_ med	Empl_ high	Empl_ agr	Empl_ ind	Empl_ man	Empl_ serv
Empl_bel	1									
Empl_sec	0.60*	1								
Empl_tert	0.30*	0.72*	1							
Empl_low	0.12*	–0.29*	–0.34*	1						
Empl_med	–0.28*	–0.29*	–0.40*	0.20*	1					
Empl_high	0.45*	0.41*	0.52*	–0.43*	–0.71*	1				
Empl_agr	–0.03	–0.29*	–0.06	0.30*	0.18*	–0.25*	1			
Empl_ind	–0.22*	0.02	0.06	–0.02	0.03	–0.11*	0.14*	1		
Empl_man	–0.12*	–0.08	0.09	0.17*	0.06	–0.15*	0.86*	0.87*	1	
Empl_serv	0.47*	0.10	0.06	-0.04	–0.60*	0.63*	–0.41*	–0.95*	–0.94*	1
B_G_ICT	0.15*	–0.01	–0.08	–0.09	–0.23*	0.22*	–0.24*	–0.24*	–0.18*	0.26*
ICT_invest	0.39*	0.47*	0.24*	–0.15*	-0.06	0.18*	–0.26*	–0.21*	–0.21*	0.22*
VC_invest	–0.06	–0.09	0.03	–0.16*	–0.28*	0.23*	–0.16*	–0.19*	–0.14*	0.30*
Start-up	0.09	–0.02	0.06	0.09	0.01	–0.09	0.25*	0.07	0.17*	–0.13*
S_patent	0.09	–0.08	–0.12*	0.08	0.28*	–0.26*	–0.18*	–0.15*	–0.13*	0.24*
Top_doc	0.02	–0.25*	–0.17*	–0.18*	–0.28*	0.32*	–0.09	0.11*	–0.09	0.28*

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on: ILOSTAT (2024), OECD (2023a, 2024a, 2024b, 2024c, 2024e, 2024f, 2024g, 2024h, 2024i), OECD.Stat (2023a).

The results also indicate a positive relationship between people employed in high-skill occupations (levels 3 and 4) and indicators measuring innovation (Fig. 6). On the other hand, the relationship between people employed in low and medium-skill occupations (levels 1 and 2, respectively) and indicators measuring innovation was negative. This implies that high-skilled employees usually benefit from technological changes because their skills can be used or transformed into other jobs, and they are more likely to complement new technologies. In contrast, low-skilled employees usually need to reskill because their jobs are more likely to be automated, and routine tasks are more susceptible to being replaced by robots or automation (e.g. the study by Frey & Osborne, 2017; Schroeder, Greef & Schreiter, 2017; Agolla, 2018). These results support the fourth hypothesis that the occupations that are least at risk from automation and robotisation are those that require high skill levels. Therefore, adequate social protection is crucial to enable a successful transition for all, particularly through training courses (OECD, 2019).

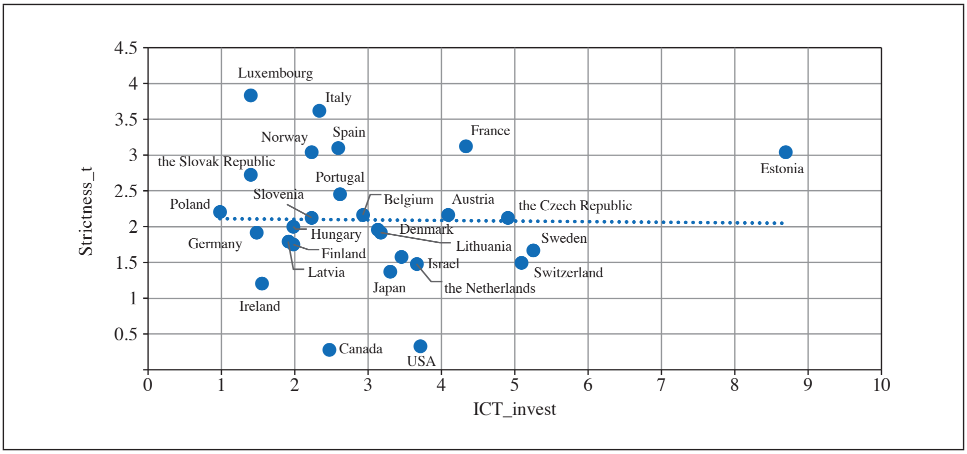

Fig. 1. Correlations between Strictness_t and ICT_invest (–0.31*)

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The values of correlation and their significance were shown in parentheses. The figure shows the results for 32 OECD countries in 2021 (due to insufficient data the United Kingdom was excluded). Due to limitations in the size of the article, the figure is limited to presenting relatively strong correlations, i.e. > |0.3|. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD.Stat (2023a, 2023b, 2023c), OECD (2024e).

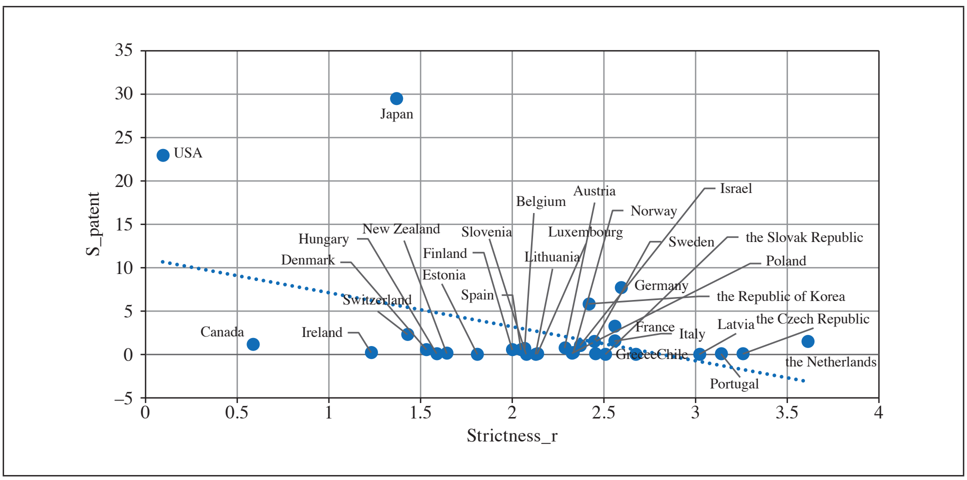

Fig. 2. Correlations between S_patent and Strictness_r (–0.44*)

Notes: the same as for Figure 1.

Source: the author's calculations, based on OECD.Stat (2023a, 2023b, 2023c), OECD (2024e).

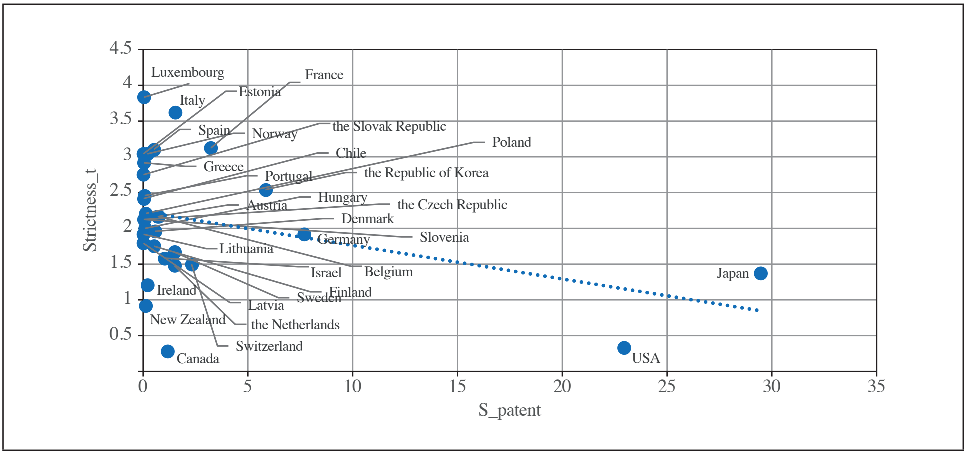

Fig. 3. Correlations between Strictness_t and S_patent (–0.37*)

Notes: the same as for Figure 1.

Source: the author's calculations, based on OECD.Stat (2023a, 2023b, 2023c), OECD (2024e).

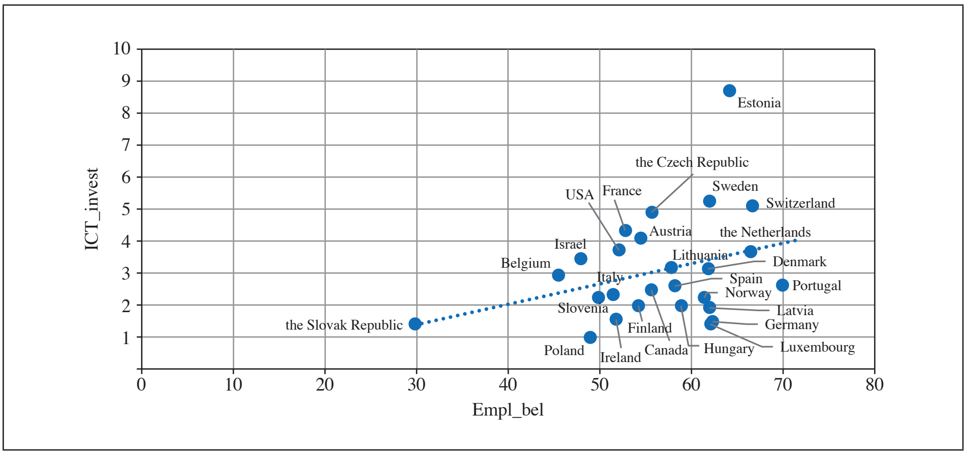

Fig. 4. Correlations between ICT_invest and Empl_bel (0.39*)

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The values of correlation and their significance were shown in parentheses. The figure shows the results for 28 OECD countries in 2021 (due to insufficient data the following countries were excluded: Chile, Greece, New Zealand, the Republic of Korea, the United Kingdom). Due to limitations in the size of the article, the figure is limited to presenting relatively strong correlations, i.e. > |0.3|. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD.Stat (2023a, 2023b, 2023c), OECD (2024e).

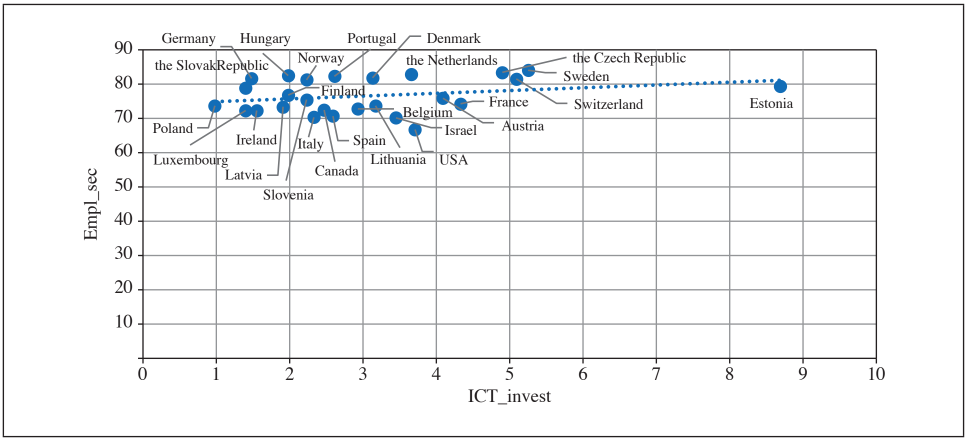

Fig. 5. Correlations between Empl_sec and ICT_invest (0.47*)

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The values of correlation and their significance were shown in parentheses. The figure shows the results for 28 OECD countries in 2021 (due to insufficient data the following countries were excluded: Australia, Chile, Colombia, Costa Rica, Iceland, Mexico, Turkey, Greece, New Zealand, the Republic of Korea, the United Kingdom). Due to limitations in the size of the article, the figure is limited to presenting relatively strong correlations, i.e. > |0.3|. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD (2024c, 2024e).

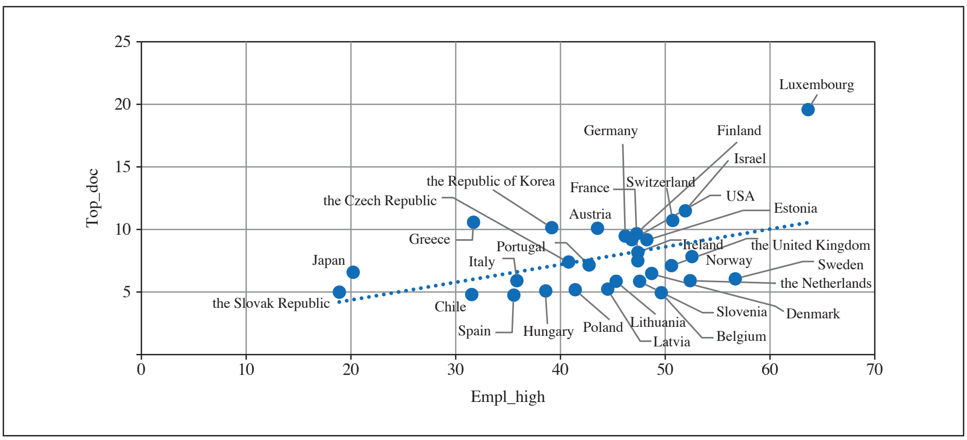

Fig. 6. Correlations between Top_doc and Empl_high (0.32*)

Notes: ***, **, * means statistically significant at 1%, 5%, 10%, respectively. The values of correlation and their significance were shown in parentheses. The figure presents the results for 31 OECD countries in 2021 (due to insufficient data the following countries were excluded: Australia, Canada, Colombia, Costa Rica, Iceland, Mexico, Turkey, New Zealand). Due to limitations in the size of the article, the figure is limited to presenting relatively strong correlations, i.e. > |0.3|. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD (2024c, 2024e).

Additionally, the results regarding employment by education level and employment in differently skilled occupations suggest that the work performed is not always related to one's education (especially higher education). This also means that individuals often work in jobs that are inconsistent with their education or even below their qualifications.

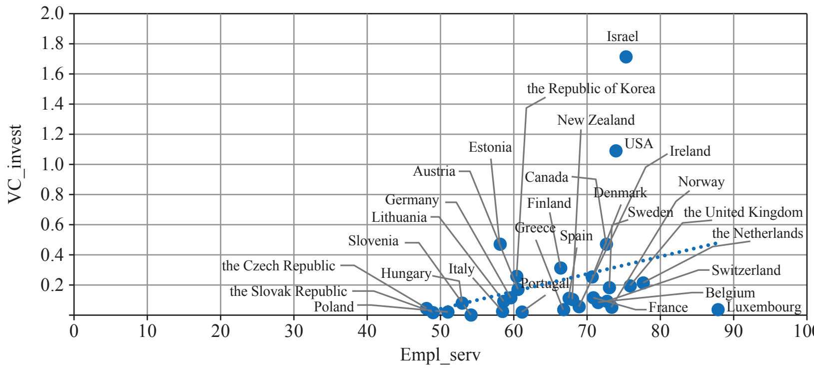

Fig. 7. Correlations between VC_invest and Empl_serv (0.30*)

Notes: *** ,**, * means statistically significant at 1%, 5%, 10%, respectively. The values of correlation and their significance were shown in parentheses. The figure presents the results for 30 OECD countries in 2021 (due to insufficient data the following countries were excluded: Australia, Chile, Colombia, Costa Rica, Iceland, Japan, Latvia, Mexico, Turkey). Due to limitations in the size of the article, the figure is limited to presenting relatively strong correlations, i.e. > |0.3|. The correlation analysis is based on cross-sectional data from 2021 for OECD countries.

Source: the author's calculations, based on OECD (2024c, 2024e).

The results also indicate that the relationship between indicators measuring innovation and employment can vary across different sectors, which supports the fifth hypothesis. In particular, indicators measuring innovation tend to show a positive relationship with employment in services (Fig. 7), while they might have a negative relationship with employment in other sectors. The positive relationship between innovations and employment in services might result from several factors, such as developing new business models, improving service delivery and relationships with customers and clients, developing new service-oriented activities (e.g. data analysis, IT support), or services within digital government. In contrast, the negative relationship between indicators measuring innovation and employment in other sectors can result from the fact that innovations in industry and manufacturing sectors are mostly based on automation and robotisation, which can replace human workers with robots (OECD, 2016). Moreover, new technologies and innovations usually result in greater productivity, which may lead to lower demand for employees. Finally, even though overall employment in a given sector may be reduced, the demand for highly skilled workers will probably increase in the digital economy. To sum up, the negative relationships between innovations and employment in sectors other than services often result from replacing the labour force with machines and robots to achieve greater productivity, which is consistent with the study by Acemoglu and Restrepo (2020).

5. Conclusion and Discussion

In conclusion, the empirical analysis indicates that investments in ICT in the OECD countries are positively associated with public spending on labour market policies. First of all, investments in ICT can enhance the effectiveness of public spending on labour market policies, improve job matching and the organisation of online training, and create new jobs in the digital economy. Moreover, greater involvement of employees in technology-driven processes and their better-informed contributions to R&D initiatives might result in an increase in R&D spending. Considering that investment in labour market policies contributes to the development of employees' human capital, this expanded human capital may also encourage educational institutions to increase their efforts in the field of R&D. However, a negative relationship was observed between public spending on LMP and the share of start-up firms in the business population, as well as the share of countries in "triadic" patent families. This may be due to the fact that start-ups in the ICT sector often rely more on private financing and venture capital, which is consistent with the implications of international organisations working on this phenomenon (OECD, 2024i).

The empirical analysis also indicates that a higher level of unionisation in the OECD countries is positively correlated with business R&D expenditure in information industries. Thus, it can be supposed that in the era of new technologies, trade unions may intensify their efforts to ensure that employees have access to training programmes to keep up with technological advancements. Consequently, in the new digital labour market, trade unions may be more involved in negotiations related to new technologies and innovation, ensuring that the adopted changes are beneficial for employees (e.g. Pilc *et al*., 2022). However, the impact of innovation and new technologies on the labour market is considered complex, and as a result, outcomes might also vary depending on factors such as e.g. collective bargaining in wage determination (Corrocher *et al*., 2023).

Furthermore, stricter employment protection legislation is usually associated with lower values in indicators measuring innovation in the OECD countries. However, in the case of start-up firms, the results show that strict employment protection may create an environment supportive of new business activities in some instances. This needs further research, but it may suggest that strict employment protection encourages employers to start businesses because they feel more secure in a changing labour market. The results also indicate that the relationship between indicators measuring innovation and employment can vary across different sectors. In particular, indicators measuring innovation tend to show a positive relationship with employment in services, while they often have a negative relationship with employment in other sectors due to the replacement of the labour force with machines and robots to achieve greater productivity, which is consistent with the study by Acemoglu and Restrepo (2020).

Additionally, the results indicate a positive relationship between people employed in high-skill occupations and indicators measuring innovation. In contrast, the relationship between people employed in low and medium-skill occupations and indicators measuring innovation was negative. This implies that high-skilled employees usually benefit from technological changes because their skills can be used or transformed into other jobs. On the other hand, low-skilled employees usually need to reskill because their jobs are more likely to be automated, and routine tasks are more susceptible to being replaced by robots or automation. These results are consistent with previous studies (e.g. Frey & Osborne, 2017; Schroeder, Greef & Schreiter, 2017; Agolla, 2018), which indicate that professions involving repetitive, routine tasks are most at risk of automation, while occupations requiring high skill are least at risk from automation and robotisation.

One of the limitations of this analysis is the fact that the research is limited by the countries covered and the timeframe applied. Secondly, the study established important relationships between labour market characteristics and innovation based on the correlation analysis, which, however, does not provide a causal link between variables. Additionally, correlation analyses may not fully capture the contextual factors (e.g. economic) that might have an impact on the relationship between labour market institutions and innovation. As part of future research, it is worth analysing the causal link between labour market characteristics, with particular emphasis on the role of labour market institutions and innovation in the digital economy.

Conflict of Interest

The author declares no conflict of interest.

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