# The Contribution of Workers' Attributes on Sustainability of Construction Project Realization Goals—Survey on the Impact on Productivity in Croatia

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# The Contribution of Workers' Attributes on Sustainability of Construction Project Realization Goals—Survey on the Impact on Productivity in Croatia

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**Abstract:** The work of workers is still dominant in the realization of most construction projects and therefore has a great impact on the productivity of contractors and, thereby, on the sustainability of realization of the goals of contractors and clients. This article provides an overview of the results of more than 100 studies from the previous decade on the impacts of factors related to the personal attributes of workers on the productivity and performance of construction projects. Based on the reviewed literature and semi-structured interviews with experienced professionals in the construction industry, the relation between worker characteristics and other influences on labor productivity is defined and a list of worker characteristics suitable for research in Croatia is compiled. A survey of 262 workers, engineers, and managers from construction industries of Croatia's eastern region, Slavonia and Baranja, showed that the worker characteristics that most influence labor productivity are experience and dexterity. It was also noticed, with a high correlation between the different groups of respondents, that physical strength and morale and morality of the workers were rated as highly influential, while education level was rated as the least influential. The research results are useful because they indicate the possibility of significantly improving the productivity of construction contractors by selecting workers with appropriate physical abilities and cognitive and non-cognitive skills, as well as developing a suitable system for training and motivation of employees.

**Keywords:** labor productivity; attributes of workers; project realization goals; impact rank; survey; Croatia; improvement measures

## 1. Introduction

Construction contractors must have good productivity to operate profitably, which means efficiently converting resources into marketable products [1]. The productivity of contractors has multiple impacts on their own business and the construction industry as a whole, as well as on other industries and the national economy [2]. At the construction projects level, improving the productivity of construction contractors reduces time and realization costs, allows for more competitive bids in job tenders, and creates the space to increase quality [3]. Productivity is positively correlated with the percentage of plan execution, i.e., the measure of changes in the work schedule [4], or, the sustainability of the initially set goals. Extending the realization deadline reduces the profit of construction contractors, and delays the possibility for clients to use the results of their investment and thus reduces their profitability [5]. Therefore, the subject of a large amount of research is the productivity of construction contractors and the factors that affect it.

Construction is a labor-intensive industry and there is, usually, a large share of labor in project realization, although this largely depends on the type of project (the different types of work it consists of) and the construction contractor (available technology). The execution of most construction operations and processes is based on the performance of working groups and the productivity of contractors is mostly related to this [6]. Therefore, the term productivity of construction contractors usually refers to labor productivity. Labor productivity in construction is usually defined as the ratio of output to inputs in production [7], i.e., the amount of work realized in a unit time [3,8] or its reciprocal value [1,9,10]. Labor productivity is one of the most frequently used performance indicators of the success of realization of a construction project [11]. Contractor productivity mainly depends on human effort and worker performance [12] and, according to research provided by Nasir et al. [13], construction contractors consider human resource management to be a high priority with respect to assessing project performance in Canada. Figure 1 highlights the characteristics of workers as one of the main groups that influences the achievement of project performance assessment goals, which are in the domain of the contractor.

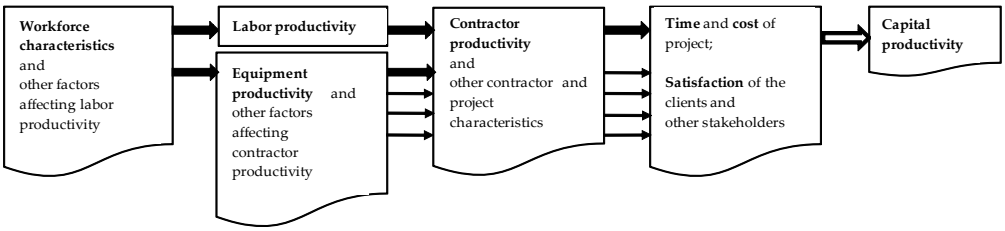


**Figure 1.** The chain of influence on productivity during the implementation of construction projects.

The productivity of construction contractors is a dynamic category dependent on many factors, in connection with which certain corrective measures can be taken in a timely manner. In order to be able to manage productivity comprehensively and successfully, it is necessary to determine which characteristics and how these characteristics of workers significantly affect labor productivity.

## 2. Literature Review: Previous Research on the Influence of Labor Force Characteristics on Labor Productivity and the Performance of Construction Projects

### *2.1. The Influence of Labor Force on Achieving the Goals of Realization of Construction Projects*

Most research on the impact on construction performance or time (delay) and cost of realization of construction projects consider some of the attributes of the labor force as important influencing factors. Based on past research papers, Soekiman et al. [14] compiled a list of 113 factors affecting construction labor productivity. Of the total number of factors, 18 factors are included in the group "labor", and some of them are related to the personal attributes of workers. Zidane and Anderson [15] found out that, in 105 studies (1988–2017) from 46 countries worldwide, "poor labor productivity and shortening of skills" is 8th in the top ten universal delay factors (that factor was cited in 45% of studies). Asmi et al. [16] reviewed 12 studies (1996–2009) and found that "labor productivity" is the 5th to 7th factor of delay according to the frequency of appearance (in 42% of studies). Hesham et al. [17] reviewed 14 articles on research of causes of delay (2002–2016) and found that 50% of them include "unqualified workers" and 36% of them include "poor productivity of workers". Abebe [18] reviewed 24 surveys of causes of construction delays in 17 African countries (2010–2020) and found out that "low productivity of labor" and "shortage of skilled labor" were second ranked factors (each in 54% of surveys), and "unqualified/inadequate experienced labor" was the sixth ranked factor (in 38% of studies).

In these studies, questionnaires are mostly used for data collection and evaluation. The assessment of impact factors is usually from 1 to 5, and the rank can be determined according to mean score (MS), relative importance index (RII), average index (AI), important weight (IW), severity index (SI),

frequency index (FI), important index (IMP.I), etc. (The same factors are sometimes called differently in different studies).

Table 1 highlights the labor attributes, which in surveys in 41 different countries and parts of countries published in the last decade, are ranked as factors that affect the performance of construction projects (P), i.e., their delay (time overrun—T) and cost (C), with minimal uniformity of originally used terms. In order to better identify the significance and ratio of the magnitudes of individual factors, Table 1 contains, for each survey, the data of the respondents (project manager—Pm, project designer—Pd, clients—Cl, consultants—Cns, and contractors—Cnt), on the total number of evaluated factors (in relation to contractors) and the rank since they have different perceptions of the magnitude of the influence of individual factors.

**Table 1.** Influence of worker characteristics on the performance and goals of construction projects according to 55 chronologically arranged research papers. Construction projects—P, time overrun—T, cost—C, project manager—Pm, project designer—Pd, clients—Cl, consultants—Cns, contractors—Cnt.

| Reference & Area of Research | Number and Structure of Respondents | No. of Factors | Affect on | Rank Factor (Related to Labor) Which Affects Realization of the Construction Project |
|---|---|---|---|---|
| [19], Malaysia | 15 construction experts in Cl, Cns, and Cnt | 59 | C | 28–30. Labor productivity |
| [20] Central regions of Malaysia | 140 Cnt (46%), Cns (38%), and Cl (16%) | 8 | T&C | 6–7. Labor resource |
| [21], UK | 44 Cns (43%), Cnt (30%), and Cl (27%) | 45 | T | 18./22./23. Low skill of manpower—according to Cl/-according to Cnt/-according to Cns |
| [21], Libya | 72 Cl (39%), Cnt (33%), and Cns (28%) | 45 | T | 2./10. Low skill of manpower—to Cl/-to Cns and Cnt |
| [22], West. Australia | 32 Cns (53%), Cnt (34%), and Cl (13%) | 48 | T | 1. Shortage of skills |
| [23], Afghanistan | 60 Cl, Cns, and Cnt | 83 | T | 4. Unqualified workforce—according to Cl |
| [24], Malawi | 45 managers and engineers in Cnt (44%), Cl—Malawi Roads (29%), and Cns (27%) | 72 | T | 26. Low productivity of labor<br>37. Unqualified workforce |
| [25], Egypt | 2500 managers and engineers in 400 Cnt and Cns | 99 | T | 19. Unqualified/inadequately experienced labor<br>32. Low productivity of labor<br>85. Low motivation and morale |
| [26], Turkey | 64 managers, engineers, site supervisor, technician, and architects | 83 | T | 7–8. Unqualified/Inexperienced workers<br>31. Low worker productivity<br>52. Low worker motivation and morale |
| [27], Albania | 26 Pd (50%), and managers & engineers (50%) in Cns, Cnt, and Cl | 27 | C | 17–18. Labor productivity |
| [28], Jordan | 30 engineers in Cl—Ministry of public works and Cnt | 37 | T | 8–10. Presence of unskilled labors |
| [29], Jordan | 145 Cns (37%), Cl (32%), and Cnt (31%) | 45 | T | 25. Presence of unskilled labors |
| [30], Kuwait | 162 senior managers in Cnt | 45 | C | 19. Low labor productivity |
| [31], Egypt | 33 Cl, Cns, and Cnt organizations | 43 | T | 4. Low productivity of labors<br>10. Unqualified workforce |
| [32], Kampala, Uganda | 52 participants in the realization of construction projects | 27 | T | 12. Unqualified/inadequate experience<br>13. Low motivation and morale of labor<br>14. Low productivity of labor |
| [33], Hanoi, Vietnam | 51 graduate and postgraduate respondents in Cnt | 25 | T | 11–12. Workers' awareness<br>13–14. Low skilled workers |
| [34], Tamil Nadu, India | 60 engineers in private sector (50%) and in government (50%) | 54 | C | 3./4. Unqualified/inadequate experienced labor—District engineers/-Private engineers |
| [35], Tamil Nadu, India | 100 engineers in the private sector (50%) and in the government sector (50%) | 40 | T | -Low productivity of labor (All outside top ten)<br>-Unqualified/inadequately experienced labor<br>-Low motivation and morale of labor |
| [36], Sri Lanka | 58 building construction projects | 44 | T | 7. Low productivity of labors |
| [37], Jordan | 106 Cl (36%), Cnt (34%) and Cns (30%) | 49 | C | 18. Low productivity of labor |
| [38], Iraq | 134 Cnt (34%), Cns (34%), and Cl (32%) | 65 | T | 15. Poor manpower productivity—to Cnt |

**Table 1.** *Cont.*

| Reference & Area of Research | Number and Structure of Respondents | No. of Factors | Affect on | Rank Factor (Related to Labor) Which Affects Realization of the Construction Project |
|---|---|---|---|---|
| [39], Botswana | 39 Pm and team member and others from Depart. of Build. and Engineer. Services | 77 | T&C | 17. Low productivity of labor<br>30–31. Unqualified/inadequate skill labor<br>35. Low motivation and morale of labor |
| [40], Slovenia | 62 Cl, Cnt and engineers, Pd and managers | 12 | T | 10. Unqualified workforce |
| [41], Poland | 927 Cl | 18 | T | 2. Quality of workforce |
| [42] Mecca, S. Arabia | 28 Cnt (75%), Cns (14%), and Pm (11%) | 81 | T | 1–2. Low productivity of labor<br>6. Unqualified workforce |
| [43], Qatar | 179 Cnt & Subcontractors (46%), Cl (30%), Cns (17%), and others | 42 | T | 1./7. Low productivity of labor—to FI/-RII<br>5./8. Unqualified workforce—to FI/-RII |
| [44], Kuwait | 22 engineers in Cnt, Cns and Cl | 40 | T | 28. Low productivity levels of general labor or qualified trade personnel |
| [16], Jakarta, Indonesia | 88 Cnt (64%), Cns (18%), Developer (9%), and Cl (9%) | 57 | T | 9. Labor productivity |
| [45], South Gujarat, India | 80 site supervisor, project engineer and Cnt | 54 | C | 20–21. Unskilled labor |
| [46], Jhansi area, India | Number and type of respondents unknown | 58 | T | 3. Thefts on site<br>7. Low productivity of labors |
| [47], India | Cnt, Cns, and public Cl (number of respondents unknown) | 24 | T&C | 5. Unskilled operators<br>7. Low productivity of labor |
| [48], India | Cns and Cnt (number of respondents unknown) | 78 | T | 17. Low productivity of labor<br>23. Unskillful equipment operator |
| [49], Afghanistan | 30 related ministries | 30 | T | 18. Low productivity of labors<br>20. Low motivation and morale of labor |
| [50], Ethiopia | 51 Cnt (35%), Cl (35%), and Cns (30%) | 88 | T | 8. Low productivity of labor<br>9. Unqualified/inadequately experienced labor |
| [51], Western Ghana | 99 construction professionals | 34 | T | 17–18. Unqualified workforce |
| [52], Lagos Alure, Ondo state, Nigeria | 60 engineers, quantity surveyors and architects in Cl (42%), Cns (33%), and Cnt (25%) | 30 | T | 13. Labor productivity |
| [53] Lagos Mega-city, Nigeria | 86 architects, engineers, builders, and quantity surveyors in Cnt | 32 | T | 7. Labor productivity<br>30. Low motivation and morale |
| [54], Ethiopia | 77 experienced participants (type of respondents unknown) | 52 | T | 12. Unqualified/inexperienced workers<br>37. Low productivity<br>39. Less motivation and morale<br>52. Discipline problem |
| [55], South Africa | 75 Cns (37%), Cnt (36%), and Cl (27%) | 48 | T | 18/25. Low productivity of labors |
| [56], Pakistan | 96 practitioners involved in construction industry | 42 | T | 16. Poor skill labor |
| [57], Afghanistan | 51 Cnt (45%), Cl (35%), and Cns (20%) | 69 | C | -Low productivity of labor (outside top 10) |
| [58], Yemen | 22 Pm in Cnt (54%), Cns (32%), and Cl (14%) | 55 | P | 3. Low labor productivity |
| [59], Iran | 175 Cl (36%), Cnt (33%), and Cns (31%) | 78 | T | 7–9. Unqualified workforce<br>18–19. Low productivity of labors |
| [60], Edirne, Turkey | 34 architects, builders, civil engineers, and other in Cnt and Cl | 54 | T | 8. Unskilled and/or unqualified labors |
| [61], Egypt | 67 Cnt (40%), Cns (33%), and Cl (27%) | 26 | T | 1. Labor productivity<br>3. Motivation and morale of labor |
| [62], UAE | 194 managers and engineers | Unknown | C | 1. Poor productivity |
| [63], Morocco | 330 Cnt (57%) and Cns (43%) | 49 | T | 10. Unskilled workforce<br>19. Low productivity of workers |
| [64], Bangkok & Vicinity, Thailand | 345 Pm, engineers, and executives in construction companies | 57 | P | 20. Workers' Moral<br>31. Labor productivity<br>36. Teamwork |
| [65], Central Sulawesi, Indonesia | 38 section chiefs, work unit heads, commitment officers, assistants, and field supervisor coordinators | 36 | T | -Low labor productivity (all outside top 3 factors)<br>-Low mentality and morality |
| [17], Jordan | 113 Cl (54%), Cns (27%), and Cnt (19%) | 56 | T | 43. Unqualified workers<br>48. Poor productivity of workers |

**Table 1.** *Cont.*

| Reference & Area of Research | Number and Structure of Respondents | No. of Factors | Affect on | Rank Factor (Related to Labor) Which Affects Realization of the Construction Project |
|---|---|---|---|---|
| [66], Shan-Ewadh, India | 40 Cnt, engineers, different departments | 81 | T&C | 3. Unskilled labors/labor strikes |
| [67], South Korea | 33 BIM Cns (33%), Cl (18%), Cnt (15%), architects (15%), managers (12%), and others | 34 | T | 15. Low labor productivity |
| [68], South western part of Nigeria | 78 engineers (46%), quantity surveyor (23%), architects (19%), and builders (12%) | 12 | C | 4./7–8. Low productivity of labor—Tendering methods selective/-Competitive open |
| [69] Abuja, Lagos & Portharcourt, Nigeria | 129 Cnt & Subcontractors (47%), Site-engineers (19%), Cns (17%), Pm (9%), and Cl (8%) | 20 | C | 10. Low skilled manpower |
| [70] Portugal | 94 Cnt (56%), Cns (32%), and Cl (12%) | 47 | T | 10. Poor labor productivity and shortage of skills |

In 65.5% of the research in Table 1, "labor productivity", which results from several attributes of workers, is included among the influential factors. In 56.4% of the research, the impact of skills/qualifications of the workforce was evaluated (in seven studies "experience" is also stated in addition to "skills"), and in 20.0% "morale/morality" (independently or with motivation). The established rank of the importance of labor productivity and the attributes of workers differ significantly, so, for example, "labor productivity" in the reviewed studies is ranked in the range of 1st to 48th place.

Looking at the results of the studies, it can be seen that the impact of "labor productivity" on the performance of construction projects is greater in cases where:

- there are no other problems that interfere with the performance of works, or where there is good organization of performance (no shortages of materials, equipment, equipment failures, etc.),
- there are no problems with working conditions (extremely negative environmental impacts),
- there are no changes to the project during execution,
- there are no problems with the delay of payment for work performed, and
- there are no other problems with the investor or consultants.

### 2.2. Characteristics of Workers Affecting the Construction Productivity

Inconsistency of labor productivity is a severe problem in many countries. Therefore, labor productivity and factors affecting productivity has become one of the most regular topics for researchers [1,2,71–76].

Borcherding [77] states that selection of workers is one of the factors that most influences productivity in large construction projects. Based on surveys of leading construction companies in Singapore, Alum and Lim [78] identified that hiring suitable workers is among the three most important factors affecting productivity. A survey by Mojahed and Aghazadeh [79] reveals that the skills and experiences of the workforce are the most influential factors for construction productivity on wastewater treatment plant projects in southern United States. Huang et al. [80] reviewed the literature and found that skilled labor availability is the most common influencing factor for productivity in U.S. construction. According to research by Inuwa [81] in Nigeria, adequate and competent workforce is a top-ranked measure for enhancing contractors' project planning.

In studies of the impact on productivity and performance of construction projects, factors are often divided into groups called "people", "workforce", "labor characteristics", etc. These groups include a number of attributes of workers and various other influences related to human resources (there is no uniformity in their definition). A comparative presentation of the relationship between the determined values of direct and indirect influences of the attributes of construction workers on labor productivity according to four research studies is given in Table 2 (research [76,82] shows only skill aspect factors).

**Table 2.** Comparison of the extent of influence of workers' attributes researched in four previous papers (the mentioned ratios of magnitude influence were calculated from the data in published studies).

| Research | Worker Attributes | Experience (and knowledge *) | Good Habits and Work Practices | Learning at Work | Training (at Work*) | Education Level | Age | Strength | Dexterity | Possibility of Independent Work | Sense of Responsibility & Willingness to Accept the Responsibility | Willingness to Improve Work Attitudes | Initiative | Pride and Interest in Work | Commitment to the Performance of Task | Personal Issues | Misunderstanding Among Workers | Co-operation with Management | Absenteeism |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [82], UK | | 1.0 | | | 0.63 | | | 0.75 | 0.50 | | | | | | | | | | |
| [83], Singapore | | | 0.95 | | | | | 0.86 | | | 1.0 | 0.94 | 0.84 | 0.90 | | | | 0.92 | |
| [76], Malaysia * | | 1.0 | | 0.89 | 0.82 | 0.77 | | | | 0.94 | 0.93 | | | | 0.97 | | | | |
| [84], India | | 1.0 | | | | | 0.83 | | | | | | | | | 0.50 | 0.65 | | 0.96 |

* Only skill aspect factors (the influence of the group of factors "communication aspect" and "work culture aspect" was evaluated especially and "good interpersonal relationship between the workers" was ranked first, while "sharing knowledge and work information" and "attitude and behavior of people at the construction site" was ranked second).

In a study of negative factors impacting productivity on construction sites in Croatia 35 years ago, Oštarijaš [85] singled out 9 basic factors, among which are poor characteristics of workforce—insufficient training of workers, alcohol consumption on construction sites, and smoking and rest at unforeseen times. According to the survey in the Czech Republic [86], the productivity of small construction companies is mostly influenced by training and experience of the workforce, while in medium and large companies it is the 5th–8th factor (out of 17 factors).

Based on the scoring of results of 47 studies in 28 countries during the period 1983–2019, Hamza et al. [87] found that "worker efficiency/skills training" and "effectiveness/experience" of workers are 4th and 5th ranked factors according to construction labor productivity, while "personal problems" are 32nd–33rd ranked factors (out of 34 analyzed factors). Although the included studies examined the effects of different factors, some of them did not consider the characteristics of the workers at all.

In Table 3, the characteristics of different types of construction workers (craftsmen, auxiliary workers on site, equipment operators, and others) have been evaluated in research on the impact on construction productivity in the period from 2012 to 2020 in 44 different countries, regions within countries, and groups of countries on five continents. Part of the conducted research defines as an influential factor one or more characteristics of workers, while part of the research considers as an influential factor the absence of some of these characteristics (e.g., lack of skills, lack of training or inadequate training, poor health, etc.).

**Table 3.** Attributes of construction workers that affect productivity evaluated in previous research.

| Labor (Worker/Craftsmen) Characteristics as Factors Influencing Productivity | Label |
|---|---|
| Skills (level) | F1 |
| Quality of work/performance of labor | F2 |
| Occupational education level/training (technical knowledge) | F3 |
| Experience (level) | F4 |
| Age | F5 |
| Gender | F6 |
| Health | F7 |
| Strength and physical (fitness/ability) | F8 |
| Physical fatigue | F9 |
| Alcoholism | F10 |
| Addiction/drug abuse/similar problems | F11 |
| Personal issues (family problems, poor economic condition, etc.) | F12 |
| Loyalty | F13 |
| Job satisfaction | F14 |
| Workers' pride in their work | F15 |
| Habits | F16 |
| Discipline | F17 |
| Laziness | F18 |
| Commitment | F19 |
| Initiative | F20 |
| Team spirit among workers | F21 |
| Labor morale | F22 |
| Worker's integrity | F23 |
| Psychophysiological ability | F24 |
| Ability to adapt to changes and new environment | F25 |
| Sense of observance of regulations | F26 |

Table 4 provides data on research that examined the impact of worker characteristics (listed in Table 3) on productivity and their impact rank, as well as the size of the impact index, i.e., indicator.

**Table 4.** Ranking of the influence of the attributes of construction workers on productivity in the implementation of different types of construction projects in 55 chronologically arranged research. Construction projects—P, time overrun—T, cost—C, project manager—Pm, project designer—Pd, clients—Cl, consultants—Cns, contractors—Cnt.

| Reference & Area of Research | Number and Structure of Respondents | No. of Factors | Influence of Labor Force Characteristics on Construction Productivity |
|---|---|---|---|
| [88], USA | 28 project engineer (39%), Pm (14%), architect (11%), and others (36%) | 40 | 12. F4 ($RII_2$ = 488.75); 30. F10 ($RII_2$ = 425.50); 34. F5 ($RII_2$ = 408.25); 39. F13 ($RII_2$ = 373.75); 40. F12 ($RII_2$ = 368.00) |
| [89], Iran | 82 biggest construction companies | 31 | 3. F1 and F4 |
| [90], Malaysia | 37 managers, engineers, and others in Cnt | 5 | 3. F1 and F3 (MS = 3.95) |
| [91], Lagos, Nigeria | 37 architects, builders, civil engineers from const. comp. | 16 | 1. F4 (MS = 4.38)<br>14. F5 (MS = 3.25) |
| [92] South Gujarat, India | 51 Cnt | 27 | 3. F1<br>7. F9 |
| [8], Kerale, India | 185 site engineers/supervisors (49%), craftsmen (32%), and Pm (19%) | 44 | 13. F4 (SI = 0.32); 23. F21 (SI = 0.30) |
| [93], Chambal Region, India | 37 professionals on the project from management to execution level | 45 | 5. F9 (RII = 72.43%)<br>9. F1 (RII = 69.72%) |
| [94], Spanish | 376 different employees of construction companies | 35 | 5. F1 and F4 (RII = 83.16%)<br>11. F25 (RII = 80.84%); 17. F23 (RII = 75.00%) |
| [95], New Zealand | 37 Cnt & subcontractors (61%), and Cns (39%) | 56 | 6. F1 and F4 (MS = 3.83)<br>14. F19/Level of motivation (MS = 3.60);<br>41. F7 (MS = 2.79) |
| [96], Trinidad & Tobago | 30 Cnt | 42 | 5. F1 (RII = 87.5%)<br>30. F9 (RII = 71.67%) |
| [97], GCC | 16 Cnt (81%), Cns (13%), and Cl (6%) | 40 | 8–13. F4 (RII = 38%)<br>8–13. F12 (RII = 38%); 14–20. F13 (RII = 31%) |
| [98], Saudi Arabia | 41 Cnt | 32 | 1. F4 (RII = 75.1%)<br>13. F13 (RII = 63.5%); 26. F12 (RII = 52.2%) |
| [99], Gaza Strip, Palestine | 110 craftsmen (at 25 sites) | 20 | 5–6. F4 (R = 0.70) |
| [100], Egypt | 55 Cnt, Cns, managers, and engineers | 27 | 2. F1 (RII = 86.91%)<br>12. F9 (76.00%) |
| [101], South Africa | 62 managers, site engineers, quantity surveyors, and architects in Cnt (60%), Cnt (21%), architect. (11%), and proj. management firm (8%) | 178 | 16–18. F1—equipment operator (MS = 4.23);<br>41–46. F17 (MS = 3.98); 61–69. F10 (MS = 3.85);<br>84–88. F9 (MS = 3.74);<br>102–103. F5 (MS = 3.60) |
| [102], Zimbabwe | 43 Cns (51%) and Cnt (49%) | 40 | 5. F1 (MS = 4.14)<br>6. F4 (MS = 4.05) |
| [103], South-South Zone of Nigeria | 1043 craftsmen (60%) and project supervisors/engineers (40%) | 15 | 1. F15 (MS = 3.55)<br>2. F1 (MS = 3.26)<br>5. F12 (MS = 3.09)<br>6. F4 (MS = 2.98)<br>7. F7 (MS = 2.95)<br>12. F13 (MS = 2.59); 13. F5 (MS = 2.56);<br>14. F10 & F11(MS = 2.49) |
| [104], Nairobi County, Kenya | 99 foremen, contactors, cost estimators, const. managers, and others in contractors company | 12 | 1. F3/F1 (frequency of responses to get weighted total for responses =138) |
| [105], Saudi Arabia * | 36 professionals (from top managers to technicians and foremen) in 3 off-site Cnt | 43 | 5. F4 (II = 0, 63.89%)<br>12. F12 (II = 55.56%); 20–24. F13 (II = 52.22);<br>38. F5 (41.67%) |
| [106], Iraq | 83 employees in 9 Cnt & subcontractors (73%) and in Governmental Technical Department (27%) | 21 | 1. F4 (RII = 95.18%)<br>7. F12 (RII = 73.49%)<br>13. F5 (RII = 70.48%); 21. F13 (RII = 62.35%) |
| [107], Pakistan | 100 engineers in construction company | 41 | 1. F4 (RII = 0.89)<br>7–8. F5 (RII = 0.81)<br>15–18. F13 (RII = 0.74); 19–20. F7 (RII = 0.72) |
| [108], Karachi, Pakistan | 134 Cnt (41.2%), Cns (38.2%), and Cl (20.6%) | 37 | 3. F1 (RII = 0.79)<br>12. F17 (RII = 0.73); 17. F9 (RII = 0.71);<br>21. F10 & F11(RII = 0.69) |
| [109], Turkey | 126 craftsmen employed in 4 construction projects | 37 | 21–22. F3 (MS = 3.53) |

**Table 4.** *Cont.*

| Reference & Area of Research | Number and Structure of Respondents | No. of Factors | Influence of Labor Force Characteristics on Construction Productivity |
|---|---|---|---|
| [110], Egypt | 227 Pm, engineers, construct. managers, foremen, site supervisors, quantity surveyors and architects in construction companies | 41 | 4. F17 (RII = 82.63%)<br>7. F4 and F1 (RII = 81.96%)<br>13. F12 (RII = 80.4%); 24. F9 (RII = 74.5%);<br>25. F5 (RII = 74.3%) |
| [111], Bale Zone in Oromia, Ethiopia ** | 83 Pm, engineers, mason, foreman, superintendent and others in 9 road construction projects | 61 | 1. F4 (RII = 0.91)<br>3. F1 (RII = 0.84)<br>6. F16 (RII = 0.89)<br>23. F13 (RII = 0.71); 24. F23 (RII = 0.70);<br>25. F12 (RII = 0.68); 33. F25 (RII = 0.64);<br>50. F5 (RII = 0.57) |
| [112], Jordan | 150 Cnt (33.3%), Cns (33.3%), and Cl (33.3%) | 37 | 23. F12 (RII = 61.37%)<br>32. F20 (RII = 54.86%) |
| [113], Madurai, India | 77 Pm, engineers and labors | 72 | 3. F10 (MS = 4.17)<br>20. F4 (MS = 3.71); 56. F12 (MS = 3.13);<br>66. F13 (MS = 2.99); 72. F5 (MS = 2.78) |
| [114], Gwalior, India | 23 Pm, project coordinators, site engineers, and Cl | 26 | 8. F4 (RII = 0.62)<br>-F13;—F12 (outside top 10) |
| [115], Tamil Nadu, India | 108 Pm, site engineer, architect and other at different level from the various constr. industries | 54 | 1. F1 and F4 (RII = 86.48%)<br>3. F7 (RII = 85.98%)<br>-F22/F19;—F5 (outside top 10) |
| [116], India | 35 Pm (40%), engineers (34%), Cnt (23%), and Cns (3%) | 25 | 8. F1 (Importance according to AHP = 0.045)<br>23. F4 (Importance according to AHP = 0.013) |
| [117] India *** | (number and type of respondents unknown) | 48 | 9–11. F1 (RII = 0.65)<br>18–19. F7 (RII = 0.59); 20. F5 (RII = 0.58);<br>30–31. F8 (RII = 0.56) |
| [74], India | 140 employees in construction sector from top management level to operational level | 24 | 8. F1 (RII = 0.741)<br>10. F1 and F2 (RII = 0.739) |
| [118] Peshawar Khyber Pakhtunkhwa, Pakistan | 100 Cl, Cns, Cnt, and civil engineers | 23 | 3. F1 (RII = 0.78)<br>12. F3 (RII = 0.64); 16. F9 (RII = 0.58) |
| [119], Cambodia *** | 73 Cnt, project engineers, and Pm | 36 | 21. F3 (RII = 0.687); 23. F7 (RII = 0.654) |
| [120], Singapore | 32 Pm, quantity surveyors and team members in Cns (38%), developers (37%), and Cnt (25%) | 26 | 2. F4 (MS = 3.84)/1. in green building projects—(MS = 4.44)<br>5. F1 (MS = 4.06)/5. in green building projects—(MS = 4.22) |
| [121], Singapore | 65 managers | 14 | 1. F1 (MS = 4.36) |
| [122], Klang Valley, Malaysia **** | 170 Cnt | 19 | 3. F4 (IMP.I = 60.0%)<br>18. F12 (IMP.I = 14.4%) |
| [123], Saudi Arabia | 1454 employees at Cnt & subcontractor on the 25 construction projects | 31 | 5. F3 and F4 (MS = 4.02) |
| [124], Croatia | 157 civil engineers | 17 | 2. F14 (RII = 4.17)<br>7. F17 (RII = 3.55) |
| [125], Egypt ***** | 50 Cl, Cns, and Cnt | 86 | 17. F4, F1 and F2 (II = 0.78);<br>52–55. F18 (II = 0.65) |
| [126], India | 108 Pm and engineer, architect and other on project from management level to operational level | 19 | 1. F1 and F4 (RII = 86.48%)<br>3. F7 (RII =85.98%)<br>-F5;—F19 (outside top 10) |
| [127], India | 50 (type of respondents unknown) | 43 | 27–30. F7 (RII = 0.69); 31–32. F16 and F11 (RII = 0.67); 35–38. F5 (RII = 0.65);<br>42–43. F12 (RII = 0,61) |
| [128], Hanoi, Vietnam | 185 (type of respondents unknown) | 43 | 1. F4 (RII = 4.31)<br>2–3. F17 (RII = 4.28)<br>9. F8 (RII = 4.20)<br>19. F26 (RII = 3.81); 24–26. F24 (RII = 3.74);<br>32–33. F5(RII = 3.52);<br>40. F6 (RII = 3.22); 43. F3 (RII = 3.08) |
| [129], Alberta, Canada ****** | 35 tradespeople (as foreman, laborer, equipment operator and welder—57%) and Pm experts (43%) | 14 | 2./3. F4—equipment operator (score = 90.22%)—Tradespeople/(score = 91.58%)—Project management<br>5./9. F1—crew (score = 85.86%)—Project management/<br>(score = 79.21%)—Tradespeople<br>6–8. F1—equipment operator<br>(score = 81.17%)—Project manager<br>7. F4—Crew (score = 82.69)—Tradespeople |

**Table 4.** *Cont.*

| Reference & Area of Research | Number and Structure of Respondents | No. of Factors | Influence of Labor Force Characteristics on Construction Productivity |
|---|---|---|---|
| [130], Poland | 142 craftsmen (54%) and engineers, managers, directors, construction company owners, and others (46%) | 17 | 2. F7 (MS = 4.27)<br>3. F9 (MS = 4.18)<br>5. F5 (MS = 3.83)<br>17. F8 (MS =3.09) |
| [131], Iran and Lithuania (for all) ******* | 4 members of the project management team | 18 | 4. F3 (fuzzy importance measures = 0.45%)<br>10. F4 (fuzzy importance measures = 0.03%) |
| [132], Iran | 63 Cl, Cns, and Cnt | 60 | 1. F9 (Effect rate = 0.135)<br>4. F1 (Effect rate = 0.108)<br>-F4 (outside top 12) |
| [133], Yemen | 91 architectural and structural engineers on construction projects | 52 | 1. F4 and F1 (RII = 88.6%)<br>28. F8 (RII = 73.6%); 35. F5 (RII = 69.6%);<br>52. F3 (RII = 58.4%) |
| [134], India ******** | (number and type of respondents unknown) | 20 | 2–3. F3 i.e., F1 (RII = 0.75)<br>2–3. F2—regarding the F5, wages, worker effort, work environment at the time supervision (RII = 0.75) |
| [135], Maharashtra, India | 302 construction workmen | 29 | 1. F12 (RII = 55.4%)<br>13. F9 (RII = 47.6%); 16. F13 (RII = 47.1%);<br>27. F1 (RII = 39.0%) |
| [136], Ahmedabad, Vadodara and Gandhinagar, India | 111 Pm and site engineers | 72 | 4. F1 (RII = 0.78) |
| [137], Khulna city, Bangladesh | 100 Cl, engineers, Cnt, and subcontractors | 15 | 2. F1 (RII = 0.81) |
| [138], Libya | 76 Cns, Cnt, managers, and engineers | 30 | 2. F4 and F1 (RII = 0.87)<br>18. F9 (RII = 0.65) |
| [139], South Africa | 58 Cnt (that operate on building projects) | 33 | 4. F4 (RII = 0.67) |
| [140], Vietnam | 56 Pm | 45 | 3. F17 (RII = 0.79)<br>12. F4 and F1 (RII = 0.76); 17–18. F5 (RII = 0.74);<br>17–18. F8 (RII = 0.74); 33. F3 (RII = 0.71);<br>39. F12 (RII = 0.69) |

Labor Productivity in: * off-site construction; ** road construction projects; *** residential building projects; **** non-residential projects; ***** pre-stressed concrete bridges; ****** equipment-intensive activities; ******* high-rise building; ******** precast bridge construction.

It can be seen that the studies involving factors affecting productivity often include those attributes of labor that have been considered in other studies (in Table 1) and that affect performance and delays and cost overrun in construction projects as to the goals of realization of construction projects. Tables 1–3 and Table 5 confirm the finding of previous literature reviews [141] that research differs in the structure of the study (surveys) and in evaluation of the importance of influencing factors.

According to 55 studies included in Table 4, "skills" and "experience" were the most frequently evaluated characteristics of workers and were rated as the most important in terms of impact on productivity. The number of considerations and the assessed importance for the most significant characteristics in the studies from the Table 4 are presented in Figure 2. The importance was determined by the score for the ten first-ranked factors in each study (so the first-ranked received 10 points and the tenth-ranked received 1 point) divided by the maximum possible score, i.e., 55 × 10 (e.g., for "skills" 190/550 × 100 = 36.2%). Frequency percentage was calculated as the ratio of the number of studies in which a certain characteristic is evaluated (regardless of rank) and the total number of studies reviewed (e.g., for "experience" 34/55 × 100 = 61.8%, for "skills" 32/55 = 58.2%, etc.).

The Mechanical Contractors Association of America has published over the years a number of factors that affect labor productivity in the U.S., and since the 1970s their list of "factors affecting productivity" includes "morale" [142]. In the analyzed studies, morale is considered more often in studies of impact on time and performance than in studies of the impact on productivity. Horner and Witehead [82] define morale as a separate factor influencing labor productivity, and do not show how much more morale influences worker skills compared with the influences of other worker characteristics (listed in Table 2). According to [82], morale is rated in terms of good humor, cooperative attitude,

pride in work, good timekeeping, and complaints, all equally weighted. Such an interpretation is closely related to management action and employee motivation. In addition to denoting the level of enthusiasm, morale (in Croatia) is also defined as a set of social norms associated with behavior according to the principles of honesty and integrity, i.e., morality. A number of studies on impacts on labor productivity do not directly mention worker morality, but moral-related traits (e.g., integrity, theft, and general behavior).

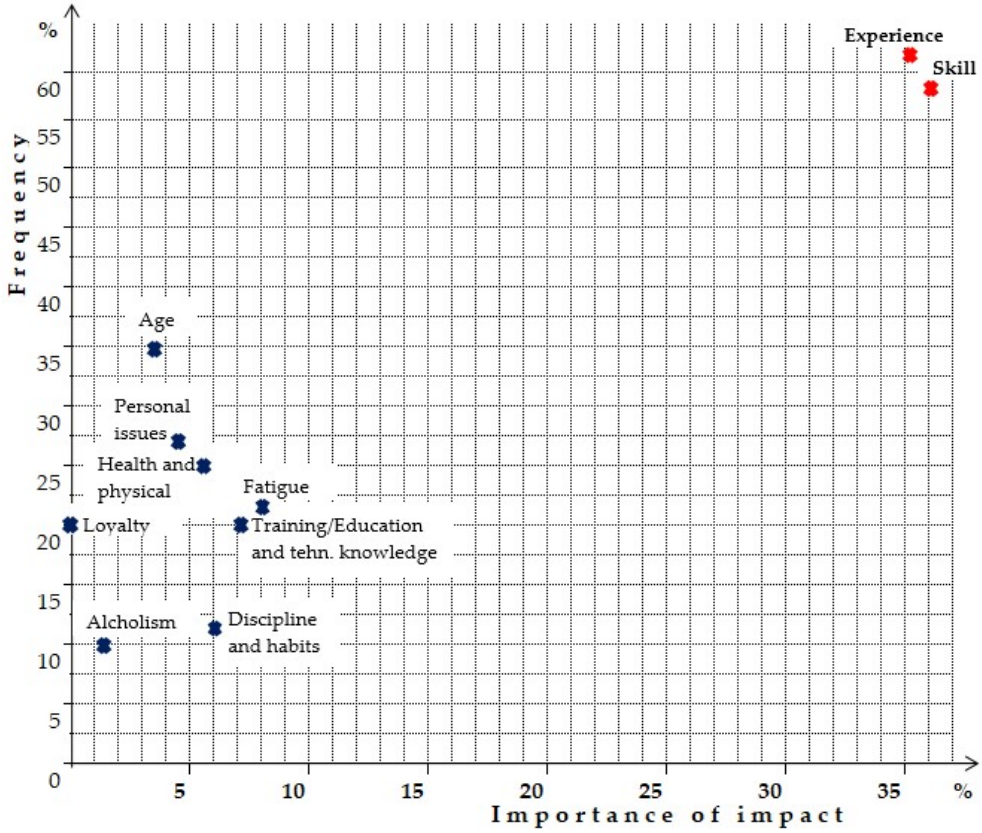


**Figure 2.** Frequency and importance of attributes of labor determined in all studies from Table 4.

**Table 5.** Factors associated with labor that are under the dominant influence of management and other factors.

| Influenced Factors | Studies on Impacts on Project Performance and Contractor Productivity |
|---|---|
| Shortage of skilled and/or experienced labor | [7,16,21,37,52,53,62,70,80,92,93,96,100,101,104,105, 112,117,119,125,136,143–155] |
| Lack of training or level of training | [62–64,95,96,102,105,114,115,117,121,128,131,132,134, 137,148,156–158] |
| Absenteeism/late arrival, early quit, and frequent unscheduled breaks | [8,14,16,19,25,34,45,53,65,84,88,91,95,98,99,102–105, 107,108,110–113,115,119,122,123,126,127,129,130,133, 135,145,159] |
| Lack of respect and personal relationsbetween workmates | [17,25,35,48,57,59,98,99,105,106,111–113,115,116,122– 124,132,160–162] |

Quite a number of research papers have identified the importance of some other factors that are closely related to the personal attributes of workers as influential on the performance of construction projects and influences on labor productivity. However, these factors are strongly influenced by

company management, social environment, and the labor market in various ways. These factors, and corresponding research that evaluated their impact, are listed in Table 5.

Absence from work and late arrival, early departure, and frequent unnecessary breaks outside the planned schedule significantly depend on discipline, work habits, competition and morale of workers, as well as on supervision and motivation (reward or punishment) by the management of contractor.

Many studies have identified motivation as a factor related to the workforce with a significant impact on productivity. However, it has not been considered in this study because, although it depends on the needs and preferences of individuals [163,164], apart from intrinsic motivation, motivation of workers primarily depends on competent management. (Thus, for example, the same worker may be motivated and productive in one company and not in another).

## 3. Investigation of the Influence Attributes of Construction Workers on Productivity in Croatia

### *3.1. Objectives, Scope and Methodology of the Research*

The main objectives of this research include the following:

- To identify the influence of construction worker attributes on contractors' labor productivity in Eastern Croatia (i.e., Slavonia and Baranja region).
- To determine the relationship between worker attributes and other factors that affect productivity.
- To quantify the influence of the possession and absence of important characteristics of workers on labor productivity in Slavonia and Baranja.
- To test the relevance of the assessed importance of worker characteristics by comparing the rankings of the characteristics between two different groups of respondents.
- To identify general actions that can be taken to influence the considered attributes of workers in order to increase contractor productivity.

The research was performed through the steps shown in Figure 3.

### *3.2. Defining the Attributes of Workers to Examine the Influence on Labor Productivity*

Based on the literature review, a list of worker characteristics that affect productivity was compiled. This list was further reviewed and updated through semi-structured interviews with seven civil engineers and one technician, who had more than 25 years of experience working with construction workers. Positive and negative impacts on the productivity of construction contractors resulting from a possession of higher level of labor characteristics or lack of labor characteristics (along with the action of other factors) selected for the survey were defined. This is shown in Table 6.

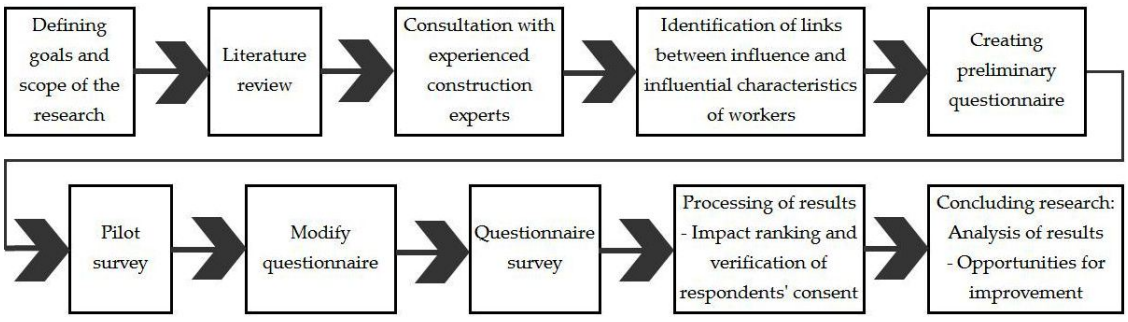


**Figure 3.** Flow chart of research in Croatian regions Slavonia and Baranja.

**Table 6.** Worker attributes and positive and negative effects on labor productivity in case the attributes are better or worse.

| Positive Effects on Productivity | Low Level | Considered Workers' Characteristics | High Level | Negative Effects on Productivity |
|---|---|---|---|---|
| Physical durability—faster realization of work tasks | ← | Strength, dexterity, and Education | → | Physical fatigue—slow work, |
| Good skills—flexibility (a wider range of action), quality performance, faster realization of work tasks, independent work action, working in a safe way | ← | Education and experience, dexterity, creativity | → | Lack of skills—small area of operation, operating errors (rework), slow work, non-independence in work, injuries |
| Adaptability to new conditions at work | ← | Adaptability to new conditions and situations (creativity and dexterity) | → | Inadaptability to new conditions at work |
| Good work habits and discipline, honesty, integrity, sense of responsibility, compliance with orders | ← | Morale and morality | → | Absenteeism/late arrival, early quit and frequent unscheduled breaks, theft, negligence, alcoholism |
| Good interpersonal relationships, work atmosphere and cooperation | ← | Affinity for teamwork (morale and morality) | → | Bad relations with coworkers, weak cooperation |

For the analysis of various influential characteristics, an Ishikawa chart was compiled with a focus on the influence of the labor on the productivity of construction contractors (Figure 4).

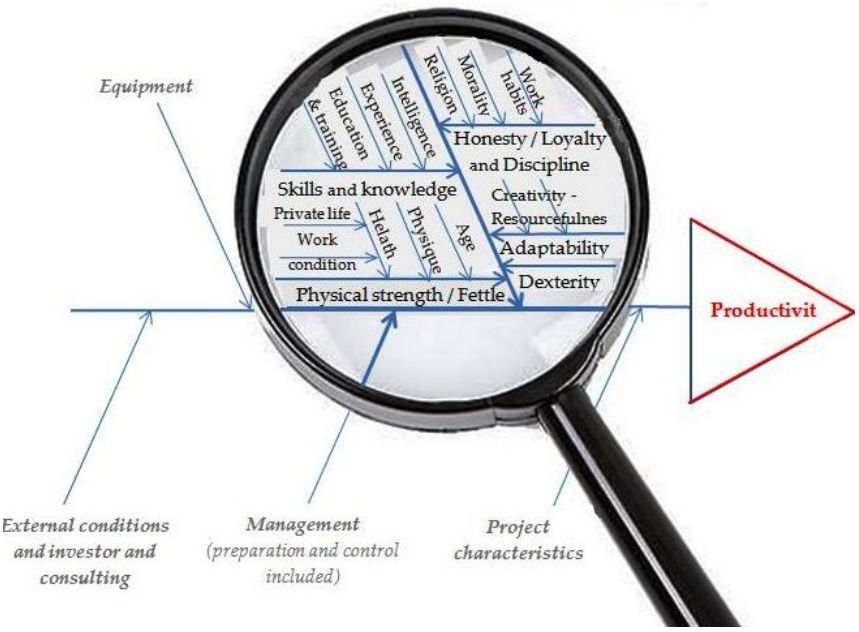


**Figure 4.** Workforce on Ishikawa chart of effects on contractor's productivity.

The consulted experts in Croatian practices emphasized the importance of independence in the work of construction workers, with additional desirable properties being the willingness to take initiative and responsibility. This is enabled by technical skills that arise from professional knowledge, i.e., training and experience.

For this research, workers' attributes that were comparable to previous surveys and that were not interdependent were selected. Physical strength was taken as one of the examined characteristics because a recent analysis by Karthik and Rao [165] showed a significant correlation between physical strength and productivity of construction labor. However, the age and health of the workers were not taken into consideration, even though physical strength is dependent on these parameters. Fatigue is

related to the physical characteristics of workers, but it largely depends on the technology and organization of work (rest schedule, etc.), and therefore has not been examined in the survey. Some of the workers' attributes mentioned in the literature (surveys included in Tables 1–4) were not included in this research in Croatia for the reasons listed in Table 7.

**Table 7.** Workers' attributes not covered by this research.

| Characteristics Omitted from the Survey | Reason for Omission |
| --- | --- |
| Loyalty, relations between workmates and superiors, diligence, obedience, job satisfaction, discipline and work habits, sense of responsibility, willingness to learn, willingness to improve work attitudes, willingness to perform overtime and shift work | Under the strong influence of other factors (largely depends on the company, or the actions of management) |
| Intrinsic motivation, personal issues, love of job, proactivity, sense of responsibility, ability to adapt to changes and new environments | It is difficult to assess the impact of such testing |
| Health, alcoholism, the sense of observance of regulations | It must be within the regulations |
| Carefulness, diligence, resourcefulness, honesty, religion | Not comparable with the results of other research |

After the pilot survey of 20 construction workers and engineers, 3 characteristics of the workers whose influence was assessed to be the least were excluded from further research—"creativity", "adaptability" (to new conditions/situations at work), and "affinity for teamwork". Furthermore, these three characteristics cannot be compared with the results of the research in Table 2. "Affinity for teamwork" and "adaptability" on average had values similar to some of the left out characteristics, so they can be taken into consideration again in future research.

Through the survey, it was possible for the respondents to suggest characteristics that were not listed, but that they considered to be important for labor productivity. None of the proposals were accepted since they were not justifiable. This fact, together with the high marks obtained for the impact of the examined characteristics, shows that the examination covered all important attributes of workers.

### *3.3. Ranking the Influence of Workers' Characteristics by Survey*

Data collection was performed using survey questionnaires that were given directly to the respondents (face to face). In the survey, grades 1 to 5 (Likert scale) were used to assess in parallel the positive impact of personal characteristics of workers on labor productivity and the negative impact in the case that these characteristics are weak or absent. (This is because some characteristics can have a very positive effect on productivity, but if their absence can be well compensated, they do not necessarily have the same negative effect). The collected responses were based on respondents' knowledge and experience and were not related to any particular building project.

The magnitude and rank of the impact were determined by the RII method, according to the equation [8,30,78,133]:

$$\mathrm{RII} = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{5\,(n_1 + n_2 + n_3 + n_4 + n_5)} \quad (1)$$

where:

$n_1$—the number of respondents who answered "very strong influence" (rated with 5),
$n_2$—the number of respondents who answered "strong influence" (rated with 4),
$n_3$—the number of respondents who answered "medium influence" (rated with 3),
$n_4$—the number of respondents who answered "weak influence" (rated with 2), and
$n_5$—the number of respondents who answered "very weak influence" (rated with 1).

Impact assessments were collected by examining 290 participants in the implementation of construction projects, employed in 60 companies for construction and supervision of construction projects in Slavonia and Baranja. A total of 28 completed questionnaires were rejected due to incorrectly completed questionnaires and inadequate profession and very few years of practice. Finally, a total of 262 completed questionnaires were analyzed.

Considering the 12,300 employees in the construction industry in Slavonia and Baranja (about 13% of construction workers in the whole of Croatia) [166], 262 answered questionnaires provide a confidence interval of 6%.

Correlation and descriptive research require at least 30 respondents in each group [167], so for the analysis, the answers of the respondents were divided according to the work they perform:

- Group A—supervising engineers and management of construction sites and construction companies and crafts,

  A1—supervising engineers (authorized supervising and members of the supervisory team), and
  A2—construction site management (headman and other engineers and construction technicians), management and owners of construction companies and crafts.

- Group B—workers at the construction site,

  B1—gang foreman and workers of various construction occupations (masons, carpenters, reinforcement workers, roofers, painters, and installers),
  B2—site mechanization operators and drivers in construction companies, and
  B3—auxiliary workers on the construction site (only with 5 and more years of practice in construction).

Figure 5 shows the percentages of respondents according to the jobs they were engaged in and their average years of experience in construction practice. The ratio of respondents from group A and group B was 37% to 63%. Supervising engineers had the most years of work in construction practice on average, and auxiliary workers the least.

### *3.4. Results of Surveys*

The survey results for all groups of respondents are processed in Table 8. The magnitudes of the positive and negative effects of the examined characteristics of workers on productivity according to the assessments of all respondents are shown in Figure 6.

According to RII values, the positive impact on productivity of "experience in construction" and "dexterity" is very high (RII > 0.80). All other assessed influences were high ($0.60 \leq$ RII $< 0.80$). The order of magnitude of the positive impact of good worker traits on labor productivity is similar to the order of magnitude of the negative impact on productivity if those traits are lacking. Spearman's rank correlation coefficient between positive and negative influence is $r_{s'} = 0.8$, (a very good correlation between the rank of positive and negative action is when $r_{s'} > 0.76$ [168].) On average, according to all respondents, the positive impact of possession of all assessed characteristics is greater than the negative impact due to their absence (from 16.4% to 40.2%). The most pronounced difference is the magnitude of the positive and negative impact of the worker's experience, which shows that respondents believe that the lack of experience can be compensated in some way (such as including an experienced worker next to inexperienced workers). The smallest difference between a positive impact and a negative impact is related to workers morale/morality (since the lack of this characteristic cannot be compensated).

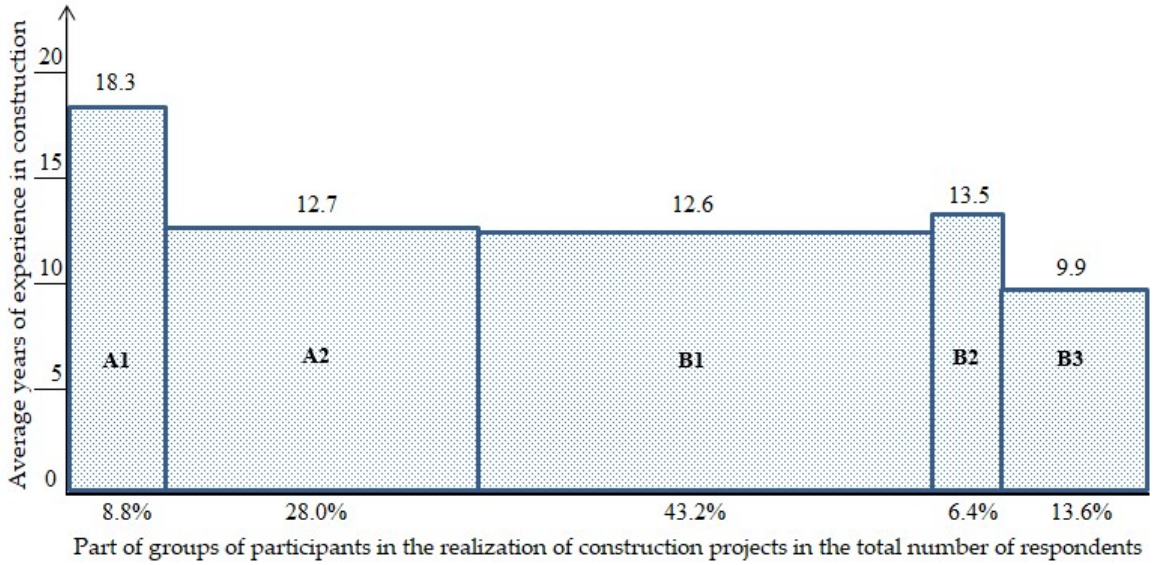


**Figure 5.** The percentages of groups of respondents and the average years of experience in construction.

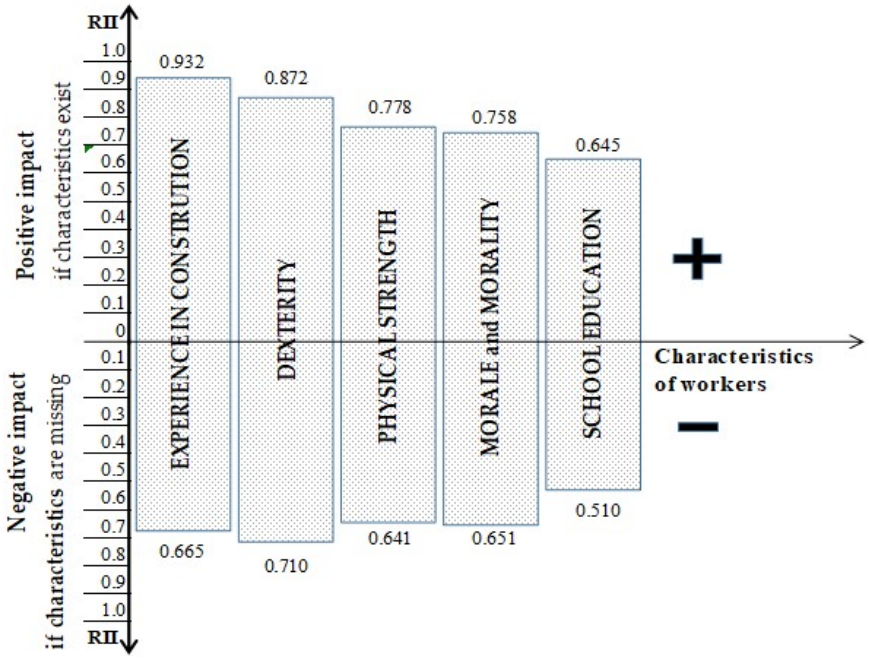


**Figure 6.** Characteristics of workers ranked by the magnitude of the impact on labor productivity according to the opinion of all respondents.

Table 8 shows that all groups of respondents also rank the first two characteristics according to the positive impact on productivity, and only supervising engineers do not rate school education as having the weakest impact. The degree of agreement in ranking the impact of worker characteristics by different groups of respondents was also expressed using Spearman's rank correlation. All groups of workers (B1, B2, and B3) also ranked all characteristics of workers according to the positive impact ($r_{s'} = 1.0$). When evaluating the positive impact of the characteristics of workers from group A and group B (the same order was obtained for the whole group A as for group A2 because there were three times more respondents in group A2 than in A1), $r_{s'} = 0.9$, which means that there was an excellent correlation, i.e., agreement. The rank of negative influence due to the absence of evaluated characteristics from group A (same for A2) and B was $r_{s'} = 0.55$, which means that there was a medium-strong and positive relationship ($r_{s'} > 0.5$ [168]) between the grades of these two groups of

respondents. Due to this agreement in ranking by different groups of respondents, the results of this study can be considered reliable.

**Table 8.** The rank of importance of workers' characteristics by groups of respondents.

| **Attributes of Workers** | **A1** | | **A2** | | **B1** | | **B2** | | **B3** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Presence of attribute** | RII | Rank | RII | Rank | RII | Rank | RII | Rank | RII | Rank |
| Experience in construction | 0.945 | 1. | 0.918 | 1. | 0.915 | 1. | 0.975 | 1. | 0.888 | 1. |
| School education | 0.654 | 4. | 0.662 | 5. | 0.624 | 5. | 0.738 | 5. | 0.624 | 5. |
| Dexterity | 0.836 | 2. | 0.903 | 2. | 0.872 | 2. | 0.887 | 2. | 0.824 | 2. |
| Physical strength | 0.609 | 5. | 0.729 | 4. | 0.831 | 3. | 0.862 | 3. | 0.782 | 3. |
| Morale/morality | 0.718 | 3. | 0.863 | 3. | 0.698 | 4. | 0.750 | 4. | 0.759 | 4. |
| **Absence of attribute** | | | | | | | | | | |
| Experience in construction | 0.682 | 1. | 0.646 | 3. | 0.664 | 2. | 0.700 | 3. | 0.677 | 2. |
| School education | 0.481 | 5. | 0.523 | 5. | 0.491 | 5. | 0.625 | 5. | 0.506 | 5. |
| Dexterity | 0.655 | 2. | 0.677 | 2. | 0.744 | 1. | 0.737 | 2. | 0.688 | 1. |
| Physical strength | 0.536 | 4. | 0.600 | 4. | 0.672 | 3. | 0.775 | 1. | 0.629 | 4. |
| Morale/morality | 0.600 | 3. | 0.714 | 1. | 0.615 | 4. | 0.637 | 4. | 0.676 | 3. |

The overall assessment of the consistency of the opinions of the respondents of all groups was determined using the Kendall coefficient. A maximum of 1 means complete disagreement, and 0 means that there is a complete match [168]. A value of 0.11 for this coefficient was obtained for the answers on the positive impact of worker traits, and 0.05 for the negative impacts of the lack of traits. These values indicate a high level of agreement of all respondents on the impact on labor productivity.

## 4. Discussion on Research Results and Improvement of Important Worker Attributes

### *4.1. Comparison of Research Results in Croatia and in Previous Research*

In the Croatian regions of Slavonia and Baranja, the "experience" of construction workers was considered the most important factor for labor productivity, similar to what was obtained in the studies of Horner and Witehead [82] in the UK, Tammy et al. [76] in Malaysia, and Jain et al. [84] in India. A study by Lim [83] in Singapore showed that "good habits and work practices" have a second-ranked impact. In this research, "sense of responsibility", which is related to employee morale, was rated the most important for improving productivity, and the positive impact of morale/morality was ranked fourth (very close to the third ranked impact) in research in Slavonia and Baranja. In this research, the impact of "physical strength" was rated one rank lower than in the research of Horner and Witehead [82]. However, in the UK, "dexterity" was rated the least important for workers' skills and labor productivity, and in Slavonia and Baranja its positive impact was ranked as second, while for the lack of worker skills, respondents considered it to have the most negative impact. It can be assumed that the reason for this is the greater need for improvisation due to the presence of poorer equipment on construction sites in Croatia than equipment in the UK.

From the workers' characteristics in Slavonia and Baranja, "school education" has the least impact on labor productivity (the positive impact of experience is 44% higher), as in the research of Tammy et al. [76] (in which experience was rated close to 30% more important) and Horner and Witehead [82] (in which experience was rated 60% more important). Tammy et al. (2019) have especially emphasized the greater importance of "learning and training at work" rather than "education level" [76]. The lack of skills in Slavonia and Baranja was rated 39% more negative for productivity than the lack of school education.

### *4.2. The Possibility of Improving Contractor Productivity through Labor Force Attributes*

The results of this research in Croatia indicate the priorities of certain workers' characteristics that need to be addressed in order to increase productivity. In order to identify possible ways to improve productivity through the labor force attributes, it is necessary to determine which attributes directly and indirectly affect productivity and which factors affect these attributes. The ability of workers consists of mental and physical activities and knowledge [169]. Figure 7 defines the flow of action and impact on the ability and willingness to work of workers, both of which, together, determine labor productivity [170].

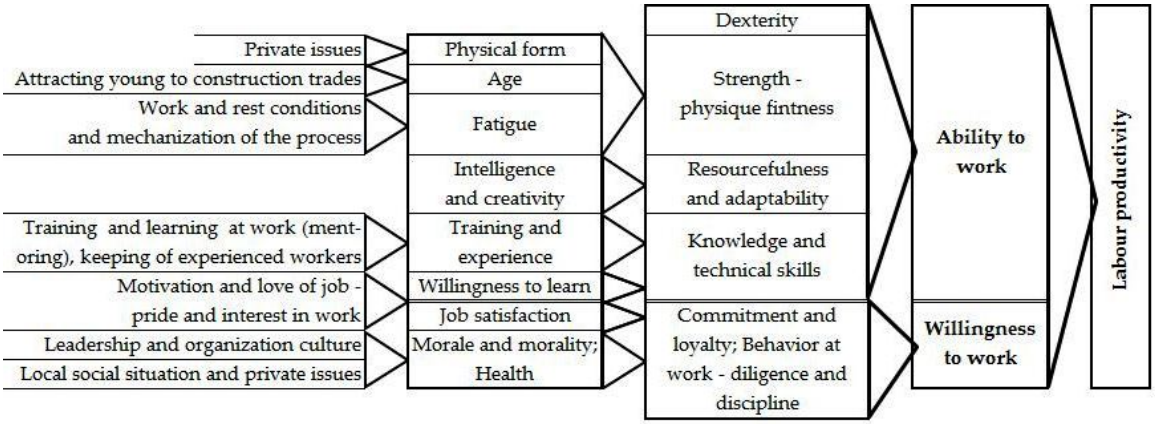


**Figure 7.** The order-related effects on labor productivity.

The employers cannot significantly influence some attributes of workers, but they should certainly take them into account when hiring and choosing workers for a particular job. In addition, it is possible for contractor management to act through:

- Leadership, appropriate supervision of workers, organization of work on the construction site (conditions for work and rest), incentive programs and development of the organization's culture;
- On-the-job training (with incentives to acquire new competencies) and an internal mentoring system for under-trained workers; and
- Recognizing and retaining existing quality, experienced workers, and attracting young, quality workers.

The employer often does not have much choice when hiring construction workers, but it is important to recognize those workers who have desirable characteristics while working with employees and try to encourage them to transfer those characteristics to other workers. A continuous and consistent business policy with personalized measures is needed to maintain employee satisfaction, at least to the extent of satisfying their extrinsic (hygienic) motivational factors (i.e., avoiding dissatisfaction that would prevent workers from working within their capabilities or seeking another employer [171]).

In addition to technical skills, workers need to consider their cognitive (intelligence) and non-cognitive skills (such as personal traits and emotional stability [172]), which affect the willingness to work and thus can have a major indirect impact on labor productivity. (Non-cognitive skills can influence the use of cognitive skills [173].)

While the level of training and exercise, and especially experience, cannot be improved quickly, motivation of the worker can usually be raised very quickly. However, measures for external motivation are usually of temporary duration, i.e., until the individual's needs are met and thus the motivational cycle is completed [174]. To be effective, the way of motivating should be adapted to the psychological characteristics (preferences) of employees and their needs, because the key motivators of one compared to another worker may differ [175]. In addition, motivation is significantly influenced by work-related perceptions and the work environment [176].

Previous research around the world shows the magnitude and frequency of the impact of skills and training of workers, and the importance of training on labor productivity has been confirmed by this research in Croatia. The globally emphasized problem of lack of training (Table 5) and satisfactorily skilled workers grows with the aging of the existing labor (which is very pronounced in Croatia [177], but also in other countries [80]).

All of the above-mentioned points to the importance of investing in the training of workers, both through education and compulsory work. The need for in-service training is emphasized by the deficit of trained construction workers and the frequent arrival in the construction industry of unskilled workers or workers from other professions who need to be retrained. Due to the introduction of new work technologies, lifelong education of workers is needed.

There seems to be a consensus on the lack of skills among construction workers [178], but there is no universal answer as to how best to improve their skills [170]. By achieving increased productivity and reductions in turnover, absenteeism, and rework due to mistakes, investments in employee training return to the employer multiple times [117,178,179].

The significantly weaker impact of school education of workers than professional experience on productivity determined by this research indicates the weaknesses of the school system of education of craft workers in Croatia. The slightest negative impact of school education deficiencies on productivity suggests that workers' skills can be successfully improved with experience and through on-the-job training.

Short training programs or daily courses and seminars in educational institutions with the support of the local construction industry, professional societies, and state authorities are recommended [180].

Fayek et al. [181], Hewage and Ruwanpura [182], Enshassi et al. [183], and Ntuli and Allopi [178] highlight internal mentoring and skills acquisition with internal supervision as the best way to train workers. In addition to basic knowledge, through work in practice, workers also acquire job competencies such as workplace culture, work norms, and values in the organization in which they work. Unskilled workers working on a construction site with good craftsmen can acquire the technical skills of skilled workers in 5 to 10 years [117] and the ability to work independently. As a rule, the acquisition of more skills increases workers' incomes, so they are more satisfied with their work [80] and more motivated to work.

Some of the desirable traits are acquired over time or are lost, and some are immanent to the individual (e.g., dexterity). As a rule, as age increases, so does experience, and physical strength decreases. Although the health of workers has not been included in the survey in Croatia, attention should be paid to the health of workers because it is associated with strength, fatigue, and absenteeism. This is primarily possible through working conditions (appropriate equipment, duration of work) and rests (timely, duration in accordance with the type of work and in good conditions) during the work shift.

## 5. Conclusions

Labor is one of the most important resources of construction contractors. Increasing its productivity means achieving better utilization of labor, which is increasingly scarce and relatively expensive.

Numerous research papers show the impact of different attributes of workers on the productivity of contractors and on the performance of construction projects, but the approach to examining the impact of these characteristics is very diverse (partly justified by regional specifics) and often lacking in previous analysis of interrelationships. Studies dealing with labor productivity do not look into enough detail with respect to differences in worker abilities.

The research conducted in this paper in Slavonia and Baranja defined the direct and indirect influence of important workers' characteristics on productivity. The survey found that "experience in construction" and "dexterity" have a very strong positive impact on productivity, and "strength", "morale" and "school education" have a strong impact. In the absence of these characteristics, all except

the "school education" have a strong negative impact. This means that none of these characteristics should be ignored and neglected.

This research provides information that can be used in the implementation of measures to properly address issues related to poor productivity on construction projects, as well as the sustainability of the set goals for their realization. Furthermore, the obtained results can be useful for future research on the issue of human resources in construction, in a wider area than the region in which the survey was conducted.

There are several directions for future research. One possible direction would be to monitor the achieved productivity of workers with different characteristics in order to quantify the impact of characteristics on productivity, and to see whether and how much productivity increases with the improvement of worker characteristics. In doing so, one would need to be cautious with regard to the number of other possible factors impacting productivity. Another direction of further research would be to examine the interdependence of individual characteristics of workers, compared to this study where characteristics that were not related were deliberately chosen. In this study, the importance of the researched characteristics of workers was confirmed through their rankings in previous research. However, it is also possible to survey the frequency of deficiencies of these characteristics in the labor force in Croatia.

The workers' characteristics that significantly affect productivity should be kept in mind when managing human resources in the company and on the construction site. Formal education, age, and years of experience are easy to determine, but both cognitive and non-cognitive skills of workers need to be considered, which can also be of influence. The importance of attracting and retaining workers in the company with desirable characteristics and programs for training workers in addition to work and the culture of knowledge transfer in the company were emphasized.

The whole country benefits from increased productivity in construction, so it is justified for the government to encourage the attraction of young labor in construction occupations and to raise the effectiveness of their education.

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