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Brucker Juričić, Belinda; Galić, Mario; Marenjak, Saša

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Review

Review of the Construction Labour Demand and Shortages in the EU

Belinda Brucker Juricic [1,*], Mario Galic [2] and Sasa Marenjak [2]

[1] PPP Centar d.o.o., Mlinarska Cesta 61A, 10000 Zagreb, Croatia
[2] Faculty of Civil Engineering and Architecture Osijek, Josip Juraj Strossmayer University of Osijek, Street Vladimir Prelog 3, 31000 Osijek, Croatia; mgalic@gfos.hr (M.G.); sasa@pppcentar.com (S.M.)
* Correspondence: belinda@pppcentar.com; Tel.: +385-91-154-1982

Abstract: This paper reviews the recent literature on skill and labour shortages in the labour market with special emphasis on the construction sector in the European Union Member States, foreseeing the Construction 4.0 era. The free movement of people is one of the rights of all citizens of the EU which also includes the free movement of workers. Labour shortages in the EU are expected to increase in the future due to a declining population and an ageing workforce. In order to recognize and forecast labour shortages, EU Member states use a variety of instruments but they do not answer as to whether it is possible to use migrant labour to appease those shortages. There are several systems used to classify labour shortages in the EU Member states. Most of the countries classify labour shortages in relation to different sectors or occupation groups as well as by skill levels, but in some Member States, classification is made according to the type of employment. Instruments used to measure labour shortages significantly differ from country to country. Several criteria are used for creating lists of shortage occupations and most of the criteria include demand side and supply side criteria. A majority of the Member States are facing labour and skill shortages in various sectors and the construction sector is not an exception. As total employment in the construction sector decreased, so did the share of employed migrants. Labour shortages in the construction sector can be eased by the availability of a labour supply willing to accept unqualified and low-paying jobs. The construction sector seeks low-, medium-, and high-skilled individuals and is most likely the sector where most of the incoming migrants will be working, which has an impact on the development and implementation dynamic of Construction 4.0.

Keywords: Construction 4.0; construction sector; labour demand; labour migration; labour shortage

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1. Introduction

The digital and information technology revolution, which we have been witnessing and contributing to for the past few decades, has arguably a significant impact on most industries and technologies. A clear focus on the development of automated processes and operations can be traced in most recent scientific studies and research. This focus and development trend in the construction industry is known as the era of Construction 4.0, which holistically refers to the architecture, engineering, construction, and facility management industry (AEC/FM) [1]. A concise study of Construction 4.0 technologies presence in construction projects presented in [2], foresees that the implementation of the aforementioned technologies will change the management of construction projects caused by the increased automation of operations. However, most of the scientific circles agree that the AEC industry is still and will be in the near future highly dependent on skilled and unskilled workforce [3–5]. Hence, the quality, directions, and duration of implementation of Construction 4.0 are dependent on the workforce in the AEC industry.

The construction sector, as one of the main sectors of industry, and a significant driver of economic development on a global scale, serves as a basis for the strategic plans of most countries. Construction is commonly regarded as a major investment component and is

highly dependent on human labour, where the most numerous workers are low-skilled workers. Furthermore, the lack of qualified workers has become a crucial issue all over the world, given the current global growth in the construction industry [6]. In this regard, the lack of skilled workers causes poor quality of project performance and higher costs [7]. It can also delay the delivery of projects and can have a negative impact on the successful completion of construction projects [8]. One of the generally accepted factors that reduces potential economic growth is skill mismatch, that requires adequate policy measures at both the national and EU level [9], which leads us to the conclusion of the importance of the holistic approach for the implementation of Construction 4.0 in the EU.

Skill shortages occur when employers are unable to find workers with the required skills in the accessible labour market and skill surpluses occur when the supply of necessary skills is higher than the demand [10]. Construction labour and skill shortages have been recently reported worldwide and, perhaps contrary to popular anticipation, shortages are reported both from well-developed and developing construction industries simultaneously. From the well-developed construction industries, such as the industry of the USA, where a study conducted in 2017 in the US was analysed in detail by authors in paper [11], revealed that there are significant shortages of a wide range of skilled construction workers. Another study [12] presented a shortage of skilled workers in the state of TX, USA, whereby the authors also underlined the main motivators for retaining the workforce in construction. Furthermore, similar shortages are reported in the construction industry of Hong Kong [13], where the author, besides the shortages, underlined the problems of the ageing workforce and skills mismatch. Interesting feedback and experiences from New Zealand were presented by authors [14], providing an insight into construction problems with a lack of skilled workers needed for a construction boom caused by urgent reworks after a disastrous earthquake. As for the shortages reported in the developing construction industries, such problems are reported in Ghana [15], Sri Lanka [16], the Lebanese construction market [17], and there are even reported construction workforce shortages caused by migration in some regions in India, which estimates a total of 36.12 million workers working in the Indian construction sector [18].

The EU, with an estimated total population of nearly 450 million and a rough estimate of 3 million workers in the construction sector [19], is in many ways a specific and diverse union of countries (i.e., politically, economically, culturally, socially). The results presented in this review confirm this thesis to be true in the construction industry as well. The more developed economies and construction sectors in the northern and western countries of the EU meet their needs and partially satisfy their workforce shortages by the migrated workforce coming from southern and eastern EU countries. This was obvious with the pandemic of COVID-19 and EU borders shutdown crisis in March 2020, which was analysed in a wider context by the author in the paper [20]. The aforementioned migrations to more developed countries cause shortages in the less developed EU countries, which are then facing workforce shortages of their own and turning their strategies of construction workers supply from third-country nationals outside from the EU.

Furthermore, the results of this study reveal an almost linear trend of construction job vacancies increase in quarterly step on the EU level. While at the same time, some EU member states do not apply any of the instruments for identifying labour shortages. This research revealed that there are not many recently (in the past five years) published articles dealing with the problem of labour and skills shortages in the EU construction sector, rather an occasional study published mostly from non-EU countries. To the best of our knowledge, a review and analysis aiming to provide data and trends of workforce shortage and demand in the EU's construction industries have not been published recently. For that purpose, this paper reviews the recent data, statistics, national reports and relevant scientific literature on skill and labour shortages in the labour market with special emphasis on the construction sector in the European Union Member States. The aim of this study is to give an overview of the methods used by EU Member states in analysing supply and demand of the construction labour market and to answer the question of how they

meet their labour needs. The results of this study serve for better understanding the significance and the construction labour market problem diversity in the EU. In addition, it might serve as a theoretical platform or a step towards structuring a coherent approach for strategic planning to address the construction labour demand and shortages in the EU at the Union level, which as revealed in this study is not or cannot be solved at the national level among EU member states. Furthermore, this study aims to provide a baseline for the strategic and comparative implementation of Construction 4.0 in the EU which is noted to be simultaneously motivated and constrained by the problem of long-term construction workforce shortages and increase of workers' skills mismatch.

In this way, the remainder of this paper is organized as follows. After the chapter presenting the methodology applied in this study, the authors present a short review of recently published findings and conclusions regarding Construction 4.0. For the sake of the context of the topic, in the second part, the authors provide a review of labour migration in the EU given that labour shortages are often compensated for by employing workers from other Member states and third-country workers. The paper continues with defining labour shortages and the overview of instruments used in defining those shortages as well as classifying them. The paper further analyses the labour shortage situation and the construction labour market in the EU. The final part of the paper consists of a discussion and conclusions of the findings in the study.

2. Methodology

In this study, the authors used a survey method of data collection and applied standard methods of graphical and numerical data analysis. For the purpose of analysing labour demand and shortages in the construction sector in the EU member states (EU27), mostly focusing on the past five years, authors processed and analysed data from the statistical office of the European Union-Eurostat, EU members national reports, and scientific journal-published articles relevant to the topic of this research. The articles processed and analysed in this review paper discuss the topic on labour migration problems, labour shortages and skills in the construction sector globally and at the EU level, as well as at the level of individual countries, with a focus on articles published in the last five years (2015–2020). Literature was researched and filtered according to the keywords listed in this paper, filtering articles published in scientific journals which are indexed in Scopus and Web of Science, as well relevant articles published on scientific conferences and congresses. Articles were analysed by the topic of their context and aims, the contributions, the main reported drawbacks and suggested further development, as well as references used for the purpose of networking the references in the topic of this study.

It is worthy to note that, as revealed in this research, while there are numerous recently published studies on the topic of Construction 4.0, there is a lack and wide gap of scientific articles on the topic of the construction labour demand and shortages in general, especially in the EU.

In addition to the articles, different studies were an important source of data. Also, the data source used in this analysis were the EMN Country Factsheets which give an overview of the most recent migration and international protection-related statistics. For analysis of the collected statistical data, authors structured a numerical representation of the relative number of job vacancies in construction in the EU27 members (quarterly periods from 2018 until 2020). For the sake of detecting and presenting a cyclic mode and a clear trend of quarterly distributed job vacancies in construction in the entire EU27, the authors presented the data graphically.

3. Short Review of the Construction 4.0 Background, Perspectives and Challenges

The galloping digital and information technology (IT) development that we have been facing for the past two decades has a significant impact on most industries but has an exponential growth only in the mentioned period. In the literature, the aforementioned digitalization and IT application for the production automation, which can be traced back

to its roots in the 1960s, is commonly referred as the Third Industrial Revolution (3IR) [21]. While the 3IR still has not reached developing countries that cover roughly half of the planet [21], the well-developed industries are strategically planning and foreseeing the era of the Fourth Industrial Revolution (4IR, Industry 4.0 or I4.0).

The discussions and framework of the 4IR are believed to be initialized in Germany [1,21] at the Hanover Fair in 2011. The main expected features of the 4IR, stated by the authors in their concise study [22], are focusing towards the vertical and horizontal integration of the production through value networks, and on the digital integration of the value chain by using cyber-physical systems (CPS). In the same study authors [22] underlined and singled-out building information modelling (BIM) as the main 4IR related enabling technology for the digitisation the construction manufacturing processes, which is followed by the Internet of Things/Internet of Services (IoT/IoS), product lifecycle management (PLM), cloud and mobile computing, augmented, virtual, and mixed reality, robotics, etc. As for the main anticipated benefits from the 4IR, those usually mentioned include: higher productivity, greater flexibility, quality, sustainability and reliability of production, safer and better working conditions, innovations, an improved collaboration of the organizations and stakeholders, etc.

The report of the World Economic Forum held in Geneva in 2016 [23], with the topic of future of employment, skills and workforce strategy for the 4IR, revealed that in most countries top trends impacting industries are changing nature of work and flexible work, mobile internet and cloud technology, new energy supplies and technologies, climate change and natural resources, the middle class in emerging markets, sharing economy and crowdsourcing. In the same report, it is concluded that in order to prevent a 4IR bottle-neck scenario caused by the trends of workforce shortages, unemployment, and growing inequality, it is crucial to ensure the reskilling and upskilling of today's workers. Furthermore, the difference between 3IR and 4IR in terms of their orientation has an impact on the approach and criteria of recruitment of the labour in 4IR [24,25]. While the 3IR tends consists of technology-oriented work tasks, those tasks are changed to process-oriented tasks [25]. In this perspective, authors [26] summarized and arranged according to a hierarchy the expectations from 4IR employees in three tiers, whilst the on the top of the expectations are the skills and qualifications, second tasks and on the third tier are tools and technologies. A study [27], aiming to present transformational changes to business environments brought by the 4IR, concluded that gap the between current capabilities of employees on the market and the evolving requirements of their roles is deepening, resulting in loop of demand for the workforce on a deficient market. For understanding the gaps and differences of the developed and developing countries foreseeing the challenges brought by the 4IR, authors [28] detected that, while the developed countries are challenged by the need for experimentation and learning, data explosion, and transformation of the workforce, simultaneously, the developing countries are facing a need for training with specific skills in managing digital jobs, scalability, and a lack of funding to initialize strategic planning at the national or regional level for the implementation of systems 4.0.

In the perspective of 4IR, a term foreseeing the era of Construction 4.0 has emerged. The European Construction Industry Federation-FIEC in their manifesto [29] stated that Construction 4.0, as a branch of Industry 4.0, is used to refer to the digitalisation of the construction industry. As such, Construction 4.0 combines cyber-physical systems (CPS) and the Digital Ecosystem. While CPS is enabling technologies to merge the virtual and physical worlds in order to create a highly networked environment in which intelligent objects can communicate and interact among themselves, the digital ecosystem is defined as an interdependent group of stakeholders and/or things sharing standardized digital platforms for mutually beneficial purposes [1].

Similarly to the results presented in [22], authors in concise research of Construction 4.0 [30] stressed the importance and domination of BIM in terms of its enabling-driver for the Construction 4.0. A study presenting the methodological and technological framework for Construction 4.0 [31], where authors proposed a framework that incorporates the

principles of the 4IR by applying the current trends of BIM, lean construction and integrated project delivery. Moreover, authors [31] highlighted the significance and implications of the upcoming adoptions, (i.e., consequences on workers adopting new role, knowledge and job profiles, the challenges in education and training, and the evolution to the new business and development models). In paper [32] the authors complement the previously stated enabling drivers for Construction 4.0 with potentials of 5G and unexplored synergy effect of the main drivers. Furthermore, researching various scheduling and optimization tools, authors [33] concluded that there is still a wide gap for studies and development of higher automation level combining BIM and standard project management tools. Similar conclusions arose in the study of BIM adoption in some EU countries [34] revealing that BIM still has not reached its potential nor the theoretical expectation by academia.

There are numerous examples when the enthusiasm of academia was stretched by the rather sluggish application in the industry. Regarding the Construction 4.0 authors agree that, besides the gap between developed and undeveloped construction industries, technological issues and drawbacks, there will be numerous non-technological challenges in front of the Construction 4.0 implementation. The main non-technological challenges in front of Construction 4.0 comprise of multiple sources [1,3,22,35,36] as follows:

- well-known construction industry sluggishness and resistance to changes
- disproportion of the value proposition among stakeholders in the construction industry
- expected high initial investments
- legal, security and GDPR issues
- lack of standards forming the main drivers
- need for enhanced skills and skilled workforce.

Regarding the enhanced, skilled workforce as one of the enabling resources, authors in [37] discuss it from a perspective of the necessity of "remodelling" the university pathways, by adjusting curriculums, streaming towards stronger collaboration with industry, and upgrading them for the 4IR. Due to the severe lack of workforce, especially the skilled workforce in construction, it is logical that universities should precede the Industry 4.0 and initialize the phase of University 4.0.

In this study, the authors address the last, but not least, challenges in front of the Construction 4.0, i.e., construction skill and labour shortages on the labour market in the EU. In this context, this study aims to emphasize this challenge which has not been fully solved in the overlapping 3IR and with the globalization trend it is reasonable to anticipate even larger gap between demand and supply of workforce in EU construction industry.

4. Labour Migration in the EU

The labour shortages in the EU are partially connected and induced by the migrations among the EU Member States. For understanding the context of the labour shortages in the EU construction industry and the challenges for the Construction 4.0 framework, elaborated in the previous chapters, it is important to understand the migrations' facts, proportions and politics in the EU.

Population migrations are shaping the social, demographic and economic state of individual countries. One of the principles of the EU is free movement of persons and it has become legally binding for the citizens of the new Member States as the EU has grown [38]. Since the free movement of people is one of the fundamental rights of EU citizens, it also includes the free movement and open market of workers [39]. The main reasons for migration in the world are the regional economic differences. Economic migrations, i.e., migrations for work are one of the most common types of migrations in the EU [40]. According to Guild, 2017 European economic integration of countries generates the free movement of workers inside the EU [41].

The European Commission treats the mobility of the labour force as a strategy for equalizing the supply and the demand on the European labour markets [38]. The size and composition of the labour force in the future will depend on the course of population development and the evolution of age-, sex-, and education-specific labour force [42].

However, in response to gloomy demographic forecasts (ageing populations, low birth-rates, and prospects of a collapsing social security system), the EU needs to import foreign labour [43]. Furthermore, in some countries in Europe, certain areas have fewer and fewer inhabitants because working-age people choose out-migration to countries where they have better employment opportunities [44]. Economic prosperity and political stability are one of the main reasons that attract immigration towards the EU [45].

Table 1 shows the employment and unemployment rate (age 15–64) by citizenship in each Member State in 2019. As it was anticipated, there are significant differences in employment and unemployment rates among member states, which can be explained by the difference in the economic development in the EU. However, it is interesting to note that there are outliers in unemployment rates of third-country nationals in some developed member states (i.e., Spain, France, Sweden, Greece).

Table 1. Employment and unemployment rate (age 15–64) of nationals and third-country nationals (TCNs) in each Member State in 2019 (the table is structured by authors upon open-source data collected from [46,47]).

	Employment Rate		Unemployment Rate	
Country	**Nationals**	**TCNs**	**Nationals**	**TCNs**
EU-27	68.9	57.4	6.3	14.9
Belgium	66.3	41.8	4.8	18.9
Bulgaria	70.1	52.7	4.3	n/a
Czechia	75.0	79.4	2.0	2.7
Denmark	76.0	58.7	4.8	9.8
Germany	78.5	57.9	2.6	9.5
Estonia	75.7	73.0	4.1	7.4
Ireland	68.9	66.8	4.9	6.9
Greece	56.7	53.7	16.8	26.5
Spain	63.7	57.0	13.3	22.5
France	66.4	49.9	8.0	18.1
Croatia	62.1	46.5	6.7	n/a
Italy	58.8	60.2	9.7	13.8
Cyprus	70.1	66.9	7.6	5.6
Latvia	72.8	68.6	6.3	7.4
Lithuania	73.0	76.8	6.5	n/a
Luxembourg	64.1	62.4	4.1	10.8
Hungary	70.1	68.0	3.4	n/a
Malta	71.9	74.3	3.0	6.9
Netherlands	79.1	58.4	3.1	8.7
Austria	75.0	58.3	3.6	13.3
Poland	68.2	76.2	3.3	5.5
Portugal	70.5	69.3	6.5	12.3
Romania	65.9	n/a	4.0	n/a
Slovenia	71.9	68.9	4.4	7
Slovakia	68.4	67.7	5.8	n/a
Finland	73.5	51.3	6.6	16.2
Sweden	79.2	52.8	5.5	26.3

Note: n/a data not available data.

A key stimulus for migration is the movement of people from areas with low productivity into areas of high productivity of labour [48]. In adjusting labour migration policies to labour market policies workers arriving from third countries should be unquestionably and systematically taken into account. The legal labour migration scheme needs to be flexible in order to adapt to the evolving labour market needs and it should respond to current labour needs [49].

Colloquially taken, the unlimited free movement of people is guaranteed for all EU citizens, but each Member State has its immigration policy regarding countries outside the EU. There are two systems available for a person to move to another Member State to

find employment. One applies to EU nationals with the full freedom of movement and the other is less opened and limited to special categories of third-country nationals. Article 14 par. 4 of the Directive 2003/109/EC determines the possibility for the Member States to limit the total number of people entitled to be granted right of residence based on the quotas system [50].

A common labour migration policy has not been developed on an EU level and there is a lot of space for each Member State to implement the rules regarding third country labour migrants [51]. Regardless of their qualifications, migrant workers are of great value as flexible labour in low-paid labour markets in Western European countries. Immigration policies regarding labour migrants differentiate between forms of labour based on the duration of work (whether the work is permanent, temporary or seasonal), required education, or the level of pay [52].

Migrant workers in the EU can be low-skilled individuals (LSIs) or high-skilled individuals (HSIs). Attracting high skilled individuals from third countries is of great importance because there is a lack of skilled labour in the EU. Lack of HSIs coupled with simultaneous demographic change is provoking governments into applying direct measures to recruit economic migrants [53]. In that regard, rich countries are developing measures for attracting HSIs. On the other hand, they are much more cautious about the LSIs whose integration in host countries in Europe is not easy [54].

A strategy to address skill shortages in Germany is the integration of foreign skilled workers. To that end, the German government is supporting the integration of foreign skilled workers and has introduced reforms. For persons who have completed vocational education and training in specially defined shortage occupations, the German Employment Regulation provides access to their labour market [55]. While in Austria, the inflow of labour migrants from third countries has been regulated by quotas until July 2011, it has been substituted for a point system of economic immigration of third-country citizens. Annual inflow of labour migrants follows the rules of a so-called Red-White Red-Card which aims at raising the inflow and settlement of skilled and highly skilled third-country citizens [56]. In developed countries in the EU with the highest economic activity and limited tensions in the labour market, most of the people are able to find work. On the other hand, the outflow of people was found in the developing Member States, but those are countries in which immigrants usually find work even easier than locals [57].

As we face a spectrum of significant changes in the world at the moment, it remains to be seen what the impact of the COVID-19 pandemic will be on economies and on labour supply and demand around the world as well as in the EU.

5. Labour Shortages Assessment in the EU

In the previous chapters, elaborating the context of 4IR foreseeing the challenges and stating the drivers, the focus was on the future of the labour markets in the EU. However, it is crucial to review the present and continuing problems of the labour shortages in a wider perspective on the EU and Member States level.

Labour shortages in the EU are expected to increase in the future due to declining population and the ageing workforce. In order to recognize and forecast labour shortages, EU Member states use a variety of instruments but they do not give an answer as to whether it is possible to use migrant labour to appease those shortages. Across the EU Member states, there are different ways of connecting labour shortages and economic migration. One of them is the supply-centred approach and the other is the demand-centred approach. The first one is based on attracting migrants with certain work skills that are lacking in the labour market, and the second seeks to reduce administrative barriers and thus speed up the process of accepting foreign workers who would be employed in certain jobs for which there is a shortage of labour. Various instruments such as labour market and employers' needs analysis, employer surveys forecasts, and foresights and qualitative studies are used to determine current occupations where there is a shortage of skilled labour and also to

predict where labour shortages will occur in the future [58]. Table 2 shows the instruments for identifying labour shortages applied by each Member State.

Table 2. Instruments for identifying labour shortages used by each Member State (the table is structured by authors upon open-source data collected data [58]).

Member State	List of Shortage Occupations	Sector Analysis	Employer Surveys	Forecast/Foresight Analysis	Qualitative Studies/Analysis
Austria	yes	yes	yes	yes	no
Belgium	yes	yes	yes	yes	yes
Bulgaria			n/a		
Croatia	yes	no	yes	no	no
Cyprus	no	no	no	no	no
Czech Republic	no	no	no	no	no
Denmark			n/a		
Estonia	yes	yes	yes	yes	yes
Finland	yes	yes	yes	yes	yes
France	yes	yes	yes	yes	yes
Germany	yes	yes	yes	yes	yes
Greece	yes	no	no	no	no
Hungary	yes	yes [(1)]	yes	yes	yes
Ireland	yes	yes	no	yes	yes
Italy	no	no	yes	yes	no
Latvia	yes	yes	yes	yes	[(2)]
Lithuania	yes	no	yes	yes	no
Luxembourg	yes	yes	yes	yes	no
Malta	yes	no	yes	yes	yes
Poland	yes	yes	yes	yes	yes
Portugal	no	no	no	yes	yes
Romania			n/a		
Slovakia	yes	yes [(3)]	[(4)]	yes	[(5)]
Slovenia	no	no	no	no	no
Spain	yes	[(6)]	no	yes	no
Sweden	yes	yes	yes	yes	yes
Netherlands	yes	yes	yes	yes	yes

Notes: [(1)] Only for healthcare sector. [(2)] Analysis of vacancies and changes of unemployed portrait. [(3)] Not used much with the exception of the automotive industry. [(4)] Not a systematic tool. [(5)] Only used under individual projects and potential studies. [(6)] Never been used but it is envisaged in the Law 14/2013. n/a Data not available.

It can be noted that surprisingly some countries do not apply any of the instruments, while most of them are applying them only partially. What seems interesting is that a significant number of countries do not apply sector analysis nor extrapolation forecasts for identifying labour shortages.

If the labour demand is greater than labour supply, labour market shortage is defined as a lack of trained workers [58]. The root cause for labour shortage is a mismatch between labour demand and supply. Jobs remain vacant despite high unemployment rates given that workers lack the relevant qualifications or skills, have insufficient information about job opportunities, or are reluctant to take up work in particular occupations or geographical areas [59].

Labour shortages are not uniformly defined across EU countries, and in some of them the term labour shortage is not even formally defined in legislative documents and in those cases, the labour shortage is often defined differently across regions and differentiates within institutions dealing with the calculation of those shortages. Furthermore, some Member states are already assessing the future labour shortages and some are preparing a scheme for forecasting labour needs [58].

Many economically dynamic cities and regions in the EU have had significant in-migration of skilled and semi-skilled workers. On the other hand, other regions, particularly those on the European peripheries, have the opposite problem [60].

6. Classifying and Measuring Labour Shortages in the EU

There are several systems used to classify labour shortages in the EU Member states. Most of the countries classify labour shortages in relation to different sectors or occupation groups as well as by skill levels, but in some Member States classification is made according to the type of employment, for example, seasonal labour. Furthermore, in some countries, there is a differentiation between short and long-term labour shortages. While short-term shortages are based on the present labour market, forecasting tools are used to recognize long-term shortages. In most Member States labour shortage data is processed at the regional level, while in some countries this is done on a national level [58].

Instruments used to measure labour shortages significantly differ from country to country but they generally involve quantitative analysis of labour supply and labour demand. Labour shortages can be measured by determining the official number of vacancies in some occupations which require particular qualifications [58].

Skill is a complex concept and challenging to measure. Skill shortages appear when employers are unable to recruit workers with the required skills in the accessible labour market [10]. In order to assess skill shortages, most EU countries use employer surveys on recruitment (although sampling techniques and survey sample size significantly differ across countries) but the results are not used to determine labour migration needs in all countries. In addition to the aforementioned instruments, labour shortages can also be measured by using sector analysis. The methodology of the sector analysis and its scope varies across Member States, as do the institutions that provide this analysis, but in most countries, these analyses are not used for determining the labour migration needs. Furthermore, forecasts and foresight analyses and qualitative studies are also carried out in some EU countries [58].

In order to counter labour shortages, employers, Member States, and the EU need to be involved. Measures to counter those shortages are measures for raising the participation rate, increasing international and cross-border mobility, increasing productivity, increasing geographical and functional mobility within the Member States, updating or changing skills, increasing the image and quality of jobs and increasing labour market transparency [61].

Development of technology, outsourcing from other Member states and economic cycle as well as the change in salaries and working conditions are some of the external elements which represent challenges to accurately establishing the shortage of occupations, even in the cases where market data is readily available and accurate [58]. Shortage occupation lists exist in a number of Member States. Those lists consist of occupations (usually high-skilled ones) in which there are hard-to-fill vacancies [9].

The procedure of creating a list of shortage occupations in most countries is led by Public Employment Service or the Ministry of labour/interior, depending on the country. Several criteria are used for creating these lists and most of the criteria include demand-side and supply-side criteria. In a number of countries, the list of shortage occupations is created by using the combination of demand and supply analyses which gives an overall ratio. Some EU countries are not linking the identified shortages to labour migration policy, some countries develop shortage lists but not for the purpose of labour migration but for the purpose of developing their labour migration policy and other countries use these lists as an aid to determining the admittance of third-country nationals [58].

In the perspective of identifying labour shortages, different EU countries adjust and modify their labour migration policies. In addition, stakeholder consultations are also an important part of adjusting and modifying those policies and are always included in the countries which create labour shortage lists. In the process of determining shortage occupation lists, key stakeholders are social partners. Other stakeholders such as ministries and state agencies as well as organisations and labour or migration experts can be a part of creating an occupation shortage list draft. In the majority of EU countries, a diversity of stakeholders are involved in determining labour shortages by way of fixed advisory structures or as necessary [58].

A strategic and breakthrough was made by the Slovak Republic approving the Strategy of Labour Mobility of Foreigners in 2018 with the main objective to address the current shortage of skilled labour. The aim of the legislative changes was to speed up the system governing the entry and residence of third-country nationals into the Slovak Republic for employment purposes and to make it more flexible, especially in professions with identified labour shortages [62].

Methodological challenges (economic cycle, technological developments, cross border outsourcing, shifts in education and training patterns, as well as changes in production organisation, wages and working conditions) and challenges related to external developments (which affect the efforts to forecast changes in labour supply and labour demand) are connected with the use of instruments for identifying labour shortages and the need for migrant labour by a number of EU countries [58].

7. Labour Shortages in the Construction Sector in the EU

With the challenges for Construction 4.0, i.e., migration problems, as well as the disproportion of the labour shortages assessment, classification, and measurement approaches among the EU Member States, elaborated in the previous chapters, the connection of the current and future problems of the lack of and rising demand for enhanced skills and skilled workforce in construction is clear. With the suggestions and conclusions emphasizing the importance of the upgrade of the educational systems qualifying the forthcoming workers, upgrades of re-qualification systems and long-life learning of workers currently available on the market, for the Construction 4.0 transition it is important to understand the current situation and recent trend of labour shortages in the construction sector in the EU.

In order for an economic sector to be successful and for the set goals to be achieved, it is necessary, among other things, to provide the workforce with which these goals can be achieved. Analysis of labour needs, especially skilled labour, is one of the activities that is carefully carried out in developed countries. A majority of the Member States are facing labour and skill shortages in various sectors and the construction sector is not an exception. A large share of workers on the market in most countries is a part of the construction industry, which significantly relies on human labour. The construction sector has a huge potential for the employment of a large number of unemployed unskilled or temporary/seasonal workers [5].

Construction is characterised by a large segment of migrant workers and the appearance of temporary and mobile worksites [63]. Migration and mobility have always been a part of the European construction sector [64]. Labour shortage in the construction sector can be eased by the availability of a labour supply willing to accept unqualified and low-paying jobs [65]. On the other hand, the construction industry also requires some of the most highly skilled workers because projects within the industry are diverse and range from less complex to the most complex ones such as nuclear power plants or oil refineries and large utilities which have the most exacting and stringent specifications [66]. The construction sector, which seeks low-, medium-, and high-skilled individuals, is most likely the sector where most of the incoming migrants will be working [67]. According to the 2015 study and synthesis report [68] presented by the European Commission (based on the reports from 25 Member States), there are eight construction workers' skills underlined as the priority for the industry, i.e., miscellaneous road and network workers, construction equipment drivers/operators, road builders, pavers, civil engineering constructors, electrical network fitters, pipelayers and site managers. In the continuation, the European Centre for the Development of Vocational Training (CEDEFOP) estimates that roughly 1 million new and replacement workers will be needed by 2025 in the EU. Additionally, it is stated that tertiary education does not fulfil the level of knowledge demand and that the skills needed in construction are likely to change to meet the demands for "green" and energy-efficient buildings [69].

Figure 1 shows that the number of employees in the construction sector overall in the EU has increased each year in comparison with the previous year since 2015.

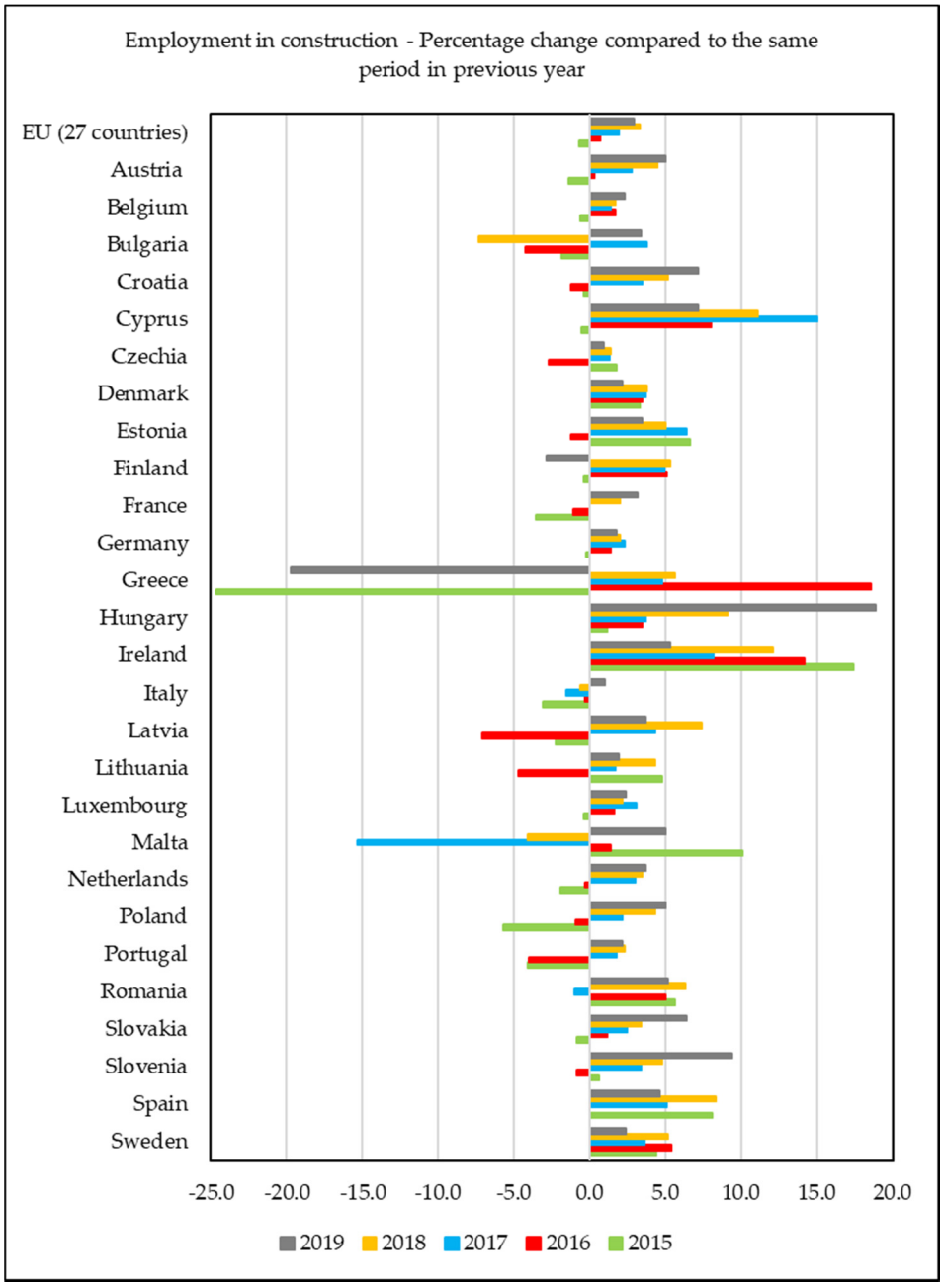

Figure 1. Employment in construction-Percentage change compared to the same period in previous year (the figure is structured by authors upon open-source data collected from [70]).

In Figure 1, it is clear that most developing countries have significant changes, i.e., scatters in the percentage changes compared to the same period in the previous year. In 2015, the percentage of employment in construction in Greece drastically decreased (by 24.6%) compared to the same period of the previous 2014, which is probably due to economic turbulence in that country, and the same happened in 2019 when the percentage decreased by 19.7% compared to 2018.

More interestingly, Table 3 shows the number of job vacancies (in thousands) in the construction sector for the last three quarters of 2018, the whole of 2019 and the first two quarters of 2020. Data for France, Italy and Austria are unfortunately not available.

Table 3. Number of job vacancies in construction-quarterly data (the table is structured by authors upon open-source data collected from [71]).

Country	2018 Q2	2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019\Q3	2019 Q4	2020 Q1	2020 Q2
EU	252,391	258,235	250,081	268,435	280,279	288,249	269,459	234,191	217,253
Belgium	11,427	13,590	8916	9867	10,707	11,067	10,812	9384	8940
Bulgaria	602	755	782	868	876	830	913	462	919
Czechia	31,532	32,486	32,290	39,777	40,752	39,733	38,581	37,985	37,485
Denmark	4554	4817	3200	3622	4045	4161	3875	4278	3228
Germany	117,692	124,497	135,256	128,595	142,482	146,980	147,208	127,452	116,882
Estonia	587	534	916	720	306	818	835	231	350
Ireland	1500	500	400	600	1200	500	400	200	100
Greece	66	276	54	24	227	295	21	22	90
Spain	4690	8231	3757	4341	4212	5564	3521	1988	4649
Croatia	1990	1827	1205	1784	1492	1496	1344	1570	1526
Cyprus	209	330	227	485	294	691	283	1052	253
Latvia	2617	2153	1944	3787	3346	3122	2720	2084	1842
Lithuania	1167	1005	783	1484	1016	1000	816	1081	1090
Luxembourg	484	400	354	396	497	453	465	455	414
Hungary	4335	4909	4794	4412	4612	4381	3894	2882	2771
Malta	n/a	n/a	471	378	313	208	267	82	120
Netherlands	16,682	16,256	16,643	18,936	18,800	18,000	16,800	13,900	13,100
Poland	30,793	25,799	17,351	25,954	24,031	27,327	20,630	10,857	11,105
Portugal	1754	2398	2447	2222	2245	3606	1695	1273	1701
Romania	2418	2775	2137	2648	2640	2471	1833	1886	1777
Slovenia	3794	3699	3173	5432	3547	3306	3105	4050	2593
Slovakia	1717	1517	2489	1794	1294	1206	975	290	315
Finland	5595	3810	2768	5267	4358	3859	3049	5646	1917
Sweden	6186	5671	7724	5042	6987	7175	5417	5081	4086

Note: n/a Data not available.

On an EU level, the data from Table 3 shows that the highest number of job vacancies in construction in 2018 and 1019 was in Q2 and Q3, and the lowest in Q1 and Q4, which indicates the seasonal type of work which is supported by Eurostat data for 2016 and 2017. Figure 2 shows that the number of job vacancies increases every year from 2016 onwards with a clear linear trend line, except in the first two quarters of 2020 where the number of job vacancies decreases, probably as a result of the Covid-19 pandemic and reduced economic activity across the EU. The reduction of job vacancies in 2020 is also the case with most EU member states. Data for Denmark also indicates a seasonal type of job as the number of job vacancies is highest in Q2 and Q3 for all years since 2016, as is the case with Portugal and Spain where Q3 has the most job vacancies of all quarters. In Ireland, the highest number of job vacancies in 2018 and 2019 was in Q2, while the number of job vacancies was similar in other quarters. Data for Q4 shows that in 2017, 2018 and 2019, the number of job vacancies was the same. Table 3 also shows that in Finland in 2018 and 2019, most job vacancies were in Q1. Germany has the most job vacancies each year compared to other EU Member states. It is important to note that the relative number of job vacancies in the German construction industry is not smoothly increasing in the observed period, and more importantly, it is the country singled out as one of the leaders of the Construction 4.0. In 2018 and 2019, the number of job vacancies increased in each subsequent quarter. Eurostat data shows that in 2016 the number of job vacancies was similar in all quarters.

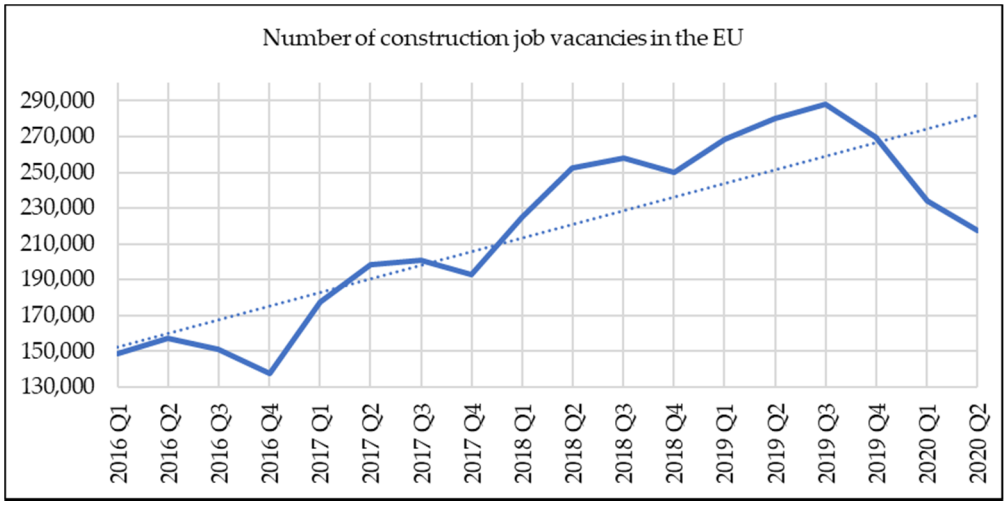

Figure 2. Quarterly trend of construction job vacancies (in thousands) in the EU (the figure is structured by authors upon open-source data collected from [71]).

Migrant construction workers are adaptive to the uncertain working environment and they expect to maintain their regular immigration status by exploiting the available opportunities. In Italy, migrant workers have been granted regular stay-permits through annual quota rates and, since 1998, bilateral agreements between Italy and third countries have defined the quota-based migration schemes [72].

The results of the article [73] which examined the development and regulation of posted labour in the construction industry show that supply and demand can develop in a dynamic interrelationship in transnational mobility. To some extent, the findings are specific to the construction sector, which is characterized by a high share of labour-intensive activities, project production process and longer subcontracting chains [73].

There are tools developed in some countries to analyse construction labour needs. One such labour forecasting tool is the labour forecasting tool (LFT) developed in the UK. It forecasts the labour needs on construction projects and the number of people employed. The tool allows users to forecast the labour demand on a month-by-month basis and occupation by occupation basis. The LFT uses historic data to forecast the number of employees for each occupation for selected project types (both public and private) given no more than the project type, location, cost and start and end date [74,75]. Even though the recent trend of the of construction job vacancies at the EU level demonstrates almost a linear growth, until the first quarter of 2020 and the COVID-19 crisis, it is worthy to notice the slowing growth of the job vacancies in the considered developed construction industries which are leading the Construction 4.0 development and implementation (i.e., Germany, Netherlands, Denmark).

8. Conclusions and Discussion

Labour migration has a significant influence on the labour market in the European Union due to several main reasons, i.e., "open" borders policy, ageing population, industry growth, economic imbalance among EU Member states, etc. Labour markets in the Member States all have varied regulatory frameworks, but in each Member State, there are continuously reported shortages of workers which need to be compensated by importing labour force with relevant qualifications from third countries or within the free movement of workers in the EU. Skill and occupational requirements are not constant but vary over time and are also influenced by technological change. Those are the reasons for which labour shortages are not easy to predict.

Furthermore, it is noted that most of the EU Member States identify current labour market shortages, in a quarterly cycle of the almost perfect linear trend of growth, but the majority of them admit labour migrants and do not link that entry to shortage occupations.

While the more developed western and northern EU countries are strategically preparing their construction industry for the fourth industrial revolution (4IR), promoting high and efficient production systems, their less developed counterparts are still overwhelmed by some aspects and issues of the third revolution (3IR). Interestingly, it is noted that the less developed countries partially cover the shortage of the workforce in developed EU construction markets. Nevertheless, the forthcoming era that most of the EU countries are still to face is Construction 4.0 bringing the digital information and process automation revolution in terms of cyber-physical systems (CPS) and the Digital Ecosystem which will at least in the near future still be highly dependent on the workforce. As well, it was revealed in this study that there is a serious skill mismatch between current and required, which leads to the conclusion of the necessity of adjusting the educational systems for the 4IR. Hence, it might be discussed that the lack of a skilled workforce in the construction industry will be the key motivator and at the same time the main constraint of Construction 4.0 development and implementation. Yet it can be concluded that most of the countries in the EU are not ready for a strategic baseline plan for implementation of such new technologies due to the lack of strategic labour shortages and anticipated high demands. The recent trend in construction job vacancies at the EU level has shown almost linear growth, although it is worthy to notice the slowing growth of the job vacancies in the considered developed construction industries and are markets where workers from less-developed countries migrate, as well which are leading the Construction 4.0 development and implementation (i.e., Germany, Netherlands, Denmark). Hence, it can be concluded that Construction 4.0 and the problem of construction labour shortages and rising demand for skilled workers should be strategically planned at the EU level. This study provided a platform and common ground by the harmonic effect of the problem, and as such can be used as a baseline for further analysis.

Some of the methods (instruments) for identifying shortages are taking stock of unfilled vacancies, employer surveys, sector analysis, forecasts/foresight analysis and qualitative studies or analysis. Methodologies used to measure and classify labour shortages differ from State to State, and most importantly there are significant differences among the approaches. Instruments for identifying shortages often overlap and/or are jointly implemented. However, it is revealed that in spite of the efforts made on the EU level there is a wide gap between Member States' policies and approaches for solving those issues and a coherent EU policy is yet to be implemented.

There are different ways of connecting labour shortages and economic migration across the EU Member states. One of them is the supply-centred approach and the other is the demand-centred approach. The first one is based on attracting migrants with certain work skills that are lacking in the labour market, and the second seeks to reduce administrative barriers and thus speed up the process of accepting foreign workers who would be employed in certain jobs for which there is a shortage of labour. Third country labour migrants are not entirely the solution for the EU economic issues, but they can help mitigate the shortage of skill and labour. The construction sector is not exempt from the issues of skill and labour shortage. On the other hand, the construction sector has always been a great source of temporary employment.

Further research on this topic should focus on the educational aspects that need to precede practical development and implementation of the Construction 4.0 drivers, importantly at the EU level. Furthermore, construction industries as well the authorities should be more involved in the aspects of developing interrelated models of prediction of labour shortages in certain periods and EU Member States. With such an approach, the gap between EU countries might support the smoother and more homogenized implementation and further development of Construction 4.0.

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S.M.; visualization, B.B.J., M.G. and S.M.; supervision, M.G. and S.M.; project administration, B.B.J., M.G. and S.M.; funding acquisition, M.G. and S.M. All authors have read and agreed to the published version of the manuscript.

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