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Workforce planning in project-driven companies: a high-level guideline

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Workforce Planning (WFP) has become a crucial part of the governance of project-driven companies and has been deemed fundamental to drive critical decisions on resource management. To manage manpower planning, companies independently developed internal procedures according to their sector, size, and skills. Despite the efforts to create a reliable workforce planning process, a lack of knowledge, standardization and sharing might lead to misalignment and to heterogeneous approaches among different organizations. This study aims at investigating the current knowledge of the WFP, pointing at the detection of its key factors in terms of process steps, application context, methods, input data, actors, tools and reports' frequency. Additionally, it attempts to define WFP high-level guidelines which can be generally valid for project-driven organizations. The research seeks to meet these goals by combining the results of the academic literature review on the WFP with the findings of the empirical study in which the representatives of ten project-based enterprises participated. The paper describes the key principles of WFP and its main process' sections, offering high-level guidelines in terms of recommended process steps, actors involved, operative models, data input, report's frequency, and tools. The presented features, generated by the literature review and the empirical study, are meant to be generally applicable to project-driven companies and to support the practitioners initiating this process in their organization.

KEYWORDS

workforce planning, workforce forecast, project-driven companies, project management, manpower planning, manpower forecast, human resource planning

1 Introduction

Workforce Planning (WFP) has become a critical process for project-based enterprises, intended as enterprises whose internal and external activities are organized in projects (Hobday, 2000). Comparing potential workforce demand and workforce capacity, workforce planning plays a key role in guiding decisions on human resources' management, contributing, if properly carried out, to the success of the company. Therefore, the projects' achievements strongly depend on workforce planning. In fact, as mentioned by Kongchasing and Sua-Iam. (2021), the shortage of qualified labor due to ineffective labor management is presented as one of the main causes of delays in construction projects. According to Bajjou and Chafi (2020), improper planning and scheduling proved to be the result of assigning works to a main contractor and of its subcontractors performing tasks without taking into account the availability of workers where there is demand. Despite the

relevance of workforce planning, as far as the multifaceted experience and the knowledge of the Authors–who work as academics, consultants and professionals in international project-driven contexts–there has been little effort to provide project-driven companies with a clear overview of the process both descriptively and operatively, resulting in a lack of knowledge standardization and in a potential deep misalignment among different organizations. Based on this, a better understanding of the key factors of workforce planning in project-driven contexts would be helpful for both practitioners and researchers. Based on a preliminary literature review aimed to highlight any possible gap in theory and practices coming from previous research about WFP in project-based enterprises, this paper aims to answer three main questions about who is involved in the workforce planning process in project-driven organizations, which are the tools used for planning the manpower in these companies, and finally how often the workforce planning is updated. The answers, integrated with the findings from a survey joined by ten project-based enterprises, qualify the academic and practical relevance of the paper, where some general guidelines for developing and improving a WFP process in project-based enterprises are proposed. This paper is composed of five sections: academic literature review, objectives and methodology of the empirical research, results, discussion, and finally, conclusions and future research.

2 Literature review

The present literature review aims at investigating the WFP process, with respect to project-driven organizations, so as to highlight the possible research (and practical) gaps to address and sufficiently support–i.e., providing sufficient and systematic information about Workforce Demand (WFD), Workforce Capacity (WFC) and their interaction–empirical research.

2.1 Paper selection and data derivation

Within the Scopus database, the selected articles were published between January 1980 and June 2021 in 14 journals considered consistent with the project-driven environment: Building and Environment, Computers & Industrial engineering, Engineering, Construction and Architectural Management, Industrial Management and Data systems, International Journal of Construction Management, International Journal of Industrial Engineering Computation, International Journal of Manpower, Journal of Construction Engineering and Management, Journal of Forecasting, Journal of Management Engineering, Journal of Performance of Constructed Facilities, Procedia Manufacturing, Public Works Management and Policy, Quality and Quantity. The subsequent reading of the aforementioned articles generated a convergence process towards the same group of journals. Math and algebra journals, whose articles had been cited by the articles found in the starting selected journals, have also been included in the review. To select the articles, the investigation was based on the presence in the title and in the abstract of the following keywords: Workforce Planning, Workforce Forecast, Manpower Planning, Manpower Forecast, Human Resource Planning and Project. Among these, articles referring to scheduling, leveling, HRM strategies, hiring, healthcare, call centers, conferences, project delays and articles not in English have been excluded. In the end, only fifty-two articles strictly related to workforce planning in project-oriented contexts which were published in the last 41 years have been taken into consideration.

2.2 Paper classification

2.2.1 Paper classification by topic and type

With the intention of understanding what the research focused on, a papers' classification by topic and type was performed. Studies conducted about the WFP are divide into three streams: one relating to workforce demand (17), a second relating to workforce capacity (16) and a third relating to both workforce demand and workforce capacity (19). As shown in Table 1 researchers have given priority to studies of mathematical nature over studies of descriptive nature or entailing a revision process. 37 articles out of 52 propose a mathematical or operative approach, especially regarding the study of the WFC.

2.2.2 Paper classification by application field

Trying to form an idea about the application fields on which the WFP research concentrated, a further analysis was conducted, yielding the following findings: WFP mainly focuses on General Civil Construction (GCC), Information Security Industry (Is.), Military (Mil.), Services (Serv.) and Volume production (Prod.). Out of 52 articles, only 28 report information about the WFP (or one of its sections) process' sector applicability. Among the sectors found, the General Civil Construction one is predominant (19/28), especially with respect to the WFD study. On the other hand, the exclusive WFC articles are de-contextualized. 24 articles out of 52 are not defined (ND) in terms of sector. The results are shown in Table1. Nevertheless, the construction industry sector can be considered a good example of a project-oriented sector.

2.2.3 Paper classification by organization type

Continuing with the attempt to contextualize the research area, the target organizations of the academic research have been pointed out. Only 25 articles out of 52 refer to the target organization as: public, private organizations and both public and private, mostly equally shared. Also in this case, the exclusive WFC articles lack context. Additionally, according to the literature, WFP is studied mainly for internal organization use (29/45 articles). In this case, the WFP process (or one of its components) is meant to be run inside the specific organization. 10 articles out of 45, instead, provide information about the use of WFP (or one of its components) outside the organization. The latter might be the case of an organization interested in knowing the future supply of professionals in a certain region or nation.

2.3 Workforce demand

Before delving into the main sections that make up workforce planning, it is worth to clarify the meaning of Workforce Planning. As the core of human resource management, WFP provides for the

TABLE 1 Paper classification by topic, type and sector.

Topic	Descr	Math	Rev	Tot	All	GCC	Is	Mil	Serv	Prod	ND
WFD	2	12	3	17	0	14	0	0	0	0	3
WFC	0	15	1	16	0	0	0	0	0	0	16
WFD+WFC	8	10	1	19	1	5	1	1	3	3	5

GCC, General Civil Construction; Is, Information Security Industry; Mil, Military; Serv, Services; Prod, volume production.

future staffing needs in terms of the right amount of skilled workers at the right moment, able to deliver a project within scope, on time, and within a budget (Khoong, 1996; Sing et al., 2016). The main goal of using Workforce Planning (WFP) is to identify the potential gap between the available workforce (WFC) and the demanded workforce (WFD) in order to plan training, recruiting (Safarishahrbijari, 2018) promotions and dismissals.

The present research interrogated the academic literature aiming at finding out what is the workforce demand, how to calculate it, which are the data needed, who should be involved, when it should be launched and by using which tools.

2.3.1 Key features

Based on the literature (Safarishahrbijari, 2018), the Workforce Demand evaluation (WFD) can be defined as a prediction of the evolution of the required workforce, exploiting a "What-If" scenario to get insight into the influence of business policies on the future personnel's structure (De Feyter, 2007). Thus, the main goal of the WFD study is to estimate the present and future workforce's requirements to execute the projects. As mentioned by Huang et al. (2009), the total demand should be in form of "projects" skill requirements [man-hours per skill or job-role], and each new project should be defined by size, calendar duration and arrival time. According to the researchers, the overall workforce demand should be composed of the demand for future projects (Huang et al., 2009), the demand for projects in execution (Dabirian et al., 2019), the demand of work backlogs (Lee et al., 2007) and the demand coming from possible changes in trends (Smith, 1971; Dabirian et al., 2019). Furthermore, Wilson (1987) indicated that the demand side of the workforce should comply with the corporate's plan, the corporate's objectives and the financial aspects.

2.3.2 Models

When it comes to the numerical calculation of future projects' demanded workforce, the literature in 21 articles out of 36 proposes six main methods: *Labor Multiplier* (5/21), *Linear Regression* (4/21), *Ad hoc Simulator* (1/21), *System Dynamics* (5/21), *Econometric model* (5/21) and the *Gray model* (1/21). The first four are considered highly compatible with project-driven contexts, since they are strictly related to the project. Regarding the application context, all the models seem to be valid in the construction field but no trends can be detected in relation to other sectors.

The *Labor Multiplier* approach assumes that in each project type, the projects will demand the same level of labor requirements per unit of project expenditure, and will follow standard patterns. From the information collected from site returns for daily labor deployment and the past projects' expenditure, the number of laborers for each trade, in form of [man-days/$M] for individual type of project, can be calculated (Chan et al., 2006). Here the equations provided by Chan et al. (2006) to define the labor multiplier L^J_{SX} of each trade/skill S at stage X of a project J [man-days/$M] (Eq. 1) and to compute the total labor demand L^D_S of the trade S for a particular construction project D [man-days] (Eq. (2)):

$$L^J_{SX} = \frac{D^J_{SX}}{E^J_X} \tag{1}$$

$$L^D_S = \sum_X L^J_{SX} \cdot E_{X(est)} \tag{2}$$

D^J_{SX} is the deployment of labor of trade S at stage X of a project type J and is historically derived from past projects' phases. E^J_X is the past project's expenditure at stage X of project type J and $E^J_{X(est)}$ is the expected expenditure of the future project per phase X. Theoretically, one past project is enough to generate a labor multiplier that can be used to forecast the manpower demanded by a new project of the same type. This makes the method suitable even for small to medium size companies, due to its little need for previous' projects data, its simplicity and acceptable accuracy. As highlighted by Wong et al. (2008), the model requires to be updated to consider any changes in technology and labor mix which could generate new sets of labor multipliers.

The *Linear regression* model is a time series forecasting method that identifies historical patterns in past data to extrapolate future trends. Also in this case, project cost and project type are considered excellent predictors of manpower requirements (Bell and Brandenburg, 2003). Assuming that there is an exponential or log-log relationship between the independent variable and the chosen dependent variable, it is possible to generate regression analysis plots for each project category (Bell and Brandenburg, 2003). Unlike the Labor multiplier method, a relatively wide sample of past projects is needed in order to have a prediction (>30). Once the costs and labor deployments per skill from at least 30 completed projects of the same type are collected, it is possible to estimate the future labor hours per skill, knowing the expected cost of the future project. The lower the dispersion of the points, the higher the reliability and the consistency of the model. This model is suitable for medium to large project-oriented companies, able to provide a relevant sample of past projects not too distant in time (old projects might have recurred to different techniques and methods, generating inconsistent manpower requirements per project cost).

The *Ad hoc Simulator* (SimMan) is a tool developed by Huang et al. (2009). It assumes that each arriving project belongs to a pre-specified set of "project types" and should be defined in size (the total man-hours required) and duration (the amount of calendar time required to complete the project). A project type is determined by the proportion of different required skills (based on historical data).

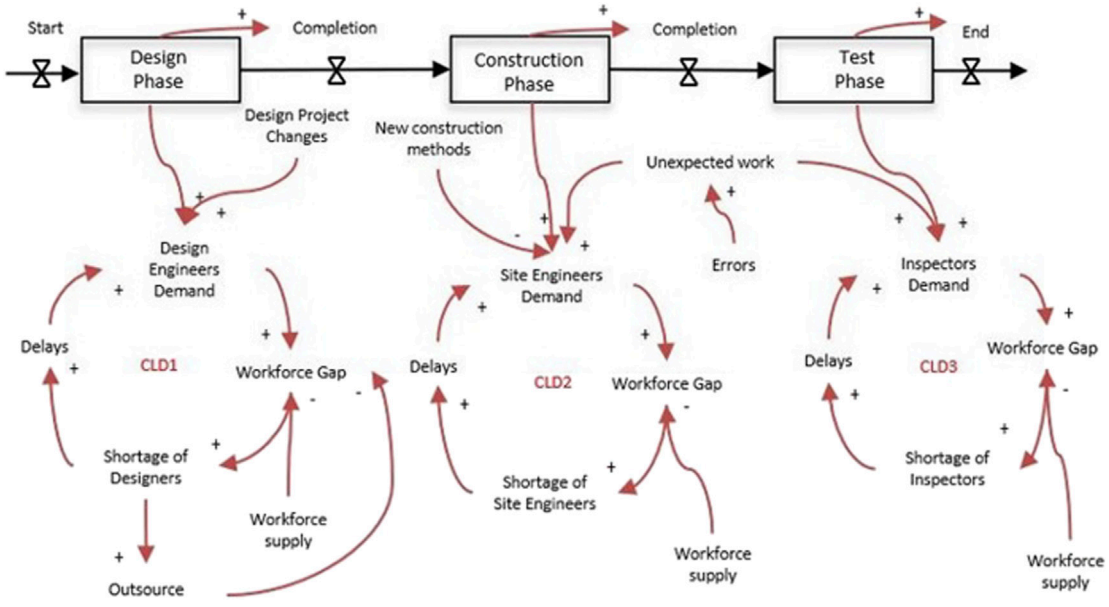

FIGURE 1
System Dynamics demand-side example.

The demand D per each skill i required by the future project can be simplified, based on Huang et al. (2009), by Eq. (3).

$$D_i = a_{ik} \cdot S_k \tag{3}$$

a_{ik} is the proportion (percentage) of the man-hours for skill i for project type k, and S is the project's size. In this approach, the project's type and size (instead of project cost) are pointed out as the best predictors of the project's demand for each skill. Labor Multiplier, Linear Regression and Ad hoc Simulator are the best candidates for a static quantitative evaluation of workforce demand. Anyways, to include the dynamic changes that are likely to modify the project's expectations, the researchers focused on the System Dynamics model.

The *System Dynamics* model is an objective-oriented methodology that uses causal loop diagrams, consisting of cause-and-effect relations between the system's variables, to represent the structures and the interactions of principal feedback loops in the system (Mutingi and Mbohwa, 2012). In line with Dabirian et al. (2019), the estimate and the collocation of labor needs must be coherent with the dynamic flow of the project. The introduction of the causal loop diagram allows to consider the impact of changes on the system's variables, by enabling the analysis of different scenarios (Sing et al., 2016). Scenario development is a predictive method in which present data are used to develop various alternative future scenarios (Ruge et al., 1998). Based on the literature's information, an example is provided in Figure 1. Assuming to divide a construction project into three phases, design, construction and test, where each generates a manpower demand for job roles (quantified by the previous models), a series of causal loop diagrams is designed to investigate the impact of changes. What if design modifications are introduced? They generate an increase in the demand for designers (+), with a consequent increase in the workforce gap and possible shortages and phase completion delays. What if more efficient construction methods are introduced? What if unexpected errors are found? The present model must be coupled with one of the previous quantitative ones to guarantee the highest level of accuracy, while embracing the dynamic nature of the projects.

The *Econometric models* aim at forecasting the total construction manpower demand as a function of relevant variables in the construction industry (Wong et al., 2011). The relation between the variables is represented in Eq. (4).

$$MD = f(Q, LP, RW, MP, BR) \tag{4}$$

where MD is the total manpower in the construction industry, Q is the total construction's output in terms of the gross value of constructions works, LP is the labor's productivity, RW is the medium monthly employment earning in the construction industry, MP is the material price index and BR is the bank interest rate (Wong et al., 2011). From historical data, the relationship between workforce demand and the other variables can be found, verified and exploited to project the future manpower demand. Unlike the other models, this method attempts to evaluate the total future workforce required by the entire construction sector, uncoupled with the single project and skills. It is useful for those organizations, either private or public, that want to conduct a macroeconomic analysis.

The same goal, but with lower accuracy, is achievable with the *Gray model*. Unlike the Econometric models, the calculation of the future manpower requirements is a function of only past recorded total manpower demands. Therefore, few previous data are necessary. A thorough study is reported by Ho (2010). As the Econometric Models, the *Gray Model* presented by the literature is not strictly related to the specific project and its skill requirements.

2.3.3 Input data

Concerning input data, only 23 articles out of 36 provide information about data sources to drive the WFD. As hinted by the aforementioned mathematical models, it is crucial to rely on historical data, either from an internal database (5/23) or from public records, if available (9/23). The numerical data from the past can be complemented by questionnaires, either submitted by internal or external experts (7/23), and by insights from internal staff, such as the project engineer's. Once again, all the shown data sources are valid for WFD evaluation for the construction sector, however, all sectors seem to base themselves on historical internal data at least.

2.3.4 Owners

To detect the key principles of WFP, it appeared helpful to interrogate previous studies about the actors involved in the WFD process' steps. Only 7 articles out of 36 deal with the topic, unfortunately without pinpointing a precise trend. The human resources department (2/7), project managers (1/7), project engineers (2/7), executive committees (1/7) and internal staff (1/7) are indicated as possible involved roles. In line with the results obtained, when it comes to this topic, the academic literature lacks clear patterns, with a consequent need for further deepening.

2.3.5 Tools

20 articles out of 36 present information about tools, however, 12 out of 20 introduce custom software only meant to verify the correctness of the mathematical model proposed. The other articles refer to an *ad hoc* simulator (Huang et al., 2009) (1/20), spreadsheets (3/20), and undefined computer-supported systems (4/20). As a consequence, the literature does not clearly answer this question.

2.3.6 Frequency

How often should the WFD be evaluated? Based on 7 articles, either yearly (4/7) or monthly (3/7). The literature does not clarify which of the two proposals is more suitable, according to the company's sector.

2.4 Workforce capacity

Like the WFD, the WFC has been investigated, with the following findings.

2.4.1 Key features

The Workforce Capacity evaluation (WFC) can be defined as a prediction of the evolution of the available workforce (Safarishahrbijari, 2018), exploiting a "What-If" scenario to get insight into the influence of business policies on the future personnel's structure (De Feyter, 2007). Thus, the main goal of the WFC analysis is to determine the number of employees available at a particular time with certain skills or competencies (Geerlings et al., 2001). The WFC evaluation should rely on a detailed and updated personnel profiles' database (Huang et al., 2009), reporting each one's main attributes such as age, grades, salary, experience, skills/job role. Once the population is defined, the analysis must consider internal mobility (employees' movements within the same dept., among different dept., promotions, trainings, holidays and illness), external mobility (resignations, retirements, attritions), and recruits (Dimitriou and Georgiou, 2021).

2.4.2 Models

Concerning the numerical calculation of the future workforce supply, 27 out of 35 articles contained within the literature outline the following five methods: *Stock and Flow* (4/27), *Markov Model* (12/27), *Ad hoc Simulator* (1/27), *System Dynamics* (8/27) and *Questionnaire* (2/27). They are all compatible with project-driven environments. The models do not seem to be specifically designed for any investigated sector.

Stock and Flow models illustrate the population's distribution as stocks, and movements between stocks as flows (e.g., promotions, job rotation and recruitment) (Dimitriou et al., 2013; Safarishahrbijari, 2018). To assess the distribution of workforce supply, a stock-flow model is the most reliable approach, as reported by Sing et al. (2012). For this reason, the present model can be used by any kind of organization, however, it does not allow any forecast about the probable future workforce supply.

The *Markov Model* is a time series approach, able to predict the distribution of personnel at any planning period (De Feyter and Guerry, 2009). It represents an upgrade of the Stock and Flow model, upon which is built. The Markov Model assumes that employees with similar attributes (e.g., skills or job role) are grouped in the same stock, which is called homogeneous class, and that within the same class they all have the same probability to move to another (Dimitriou and Tsantas, 2010). Looking at the sum of the past periods' flows N_{ij} (Eq. (6)), and at the total observed number of employees N_i in the group i till time period t (Eq. (7)), the transitions' probabilities p_{ij} of an employee moving from class i to class j (Eq. (5)) can be calculated. Thus, the future flows f_{ij} from class i to class j (Eq. (8)) can be forcasted (De Feyter, 2006).

$$p_{ij} = \frac{N_{ij}}{N_i} \tag{5}$$

$$N_{ij} = \sum\nolimits_t n_{ij}(t) \tag{6}$$

$$N_i = \sum\nolimits_t n_i(t-1) \tag{7}$$

$$f_{ij}(t) = n_i(t-1) \cdot p_{ij} \tag{8}$$

The Markov model, as mentioned by Safarishahrbijari (2018), is not able to interact with the environment, is not capable of incorporating feedbacks in the system and is based on past data, assuming that past trends will continue. In addition, it requires a wide amount of data, which makes it suitable for large organizations only (De Feyter, 2006).

Besides what has already been stated, the *Ad hoc Simulator* (SimMan) (Huang et al., 2009) suggests indicating the maximum number of jobs and training courses an employee is allowed to take on at the same time.

Through the *Qualitative models*, such as questionnaires and surveys, the available future supply can be outlined without numerical or mathematical methods. An example is reported by Sing et al. (2016). The qualitative study is one of the simplest techniques when it comes to forecasting the workforce situation (Sing et al., 2016). It is only suitable for a single and small organization, as it strongly depends on the experience and

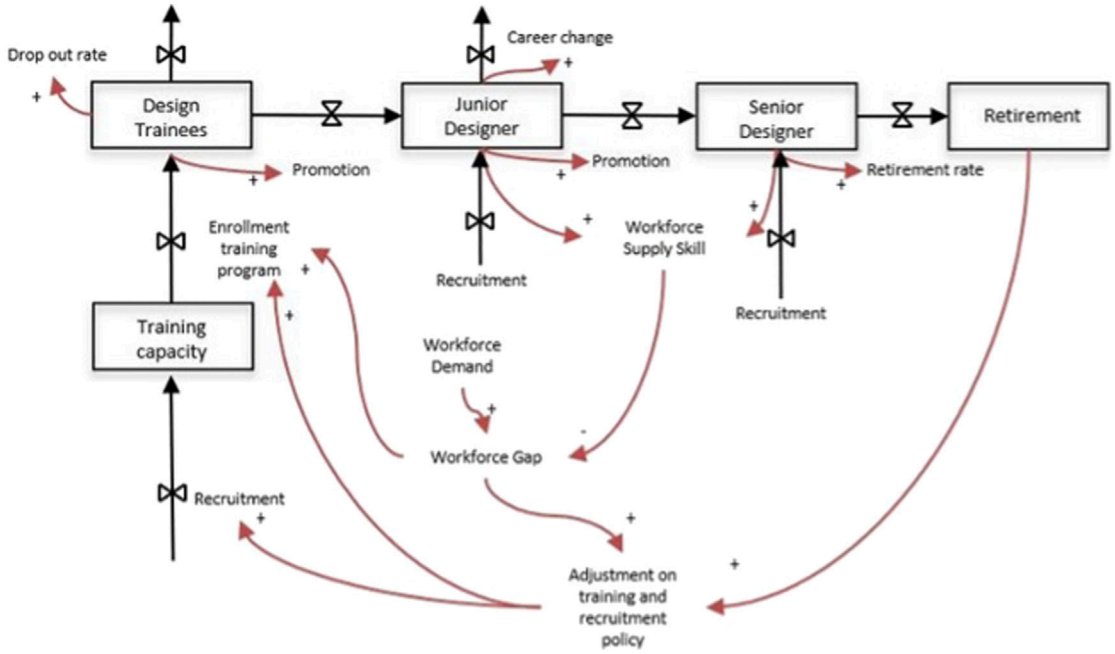

FIGURE 2
System Dynamics capacity-side example.

references of the selected experts within the field (Lawrence et al., 2006). Qualitative approaches are commonly adopted and are extremely useful to develop a forecast, especially when historical data are not available or are of poor quality (Richards and Morse, 2012). This technique can be also considered complementary to numerical ones.

When it comes to the workforce capacity side, *System Dynamics* is still the main way to embrace the dynamic nature of a project. Unlike traditional stock-flow models, the system dynamics model incorporates feedback mechanisms (Sing et al., 2016). Starting from a system representation through the stock and flow model, it is in fact possible to depict all the cause-effect connections between system variables. In Figure 2, a System Dynamics model is applied to a supply system composed of three stocks (Trainees, Junior Designers and Senior Designers). What if the recruitment rate of Junior Designers increases? What if the training completion rate increases? Is the supply still able to meet the demand? In such a way, it is possible to determine the system's evolution for every planning period (Mouza, 2010).

2.4.3 Input data

22 articles out of 35 indicate information about the data sources which are meant to drive the WFC. As hinted by the presented mathematical models, it is crucial to rely on historical and current data coming mainly from internal databases (17/22). The internal data from the past can be complemented by questionnaires (2/22), public data (2/22) and the experience of the project engineer (1/22).

2.4.4 Owners

Only 11 articles out of 35 deal with this topic, pinpointing a trend. Human resources management (HRM), represented by the manpower planner, appears to be the solution individuated by the studies (9/11). Other 2 articles proposed as options the operational manager and the internal staff. It is not clear whether the manpower planner is the best candidate with respect to all the sectors.

2.4.5 Tools

18 articles out of 35 present information about tools. However, 16 out of 18 introduce custom software only meant to verify the correctness of the mathematical model proposed. Even in the case of WFC evaluation, the other options presented are the use of a spreadsheet (1/18) and the *ad hoc* simulator developed by Huang et al. (2009) (1/18). As a consequence, the literature does not answer this question.

2.4.6 Frequency

Unlike the WFD, the frequency at which the WFC should be run and updated is only yearly. However, only 2 articles present this result, which means that further analysis might be needed.

2.5 Gap optimization

Once the demand side and the capacity side are defined, the ultimate goal of the process is to verify possible shortages or surpluses between the demanded manpower and the available manpower (Safarishahrbijari, 2018) per skill or job role, and to eliminate the gap by controlling employees' recruitment from the external environment, transfers within the organization, promotions, trainings and dismissals.

2.5.1 Models

Nine articles out of 52 indicate three models able to minimize the potential gap: *Optimal control model* (3/9), *Ad hoc Simulator* (1/

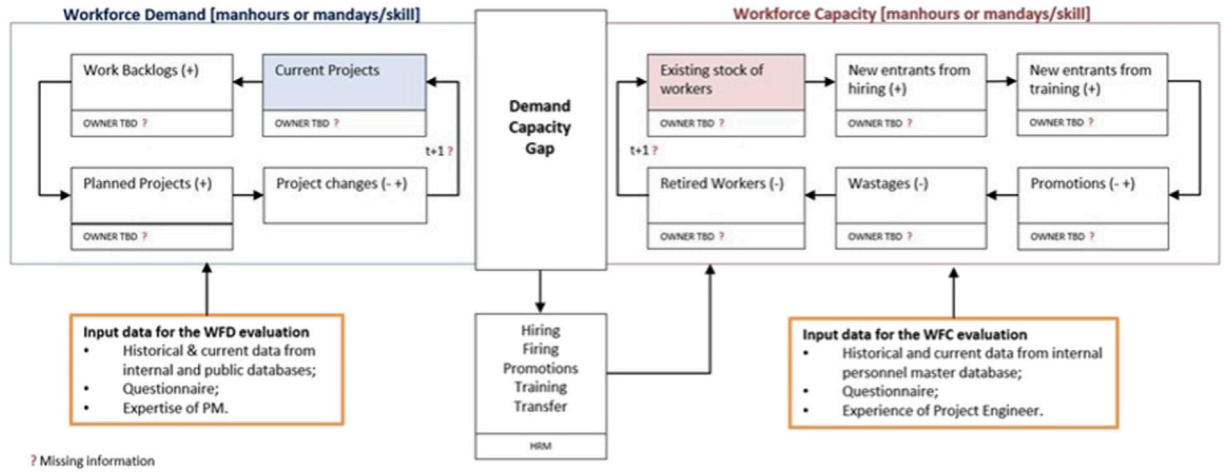

FIGURE 3
Summary of the results of the literature review.

9) and *Fuzzy model* (5/9). All the models are based on the objective linear programming technique (Geerlings et al., 2001), which aims at defining the number of employees with a certain skill or job role to be hired, dismissed, transferred, promoted and trained (so-called control variables) at every planning period in order to meet the demand. An example of the optimal control model is provided by Pooya and Pakdaman (2021), while an example of the fuzzy model is presented in Dimitriou et al. (2013). In addition to the main target, the Ad hoc Simulator and the Fuzzy Model introduce a second goal, which aims at the minimization of the operational costs generated by the processes of recruiting, firing, promoting and training. Hence, the procedure associated with the targeted manpower structures and costs will determine the appropriate values of the control parameters (Georgiou and Tsantas, 2002). All these models are fed by the data output from the WFC and WFD evaluations, resulting in the need of handling a big volume of data.

Figure 3 summarizes the results of the literature review in terms of process' steps, input data, owners, and frequency report update (t). As previously proved, the literature does not clearly provide information about WFP owners, frequency and effective tools.

3 Objective and research methodology

3.1 Objectives

The literature's review–in its summary shape, as reported in Figure 3 and commented above–underlined three main gaps. First, the actors involved in workforce planning have not been clearly defined; second, the researchers have neglected to suggest tools or software designed for the workforce planning activities both on the demand and the supply side; third, the frequency with which to execute and update workforce planning has not been made explicit.

The first objective focuses on the owners of the process' steps, both on the demand and the capacity side. The research aims at finding out which corporate figures are actually involved in this activity.

The second objective focuses on the tools utilized to manage the workforce planning, in particular, the study aims at exploring whether there currently are software on the market able to facilitate and support the process.

The third objective focuses on the update's frequency. The investigation aims, following the suggestions of practitioners from ten companies, at defining a reasonable timing to run the workforce planning. This information can complete the overview of the WFP process, integrating what has clearly already been found through the academic review.

Summing up, the research questions aimed to be answered are:

- Who is involved in the workforce planning process in project-driven organizations?
- Which are the tools and software utilized for planning the manpower in project-driven companies?
- How often is the workforce planning updated in project-driven companies?

3.2 Methodology

Given the exploratory nature of the research questions, and the limited number of studies that take into account Workforce Planning management in project-driven companies, a qualitative methodology seemed appropriate to answer these three research questions because its capability to capture weaker signals and rich variety of information that might help in exploring not-yet-settled problems (as suggested in the Operations Management, Social Sciences, Project Management research streams to mention some; also, as expressed, for example, by Patton, 2002). This study is based on a survey led and steered by ANIMP (Associazione Nazionale di Impiantistica Industriale) and IPMA Italy (IPMA: International Project Management Association). The companies chosen for the case study are ten project-based organizations present both in the Italian and the global market and operating in the sectors of EPC contracting, manufacture of components, packaging and services supplying. The total workforce

TABLE 2 Features of the companies.

Company	Sector	Employees	Part of a group
1	EPC	>250	Yes
2	EPC	>250	Yes
3	EPC	>250	Yes
4	EPC	50<&<250	Yes
5	Components	>250	Yes
6	Components	50<&<250	Yes
7	Components	<50	No
8	Package	>250	Yes
9	Services	50<&<250	Yes
10	Services	<50	No

managed by the selected companies is around 200.000 employees. The idea in selecting the sample was to explore the "average" situation of project-driven organizations, considering companies belonging to the most representative project-based sectors. The companies chosen are different in size, in order to create a sample that is representative of different situations, with the assumption that some of the answers are not dependent on the number of employees. Table 2 summarizes the features of the companies.

The questionnaire submitted to the participants relies on this core set of questions:

- Could you describe the process of workforce planning in terms of actors involved and their responsibilities?
- Which kind of tools do you use for developing/implementing/running work force planning?
- How often do you update the workforce planning report?

Once the data have been collected, the results of the surveys have been discussed by the workgroup and generally valid information has been found and consolidated. In line with the positivist tradition, the rigor of the research was assessed by four criteria: internal validity, construct validity, external validity and reliability (Gibbert et al., 2008). To guarantee internal validity, the empirical patterns have been compared with the literature's results, to verify that the observed findings can be reasonably matched with the expected results. To enhance construct validity, the results which were progressively emerging have been organized through a chain of evidence, representing the path from the initial research questions to the final conclusions. Concerning external validity, neither single nor multiple case studies enable statistical generalizations, but they allow analytical generalization. Eisenhardt. (1989) argues that case studies can be a starting point for theory development and suggests that an analysis involving 4–10 case studies may provide a good basis for analytical generalization. Reliability can be achieved by transparency and replication. Transparency has been ensured through careful documentation and clarification of the research procedures, while replication has been reached by collecting all the study notes, study documents and the narratives registered during the study in a case study database, that was organized in such a way that could facilitate retrieval for later investigators.

4 Results

The results will be presented in three sections: WFP process owners in project-driven companies, tools to manage WFP in project-driven companies and WFP update report's frequency in project-driven companies.

4.1 WFP process owners in project-driven companies

The results have been divided mindfully of the demand side and the capacity side.

4.1.1 WFD process owners

Coherently with part of the findings coming from the literature review, the WFD sub-process is based on the evaluation of the demand from future projects likely to be acquired, of the demand from projects in execution, of the demand from backlogs and, unlike the literature, of the demand for specific departments' activities. Each project should be defined by master data (type of project, project name, dates), and the demand should come in form of skill/job role requirements [man-hours], as suggested by the previous studies. Big and medium-size companies include in the analysis external man-hours. The participants were in agreement about the actors involved in each of the indicated steps:

- The workload of future projects should be calculated by the commercial department and reviewed by the operative directions. In the case of small companies, the revision can be avoided;
- The workload of projects in execution and backlogs should be communicated by the project's key figures, reviewed or approved by the project manager per each project and reviewed and validated once more by the head of department (HoD) per cost center. In the case of small companies, the HoD revision can be avoided;
- The demand for specific activities should be examined by the HoD.

4.1.2 WFC process owners

In line with the theoretical recommendations, the WFC sub-process should inform about the available hours per job role, considering internal mobility (promotions, transfers), external mobility (resignations, attritions) and recruiting. The empirical study confirmed the importance of relying on an updated personnel database. The participants agreed about who should be the owner of the WFC sub-process, coherently with the theoretical studies:

- The Human Resource department should be accountable for personnel's master data and related variations due to employees' transitions.

4.1.3 Gap optimization process owners

Once the WFC and WFD are calculated, a workload analysis providing demand/capacity trends per job role, based on dynamic what-if scenarios, should be performed. This sub-process should

provide insights and a strategy about reskilling, recruiting, promoting, and dismissing. The empirical study pointed out the actors involved in these activities:

- The HoD should be in charge of resource staffing for each project;
- The HR should lead recruiting, reskilling, promotion and dismissal processes.

4.2 Tools to manage the WFP in project-driven organizations

Concerning the tool utilized to manage the WFP, 90% of companies proved to have a structured tool to support the process. EPC companies are mostly working with *ad hoc* tools developed for the purpose, Components companies do not share any trend, using either *ad hoc* tools, spreadsheets or internally developed tools. Services enterprises rely mainly on spreadsheets, while the Package organization uses an internally developed tool. Thus, the main solution appears to be represented by *ad hoc* tools, followed by spreadsheets and internally developed tools. Four big companies, two EPCs, one Components and one Package, listed the names of the tools in use:

- Excel for collecting demand data and SAP BPC to elaborate the WFD. Capacity-side, data are stored in SAP and extracted and represented in another external interface.
- Two custom software to handle the demand, one developed on the Decisyon platform for Home-office personnel requirements, and one built on Microsoft Azure for Field workers. Capacity-side, one custom software developed on the Oracle application.
- Demand-side, the data are collected by using Excel uploaded into the SAP ERP system, while the evolution of the projects with respect to the hours available is tracked as well in SAP ERP.
- Both workforce capacity and demand are handled data-wise by using custom Excel files.

4.3 WFP update report's frequency in project-driven companies

According to the respondents, the workload report is updated either monthly, quarterly or yearly. The findings partially meet the information shown in the literature review, which indicates a yearly or monthly frequency. 70% of the respondents (from all sectors) pointed out a monthly frequency, two companies update the WFP quarterly and only one yearly.

5 Discussion

The combination of the literature studies and the empirical work gives an overview of Workforce Planning's key features and suggests some future research patterns. The first integration of the results obtained by the qualitative study allows answering the questions that remained unanswered in the literature about the workforce planning process' owners, both on the demand and the supply-side. A second integration of the empirical results allows deepening the knowledge on which tools, in terms of software, are commonly utilized by project-oriented companies to support the WFP and, finally, a third integration allows to clarify and to suggest how often the WFP should be updated. In light of what has been outlined combining the literature review and the empirical research, the WFP in project-driven companies can be described with regard to general suggested key features, key process components or steps, process' owners, main suitable mathematical models, input data, update frequency and tools.

5.1 Key features of WFP processes

To summarize, WFP in project-oriented companies should present the following key features: dynamicity, in terms of ability to follow the project's changes; iteratively and interactivity due to feedback inclusion; continuity, in terms of allowing to adjust the staff at any time; being "What-if" scenario-based, enhancing the simulation of different situations with different inputs; discretion in time; being data-driven, based on historical data; cost-effectivity. Concerning the WFP process' structure, it should be composed of three main components, or steps. First, WFD evaluation, defined by the total demand submitted in form of projects' skills requirements, including the workforce required by the planned/future projects, the current/in execution projects, backlogs and any project changes. Second, WFC estimation, intended as the ability to provision, per each planning period, the available workforce with a certain skill or per each job role demanded, considering the existing workforce, internal mobility (transfers, promotions, trainings), external mobility (wastages, retirements), and new recruits. Third, the detection, per each planning period, of certain skills gap, in order to enact recovery actions to balance the system, such as recruiting, training, promotions and dismissals.

5.2 Actors of WFP

The empirical study suggested, for each process step, the actors that should be involved. Specifically, on the demand side, the management and estimation of the future/planned workforce should be responsibility of the commercial department and should be reviewed by the operative direction, while the estimate of the workload engaged in the current projects and backlogs should be performed by the project's key figures, reviewed or approved by the project manager and finally validated by the head of the department. On the capacity side, the human resources management should be held accountable for the management of the master personnel's data and for the monitoring of the employees' distribution over the organization. Furthermore, it should lead the viable course of action to minimize the skills gap signaled by the head of the department. The overall WFP process should be coordinated by the human resources management.

5.3 Operative models suitable for WFP processes

With respect to the operative models suitable for supporting the WFP process in project-driven environments, several methods have

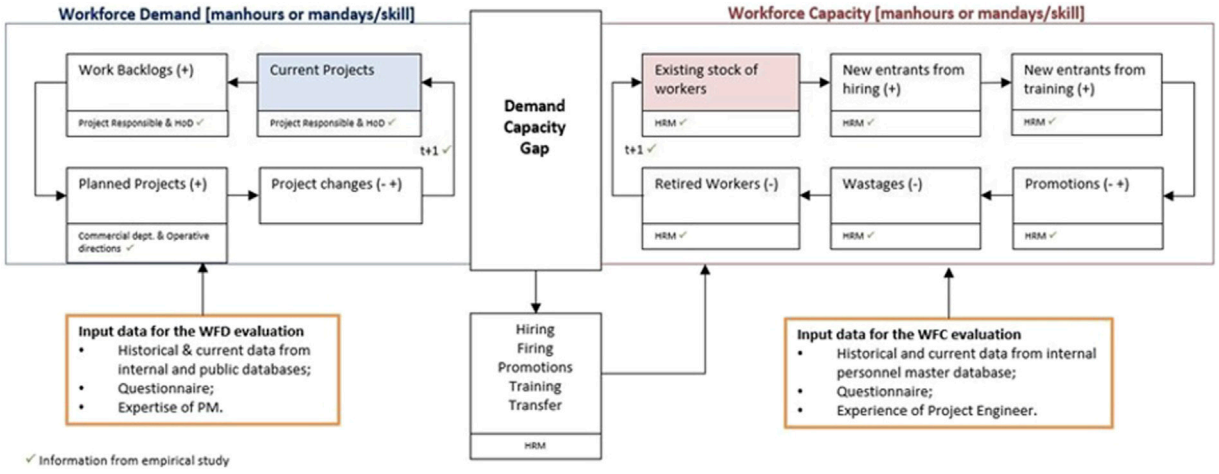

FIGURE 4
Summary of the results of the literature review and empirical study.

been detected in previous studies. Demand-wise, the estimate of the future skilled workforce required for each project can be obtained by using the labor multiplier method (few historical data needed), the linear regression method (relevant amount of data needed), or the model derived from the *ad hoc* simulator proposed by (Huang et al., 2009) (same as labor multiplier). The econometric model and the gray model seem inconsistent with respect to the assessment of the workforce related to the project itself. Capacity-wise, proper distribution of employees per skill might be obtained by using the stock and flow model and, in case of a large amount of data available, the Markov model would allow to forecast the probable internal and external movements of the employees. In addition to the presented quantitative models, the organization might leverage the system dynamics, in order to trigger a "what-if" scenario simulation, and exploit qualitative methods such as questionnaires and surveys, in order to collect data in case of their absence or to complete the already existing database. Finally, the gap detected between the two sides can be mathematically minimized by using linear object programming techniques, aiming at achieving the desired personnel structure, while minimizing the costs. The presented models can be fed by different data sources. With respect to the demand side, internal historical data from completed projects and information about the present and future projects represent the main data input. Anyway, the organization should benefit from the staff's experience. With respect to the capacity side, any project-driven organization is recommended to keep the master personnel's data updated and detailed, since it works as key information source. Even in this case, the management should tap into the staff's expertise. If the absence of data occurs, questionnaires and surveys filled either by internal or external experts can be truly helpful.

5.4 Tools for WFP

When it comes to the tools, at the moment it is not possible to suggest a single general solution able to meet all the companies' requirements. Anyway, a first step could be discerning which kind of tool might be the best fit for the organization, choosing one between *ad hoc* tools, internally developed tools and spreadsheets. Based on the experiences reported by the ten companies which took part in the study, Excel could be a solid starting point, but not only: it could also be a tool to support the process, regardless to the sector and the size of the organization. However, a big-medium size organization should aim at implementing a specific purpose tool. With reference to the latter, SAP BPC, Microsoft Azure, Decisyon and Oracle appear to be suitable platforms on which a custom solution can be designed. According to the empirical research, the overall WFP process should be updated, verified and balanced by the human resources department monthly. Figure 4 summarizes the results of the literature review and the empirical study, depicting a high-level workforce planning process, including process steps, input data, owners, and frequency (t = 1 month), that can be considered generally valid for project-driven companies.

6 Conclusion and future research

Overall, this work presents a comprehensive view of the existing knowledge on WFP (Figure 3), that paved the way to its fine-tuning, by addressing the three research objectives detailed in 3.1 (namely, WFP owners, frequency and effective tools).

In detail, this paper describes the key principles of Workforce Planning and its main process' sections, offering high-level guidelines in terms of recommended process steps, actors involved, operative models, data input, report's frequency, and tools. The presented features, generated by the literature review and the empirical study, are meant to be generally applicable to project-driven companies and to support the practitioners initiating this process in their organization. The workload of future projects should be calculated by the commercial department but it is recommended a review by the departments in charge of the operations. In case of projects in execution, the project manager should be in charge of review and/or approval, then to be validated

by the head of department (HoD) per cost centre. In the case of small organisations, the second part of the revision process could be avoided for overall cost savings. In terms of tools to manage the WFP they range from customized and more complex commercial software and platforms to very simple and easy-to-use spreadsheets. It was not possible to set a clear recommendation and any decision is highly affected by the organization context.

All in all, the outcome of this research can support the design of more effective and streamlined processes for WFP, to support project-driven organizations in getting more efficient use of their resources and saving costs.

Nevertheless, there are interesting areas of expansion/improvement of this study that could address further research. First, a future survey could focus on assessing the impact of incorrect or missing use of WFP, seeking to quantify the benefits of designing and maintaining an appropriate WFP process. In addition, subsequent studies could also examine whether the characteristics found, which are generally considered valid, are influenced by the undertaking's and type of product's industrial sector and, if so, how they could be modified. In addition, since this study focused on the use of WFP in those companies that rely only on internal resources, it would be useful to explore the applicability of the presented WFP to an "extended organization", understood as one exploiting not only the internal workforce but also the distributed workforce in the companies of the supply chain, since some of these companies could be product-oriented and since different skills, now quantified in hours-man, can be outsourced in the form of services. Finally, the absence of software that can manage the entire process of workforce planning, could represent a business opportunity itself, regarding the possibility of developing a tool, based on the high-level process presented in this study, that can be slightly customized on a case-by-case basis.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the (patients/ participants OR patients/participants legal guardian/ next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

GM: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing–original draft, Writing–review and editing. AM: Data curation, Formal Analysis, Investigation, Visualization, Writing–original draft, Writing–review and editing. FP: Conceptualization, Data curation, Investigation, Project administration, Validation, Writing–review and editing. AC: Conceptualization, Data curation, Investigation, Project administration, Validation, Writing–review and editing. MP: Conceptualization, Project administration, Writing–review and editing. AC: Conceptualization, Data curation, Investigation, Project administration, Validation, Writing–review and editing.

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Author FP was employed by Accenture. Authors AC and MP were employed by Maire Tecnimont.

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