RESPONSIBILITIES OF PROJECT MANAGERS. A TEXT MINING ANALYSIS OF JOB ADVERTISEMENTS

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Purpose: To identify the duties and responsibilities of project managers by analysing the content of online job advertisements.

Design/methodology/approach: Job advertisements were automatically downloaded for 63 countries/areas available on Indeed. A text mining analysis of fragments of the advertisements describing the scope of duties was carried out. The text mining analysis included initial text processing, creating corpora of the documents, creating a document-term matrix, and using classic methods derived from data mining.

Findings: The research established the most frequently used words and n-grams in job advertisements. They have been presented in the form of figures. The 2-grams are also presented in the form of a net, a directed graph. The LDA algorithm identified abstract topics describing the duties and responsibilities of project managers. The most frequent words, n-grams, and topics identified by the LDA algorithm were used to identify the duties and responsibilities of project managers.

Research limitations/implications: Only job advertisements written in English were analysed. The postings were downloaded only for six days. An attempt to automatically identify the responsibilities section did not yield the expected results. Therefore, it was carried out manually for random advertisements, which reduced the number of analysed documents. The content of the job advertisements was not analysed by country/area.

Practical implications: The method applied can be used by organisations training future project managers, to modify and better adapt curricula to the needs of the labour market.

Originality/value: Studies have shown that text mining of job advertisements can help determine the duties and responsibilities of project managers.

Keywords: text mining, duties and responsibilities, project manager.

Category of the paper: research paper, case study.

1. Introduction

Contemporary organisations operate in increasingly difficult conditions, characterised by the high complexity and dynamics of internal and external processes. Aggressive competition, unstable business environment, and changing customers' expectations force companies to take unconventional actions and constantly modify their offers. Traditional, rigid organisational structures do not allow companies to quickly adapt to the environment. The solution may be project management. Projects can help organisations to implement new solutions, products, and services. They make companies more flexible, enabling them to effectively and efficiently achieve their goals.

Projects are one of the more frequently used ways of structuring work in organisations (Bakker, DeFillippi, Schwab, & Sydow, 2016). They have become ubiquitous not only in the economy but also in our society and our lives (Jensen, Thuesen, & Geraldi, 2016). The growing use of project management as a way for organisations to develop their intentions has been a trend in recent decades. Project management has already proved to be more effective than traditional management methods, particularly in the case of innovative undertakings unrelated to companies' core business (Munns & Bjeirmi, 1996).

Central to the discipline of project management is the position of the project manager (Meng & Boyd, 2017; Sommerville, Craig, & Hendry, 2010). Research in the area of project management points out the critical role of the project manager in achieving project success (Malach-Pines, Dvir, & Sadeh, 2009; Müller & Turner, 2007). The competencies of this person are one of the most important factors for the success of a project (Spalek, 2005). According to Ling et al., both the competencies and responsibilities of the project manager are closely related to the factors affecting project success (Ling, Ning, Chang, & Zhang, 2018). There is a consensus in the literature that project managers have sole responsibility for the planning and effective management of projects (Ahsan, Ho, & Khan, 2013; Andersen, 2016; Konstantinou, 2015; Korhonen, Laine, Lyly-Yrjänäinen, & Suomala, 2016; Ramazani & Jergeas, 2014; Schmid & Adams, 2008).

As the knowledge, skills, and attitude of project managers significantly affect the project's success, the pressure on those in this position increases (Alvarenga, Branco, Guedes, Soares, & Silva, 2019). Project management, next to experience, is one of the most frequently sought competencies (Anantatmula & Shrivastav, 2012; Pant & Baroudi, 2008). Recruiting the 'right' project manager is a significant challenge for organisations and continues to be an important organisational imperative (Ahsan et al., 2013).

The fundamental objective of the paper was to determine the scope of the project manager's responsibilities with a text mining analysis of job advertisements. The analysis was aimed at identifying the most popular duties. The structure of the work has been subordinated to the goal. The first part of the study involved a literature review to identify and categorise project manager

competencies. The second stage was a text mining analysis of job advertisements posted to an online board. Sections with duties and responsibilities were analysed. The analysis involved text preprocessing, building of corpora of documents, construction of document-term matrices, application of classic data mining methods and a popular topic modelling algorithm. The results are shown in the figures. The most popular words, n-grams, and topics identified with LDA were presented. Two-grams were presented as a net as well. The most common duties of project managers were determined using the most frequent words, n-grams, and abstract topics identified with LDA.

2. Project manager's roles, responsibilities, and duties

The project manager's job is one of the most challenging positions in any organisation because it requires a broad understanding of the different areas that need to be coordinated and strong interpersonal skills (Ahsan et al., 2013). The project manager acts as a problem solver, finding the best options to achieve project objectives and ensure smooth execution of project team's responsibilities (Ahmed, Azmi, & Masood, 2013). Project managers who mastered the art and skills of project management (praised as being the heroes of projects management) are often those who grasped various, and seemingly unrelated, bits and pieces of project life, can manage the unforeseen, can apply principles and tools creatively, and are around to promote and offer support when needed (Blomquist, Hällgren, Nilsson, & Söderholm, 2010).

PRINCE2 defines the role of a project manager as a person who is given authority and responsibility for the day-to-day management of a project to deliver the required products within constraints (Office of Government Commerce (OGC), 2009). The role of the project manager is more challenging than the role of a typical functional manager (Anantatmula, 2010). It is extremely complex and unique as it is based on temporary assignments and the absence of formal positions (Bredin & Söderlund, 2013). This role can be described by a list of tasks and a wide range of responsibilities (Lutas, Nistor, Radu, & Beleiu, 2020).

The primary responsibility of the project manager is to ensure that the project is properly planned, executed, and completed (Mantel, Meredith, Shafer, Sutton, & Wiley, 2011), that all work is completed on time, within budget and scope and at the right level of performance (Heagney, 2016). The project manager's primary responsibilities are to deliver the final product (1) by quality requirements, (2) within budget constraints, and (3) within the schedule specified by the company or the customer (Gaddis, 1959). Primary duties of the project manager include planning activities, organising work, leading the team, and monitoring and controlling progress (Pawlak, 2006; Wachowiak, Gregorczyk, Grucza, & Ogonek, 2004). The project manager is responsible for (Pawlak, 2006):

- defining the organisational structure of the project,
- setting project goals and submitting them for approval,
- overseeing the pursuit of the goals,
- shaping the project's structure,
- planning and overseeing timetables and budget,
- assembling the project team,
- leading the project team,
- fostering information circulation within the project,
- making relevant decisions.

According to Nicholas and Steyn. The most common duties of the project manager include (Steyn & Nicholas, 2012):

- planning tasks, actions, and results under the project by drawing up work structure, timetables, and budget, assigning resources to tasks, and controlling their realisation,
- selecting and organising the project team,
- forging and maintaining relationships with project stakeholders,
- negotiating and integrating function leaders, subcontractors, and senior management team linked to the project,
- monitoring project progress,
- identifying functional and technical problems,
- resolving problems or searching for appropriate ways to resolve them,
- managing conflicts and handling crises,
- recommending project discontinuation if it is impossible to achieve its goals.

The project manager's responsibility in projects is to deal with the 'real' management and staff working on the project (Gaddis, 1959). The project manager is 'the person assigned by the performing organization to lead the team that is responsible for achieving the project objectives' (Institute & PMI, 2012; ManagementInstitute, 2017). General activity related to leading the project team is an important and onerous function of the project manager. Assembly of the project team with the right members is important but appropriate task distribution is as well. Another crucial skill is motivating the team, integrating it, resolving conflicts, and improving the efficiency of operations and communication in the team (Pawlak, 2006; Wachowiak et al., 2004).

Team leading is much more than traditional management. The project manager should share their knowledge and experience and instil a sense of confidence and responsibility for the project among the team (Pawlak, 2006; Wachowiak et al., 2004). Project team leading includes such tasks as teambuilding, project resources analysis, division of labour, team member training, work organisation, communication, knowledge sharing, decision making, motivating and evaluating, employing the right project monitoring system, controlling task progress, and conflict solving (Nicholas & Steyn, 2017).

The project manager deals with representatives of other networks of people and other resources. They form a chain of intermediaries that allow the project manager to act remotely, to make changes, and to claim to represent all those affected. There are other stakeholders, other actors outside who want to influence the project (Blackburn, 2002). The project manager is a member of the project team who reports to the project owner team, is accountable to stakeholders, and has the main goals: representing the interests of the project, ensuring that project goals are achieved, leading the project team, representing the project to appropriate environments, and supervising the preparation of project documentation (Gareis, 2005).

The project manager's responsibilities can also be perceived from the perspective of project execution management, which includes such vital issues as (Trocki et al., 2013):

- project planning – defining the objective, assumptions, scope, and effects of the project, planning project structure (jobs and actions to complete them), project timetable (to represent its course in time), project resources (assignment of resources to jobs and actions and their organisation in time), project costs (budgeting), risk plan, quality, communication, and procurements,

- project team assembly – analysing necessary human resources (particularly their competencies) and acquiring them, motivating, conflict resolving, drafting and implementing an appropriate communication strategy,

- monitoring and control – verifying project timeliness and budget compliance, delegating jobs to project team members, job quality control,

- project closure – handing the project over to the owner, settlements, drafting operational documents, project execution report, making the decision to close the project, dissolution of the project team.

Crawford et al. presented the duties and responsibilities of individual roles within the project environment (among others for a programme manager, project portfolio manager, manager of project support, or project manager). They suggested the following duties and responsibilities of the project manager (Crawford, Cabanis-Brewin, Bigelow, James, & Pennypacker, 2008):

- Define project objectives and prioritise them with the programme manager, project sponsors, director of strategic project office (SPO), or chief project officer (CPO).

- Select team members, communicate their performance information to team members' functional managers, director of SPO, and project support manager (PSM).

- Support the requirements of the enterprise program manager to provide the necessary information and support for the successful implementation of the programme.

- May be responsible for one or more projects.

- Negotiate the execution of activities with team members and their managers, if they are operating in a matrix environment.

- Be a coach in explaining assignments and deliverables; mentor others in project management practices; check the quality of work and manage the integration of team members' work.

- Develop a strategy to optimise the professional development of each team member with the PSM.

- Co-create the project charter with the team, including defining completion criteria.

- Manage and communicate a clear vision of project objectives and motivate the project team to achieve them, creating a project environment that enables peak performance by team members.

- Organise the work into manageable groups of activities (phases) and identify an effective approach to completing the work.

- Using estimators, develop a complete and accurate project estimate; make appropriate use of reserves.

- With project planner(s), prepare the project plan and obtain management approval.

- Analyse risks, develop contingency plans, and identify triggering events and responsibility for initiating mitigating actions. Oversee the activities of the risk administrator. Gather information from stakeholders and rank key project risks in terms of the total impact.

- Work with the planner/scheduler/controller to track and report on plan progress, cost and schedule reporting and change control.

- Analyse actual performance against the plan and make adjustments in line with plan objectives.

- Manage relationships with project stakeholders, including internal and external clients and vendors, keeping them informed of progress and issues to manage expectations for all project requirements and deliverables.

- Involve functional expertise and specialist SPO staff in project reviews and key decision making.

- Manage changes to maintain business plan commitments; initiate a review if objectives need to change.

- Set and publish clear priorities among project activities.

- Arbitrate and resolve conflicts and interface issues within the project.

- Manage the financial aspects of the project: budgeting, capital project management, etc.

- Supervise project documentation and update knowledge bases; analyses lessons learned and shares them with other directors and project managers.

- Together with the analyst(s), analyse the original estimates against the actual hours and duration and understand the factors that contributed to the differences.

- Effectively coordinate team activities to meet project milestones.

- Provide input/justification for project costs and budget implications.

- Cooperate with the methodologist to ensure the implementation of SPO standards, processes, and support services.
- Proactively identify changes in the scope of work and ensure appropriate planning measures are taken with internal and external clients for re-evaluation and amend the scope of work requirements, budget and schedule.
- Oversee reporting activities of planners and analysts, determining when to escalate issues to appropriate management levels.
- Represent the project in meetings (with external consultants, departmental, and senior management), make sure that priorities are communicated and understood, and that progress/delays/problems are reported.
- Determine what constitutes successful closure for all parties. Get approval and signature from all parties when closing is achieved.
- Troubleshoot customer relationship, government relationship, project quality, project risk, and project security issues.
- Manage supplier relations and procurement related to the project(s).

The nature of project management requires that the project manager fulfils various functions simultaneously. The project manager should be (Vaupel, Schmolke, & Krüger, 2000):

- the leader of the project to lead the team, set goals, and direct work,
- a mediator to identify signs of conflicts and crises in the project team and search for solutions to ensure proper work environment, negotiate with project stakeholders,
- a mentor to share knowledge and experience, participate in solving technical problems regarding project execution,
- an economist to take care of the financial results of the project, search for the most effective ways to reach project goals, know the market, know client's needs, and the role of the project in the organisation's strategy,
- an organiser to plan and organise project teamwork, search for ways to resolve complex issues, predict events and implement preventive measures,
- a bureaucrat to lay down principles and procedures for project execution, ensure project management process conformity with internal and external requirements, determine mechanisms for reporting and controlling work progress, evaluate the performance of the project team,
- manage human resources: set requirements and recruit employees, ensure their development, set rules for performance rewarding and punishing,
- a psychologist to establish relationships with people, motivate, support in difficult times, help resolve crises, consider social and emotional needs of their co-workers,
- a salesperson to work with the client, foster project image and positive involvement of stakeholders, and promote team achievements and project success.

3. Research methodology

The job advertisements for the study with 'project manager' in the title were downloaded from 17.04.2021 to 22.04.2021 from Infeed. Postings for all 63 countries/areas were searched. The process was conducted using the RStudio environment with packages *rvest* (Wickham, 2019), *downloader* (Chang, 2016), and *xml2* (Wickham, Hester, & Ooms, 2020).

The next step was to remove advertisements in languages other than English. The language was determined using packages *cld2* (Ooms, 2020) and *cld3* (Ooms, 2021). Advertisements that the author believed were duplicates of other postings were removed as well. An advertisement was treated as a duplicate if its content was identical to the content of another advertisement published by the same organisation. The advertisement content was considered a string of characters. The comparison was made in RStudio with the comparison operator '=='. The analysis involved 25,884 postings from 44 countries/areas. The advertisements were posted to data frames of 25,884 rows and four columns. A single row stored data on a single advertisement in the following columns:

- 'Adverts_ID' – generated unique advertisement number.
- 'Adverts_title' – title of the advertisement.
- 'Adverts content' – the entire content of the advertisement.
- 'Country_area' – the name of the country/area for which the advertisement was posted, for example, 'Poland' for advertisements downloaded from https://pl.indeed.com.

The preliminary analysis revealed that:

- 20,208 (78.1%) of the advertisement had other words in addition to 'project manager' in the title (for example 'IT Project Manager – Telecommunications (Permanent)', 'Senior Project Manager', 'Graduate Electronics Project Manager') – these advertisements were classified to set A;
- 5,676 (21.9%) of the advertisements had only 'project manager' in the title. They were allocated to set B;
- the advertisements did not use semantic HTML tags following JobPosting or used them incorrectly. The tags label various sections of the HTML document, such as required educational background ('educationRequirements'), job description ('responsibilities'), or financial terms ('baseSalary');
- the order of the sections and their headings varied among the advertisements (such as company overview, job description, requirements);
- some advertisements lacked certain sections, such as requirements, job description, or company overview.

The next step was to identify (1) the part describing responsibilities and (2) its heading. The identified data were put into two additional columns:

- Responsibilities – the part of the advertisement with responsibilities.
- Responsibilities_title – the heading of the part describing responsibilities.

The process was conducted manually for randomly selected advertisements because the structures of the advertisements differed, and JobPosting HTML tags were missing. Twenty A-set and five B-set advertisements were randomly selected for each country/area. If the number of advertisements for a country was lower than twenty for set A and five for set B, all advertisements were selected. Only the selected advertisements were left in the data frame and then exported into an .xlsx file. Then the content of columns Responsibilities and Responsibilities_title was created in the spreadsheet with 'select, copy, paste'. The data were then imported into RStudio. At this point, the data frame consisted of 988 rows and 6 columns.

Table 1 presents the numbers of downloaded and randomly selected advertisements by country/area and sets A and B. According to the table, 1,650 advertisements were fetched for Australia; 75.5% (1,246) were classified to set A and 24.5% to set B. Twenty five advertisements were analysed for this country (20 in set A and 5 in set B). Out of the 25,884 downloaded advertisements, 988 were analysed: 791 from set A and 197 from set B.

Table 1.
The number of job advertisements downloaded and selected for analysis

Country/area	Downloaded job advertisements				Selected job advertisements		
	A	B	Total		A	B	Total
Argentina	32 (80%)	8 (20%)	40		20 (80%)	5 (20%)	25
Australia	1.246 (75.5%)	404 (24.5%)	1.650		20 (80%)	5 (20%)	25
Austria	94 (91.3%)	9 (8.7%)	103		20 (80%)	5 (20%)	25
Belgium	391 (85%)	69 (15%)	460		20 (80%)	5 (20%)	25
Brazil	30 (73.2%)	11 (26.8%)	41		20 (80%)	5 (20%)	25
Canada	1.087 (76%)	343 (24%)	1.430		20 (80%)	5 (20%)	25
Chile	13 (68.4%)	6 (31.6%)	19		13 (72.2%)	5 (27.8%)	18
China	462 (83.5%)	91 (16.5%)	553		20 (80%)	5 (20%)	25
Colombia	24 (85.7%)	4 (14.3%)	28		20 (83.3%)	4 (16.7%)	24
Costa Rica	35 (66%)	18 (34%)	53		20 (80%)	5 (20%)	25
Czech Republic	62 (92.5%)	5 (7.5%)	67		20 (80%)	5 (20%)	25
Ecuador	4 (100%)	0 (0%)	4		4 (100%)	0 (0%)	4
Germany	323 (92.6%)	26 (7.4%)	349		20 (80%)	5 (20%)	25
Hong Kong	187 (84.6%)	34 (15.4%)	221		20 (80%)	5 (20%)	25
Hungary	136 (82.9%)	28 (17.1%)	164		20 (80%)	5 (20%)	25
India	835 (66.5%)	420 (33.5%)	1.255		20 (80%)	5 (20%)	25
Italy	40 (90.9%)	4 (9.1%)	44		20 (83.3%)	4 (16.7%)	24
Kuwait	13 (65%)	7 (35%)	20		13 (72.2%)	5 (27.8%)	18
Luxembourg	47 (90.4%)	5 (9.6%)	52		20 (80%)	5 (20%)	25
Malaysia	199 (72.4%)	76 (27.6%)	275		20 (80%)	5 (20%)	25
Mexico	103 (73%)	38 (27%)	141		20 (80%)	5 (20%)	25
Morocco	12 (85.7%)	2 (14.3%)	14		12 (85.7%)	2 (14.3%)	14
Netherlands	76 (79.2%)	20 (20.8%)	96		20 (80%)	5 (20%)	25
New Zealand	228 (69.9%)	98 (30.1%)	326		20 (80%)	5 (20%)	25
Nigeria	48 (73.8%)	17 (26.2%)	65		20 (80%)	5 (20%)	25

Cont. table 1.

Norway	30 (81.1%)	7 (18.9%)	37		20 (80%)	5 (20%)	25
Oman	14 (77.8%)	4 (22.2%)	18		14 (77.8%)	4 (22.2%)	18
Pakistan	29 (61.7%)	18 (38.3%)	47		20 (80%)	5 (20%)	25
Panama	4 (80%)	1 (20%)	5		4 (80%)	1 (20%)	5
Peru	5 (83.3%)	1 (16.7%)	6		5 (83.3%)	1 (16.7%)	6
Philippines	257 (68.7%)	117 (31.3%)	374		20 (80%)	5 (20%)	25
Poland	147 (84%)	28 (16%)	175		20 (80%)	5 (20%)	25
Singapore	907 (69.5%)	398 (30.5%)	1.305		20 (80%)	5 (20%)	25
South Africa	58 (81.7%)	13 (18.3%)	71		20 (80%)	5 (20%)	25
South Korea	31 (83.8%)	6 (16.2%)	37		20 (80%)	5 (20%)	25
Spain	127 (92%)	11 (8%)	138		20 (80%)	5 (20%)	25
Taiwan	82 (88.2%)	11 (11.8%)	93		20 (80%)	5 (20%)	25
Thailand	111 (69.4%)	49 (30.6%)	160		20 (80%)	5 (20%)	25
Turkey	30 (71.4%)	12 (28.6%)	42		20 (80%)	5 (20%)	25
Ukraine	91 (69.5%)	40 (30.5%)	131		20 (80%)	5 (20%)	25
United Kingdom	2921 (77%)	871 (23%)	3.792		20 (80%)	5 (20%)	25
United States	9.539 (80.5%)	2.307 (19.5%)	11.846		20 (80%)	5 (20%)	25
Uruguay	6 (85.7%)	1 (14.3%)	7		6 (85.7%)	1 (14.3%)	7
Vietnam	92 (70.8%)	38 (29.2%)	130		20 (80%)	5 (20%)	25
	20.208 (78.1%)	5.676 (21.9%)	5.884		791 (80.1%)	197 (19.9%)	988

The next stage was a text mining analysis of responsibilities sections stored in the Responsibilities column. The RStudio was used for this purpose. The analysis involved text preprocessing, building n-grams, creating corpora, searching for the most common words and n-grams, and generating abstract topics using the Latent Dirichlet Allocation method (LDA). Some actions were repeated until the results were satisfactory.

Some of the preprocessing operations included:

- removal of all characters except letters,
- lowercasing,
- removal of words considered useless (such as conjunctions, prepositions, etc.) with an original list of stopwords,
- stemming.

The cleaned text was used to generate n-grams of two to four words. N-grams are sequences of characters or words extracted from a text (Majumder, Mitra, & Chaudhuri, 2002). The n-grams were created separately for each piece of text with the End Of Line character (EOL) at the end. The resulting n-grams were put into additional columns: 2-gram, 3-gram etc.

Table 2.
Text cleaning and n-gram creating – example

Original	After cleaning	Two-grams
Creating and manage project plans	create manage project plan	'create manage'; 'manage project'; 'project plan'
Conduct daily stand-ups and retrospectives at the end of each sprint and ensure that the team is continuously learning from previous experience.	conduct daily stand retrospective sprint ensure team continuously learn previous experience	'conduct daily'; 'daily stand'; 'stand retrospective'; 'retrospective sprint'; 'sprint ensure'; 'ensure team'; 'team continuously'; 'continuously learn'; 'learn previous'; 'previous experience'

Table 2 shows the results of precleaning and generation of 2-grams for two random pieces of text. Column ***Original*** contains text before cleaning. The first excerpt initially consisted of a dash and five words. Column ***After cleaning*** shows the same text after it has been cleaned. The number of words was reduced to four. The dash and 'and' have been removed. 'Creating' and 'plans' were stemmed to 'create' and 'plan'. The words from the ***After cleaning*** column were used in 2-grams.

The data from column Responsibilities comprised the first document corpus. The content of each cell was treated as a separate document. The remaining corpora were generated from columns with the n-grams. A document-term matrix with the term frequency (TF) was created for each corpus. The next action was to find the most common words and n-grams and visualise them. The most common n-grams were presented as figures. Two-grams were also presented as a net with a directed graph. Words in the 2-grams were the nodes. The more popular a word in the 2-grams, the larger the node. The 2-grams were presented as edges of the directed graph. The more popular a 2-gram, the darker the edge. For example, edges of 2-grams 'project management' and 'project team' (Fig. 4) are black because these were the most popular 2-grams in the analysed documents. Less common 2-grams, such as 'quality assurance' are grey or light grey.

The last stage was the application of LDA, which is a popular topic modelling algorithm. The supposition for the algorithm is that each document is represented by a set of topics, and each topic is represented by words. The LDA method was described by D. Blei, A. Ng, and M. Jordan (Blei, Ng, & Jordan, 2003). The study employed the implementation of the algorithm available in an R package, *topicmodels*. The topics were generated for documents in column *Responsibilities*.

The topics identified by LDA with the most common words and n-grams were then used to pinpoint the duties and responsibilities of the project manager.

4. Results

Figures 1 and 2 show the most common words in the investigated fragments of job advertisements. The word 'project' was used 3,939 times. It was the most widespread one. It was followed by 'team' (1,438 times), 'ensure' (1,208 times), 'manage' (1,184), and 'management' (1,167). One can analyse the words in figures 1 and 2 containing the 80 most popular words to try to determine the most popular responsibilities of project managers. Words 'project' 'manage', and 'management' suggest that the project manager simply manages project(s). They draw up plans, schedules, budget, and project files (words 'plan'; 'schedule', 'budget', 'require', and 'documentation'). They set the project scope and resources necessary (words 'resources', 'scope', require 'require').

Figure 1. The most used words – part 1.

They manage project risks by identifying their sources and potential implications (words 'risk', 'project', 'manage', and 'identify'). They also manage costs (word 'cost') and communication within the project ('communication'). They monitor and ensure project quality (words 'monitor', 'quality', and 'ensure'). The project manager often deals with people. They lead the project team, manage, and coordinate their operations ('lead'; 'manage'; 'project'; 'team'; 'coordinate'; 'work'). They communicate with and meet clients (internal and external) and project stakeholders (words 'communicate'; 'internal'; 'external', 'client';

'project'; 'stakeholders'; and 'meet'). They manage relationships with customers (words 'customer' and 'relationship'). They address day-to-day business, search for solution and implement them to ensure project progress (words 'issue', 'solution', 'implementation', 'implement', and 'progress').
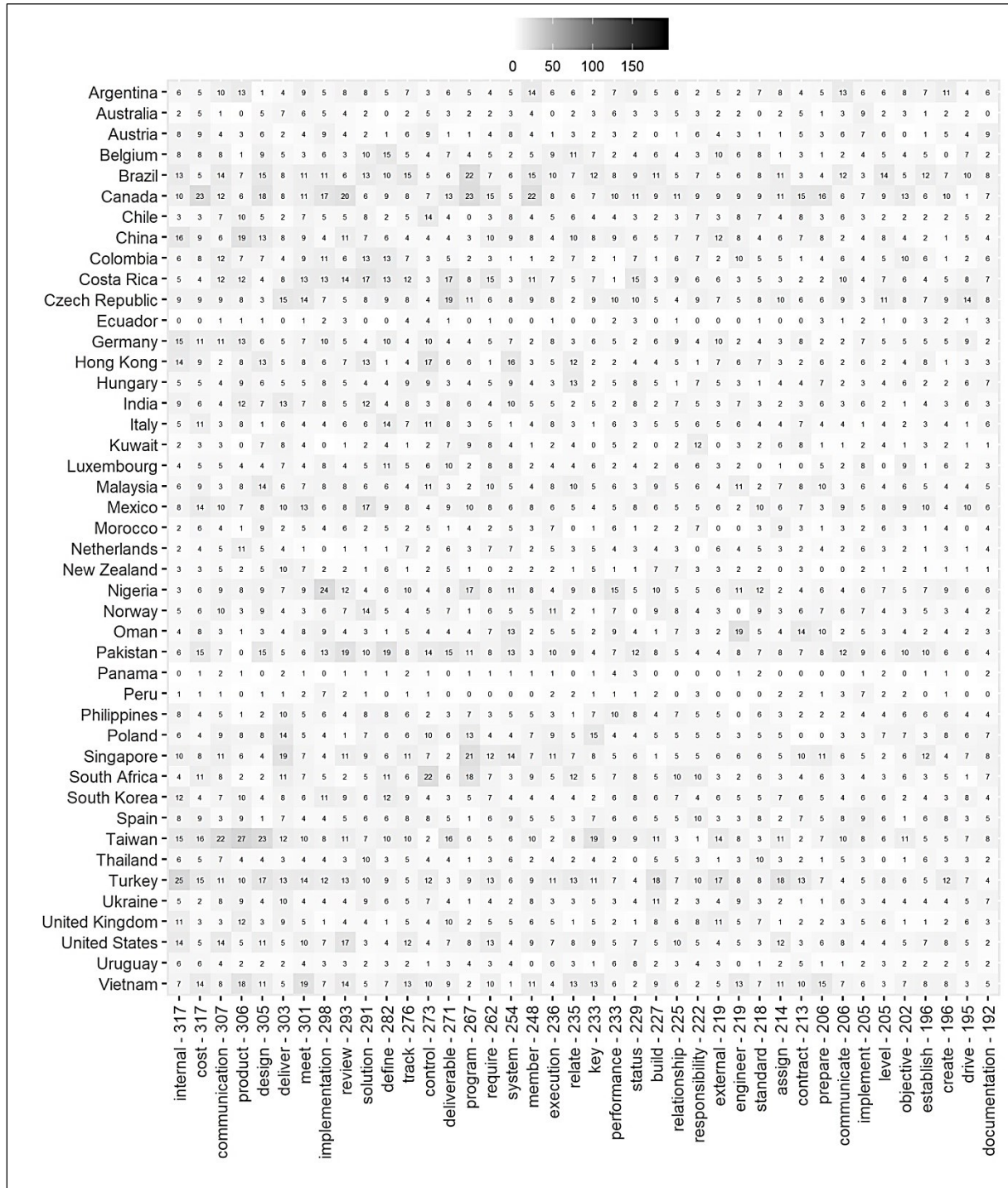
Figure 2. The most used words – part 2.

The 2-grams in Figure 3 confirm the conclusions regarding the most common words in Figures 1 and 2. The primary focus of project managers is to manage projects (2-grams 'project management', 'manage project', and 'management project'). The manager defines the plan, scope, budget, timetable, and resources ('project plan', 'project scope', 'project budget', 'project schedule', 'scope budget', 'scope schedule', 'plan schedule', and 'project resource'). They draw up project documentation (2-gram 'project documentation'), manage project risks (2-grams 'risk issue', 'risk management', 'project risk', and 'issue risk'), manage product quality (2-grams 'ensure quality', 'quality assurance', and 'quality standard'), monitor project execution ('monitor project' and 'control project'), and resolve problems ('resolve issue'). It is again apparent that the project manager should manage project stakeholders relationships (2-gram 'project stakeholder') particularly with the key ones ('key stakeholder' and 'relevant stakeholder'). The 2-gram 'external stakeholder' may suggest that project stakeholders are internal for some projects. Two-grams 'report progress', 'progress report', 'status report', 'report project' indicate that the project manager reports on the progress. Two-gram 'cross functional' may suggest that a cross-functional team could be necessary for some projects, and the project manager either leads them or is a member of that team.

project_management (275); project_team (252); manage_project (217); project_manager (196); project_plan (184); team_member (174); ensure_project (152); internal_external (122); cross_functional (100); project_scope (95); work_closely (82); project_status (77); risk_issue (70); project_delivery (62); project_budget (60); risk_management (60); project_risk (59); report_project (59); project_schedule (59); team_ensure (58); time_budget (57); project_progress (56); status_report (55); lead_project (54); project_documentation (53); functional_team (51); project_execution (50); assign_project (50); schedule_budget (48); develop_project (46); scope_schedule (46); define_project (46); policy_procedure (46); lesson_learn (42); management_project (42); responsible_project (42); change_management (42); ensure_quality (41); monitor_project (41); project_deliverable (40); include_limit (39); key_stakeholder (39); project_resource (38); relationship_client (38); manage_relationship (38); quality_standard (38); manage_change (38); external_stakeholder (37); project_include (37); support_project (37); management_team (37); management_process (37); aspect_project (37); life_cycle (37); track_project (37); communicate_project (37); create_maintain (36); ensure_compliance (36); resolve_issue (36); customer_satisfaction (36); monitor_control (36); track_progress (35); stakeholder_ensure (35); report_progress (35); control_project (35); business_development (35); scope_budget (34); relevant_stakeholder (34); senior_management (34); management_plan (34); software_development (34); maintain_project (34); change_project (34); process_improvement (34); deliver_time (33); ensure_effective (33); detail_project (33); progress_report (33); plan_schedule (33); deliver_project (33); issue_risk (33); project_program (33); project_performance (32); project_stakeholder (32); party_vendor (31); schedule_cost (31); business_process (31); quality_assurance (31); develop_maintain (31); development_team (31); ensure_timely (31); delivery_project (31); ensure_team (31)

Figure 3. The most used 2-grams.

Figures 4, 5 and 6 shows 2-grams in a net. The net in Figure 4 has 77 nodes for 93 2-grams. They are 2-grams from Figure 3 found at least 31 times in the documents. The top left corner of Figure 4 represents 2-grams 'quality standard' and 'ensure quality'. The arrow on the edge indicates the order of words in the 2-gram. There are nodes 'issue' and 'risk' below 2-grams 'quality standard' and 'ensure quality'. The edge between them has two arrows. These are two overlapping edges with opposing arrows. This piece of the net shows two 2-grams: 'risk issue' and 'issue risk'. The net in Figure 4 has some nodes linked to only one other node, such as 2-grams 'lesson learn', 'life cycle', 'work closely', or 'satisfaction customer' while others are connected to multiple nodes.

Figure 4. Two-grams as a net.

Figures 5 and 6 show 2-grams, where one of the words was the most common one in the corpora, 'project'. The net in Figure 5 shows 2-grams with 'project' as the first word, such as 'project schedule' or 'project success'. The net consists of 2-grams that occurred at least 13 times. It has 50 nodes and 49 edges, representing 49 2-grams and 50 words. The net in Figure 6 represents 2-grams with 'project' as the second word, such as 'execute project' or 'control project'. The net presents 2-grams that occurred at least 16 times. It consists of 49 nodes and 48 edges.

Figure 5. 2-grams with 'project' as the first word.

The nets in Figures 5 and 6 contain also 2-grams that were not shown in Figures 3 and 4 due to their frequencies. Results for 2-grams in Figures 5 and 6 that were not included in Figures 3 and 4 are consistent with previous analysis of the most common words and 2-grams in Figures 1, 2, 3, and 4. The project manager is a person who implements, manages, acts, works, and leads in a project or projects (2-grams 'project implementation', 'implement project', 'project deliver', 'project manage', 'project governance', 'project activity', 'project

work', 'project lead', and 'project leadership'). Executes and coordinates the project (2-grams 'coordinate project' and 'execute project'). They manage the costs and communication (2-grams 'project communication', 'project cost', and 'communication project'). They monitor and ensure project quality (2-gram 'project quality'). The project manager monitors, reports, and controls project execution (2-grams 'project ensure', 'project control', 'project report', and 'progress project'). They resolve problems (2-gram 'project issue') and ensure that objectives are achieved and the project is a success (2-grams 'project objective' and 'project success'). They manage project lead time, stages, and lifecycle (2-grams 'project time', 'project timeline', 'project phase', 'project life', 'project lifecycle', and 'phase project'). The project manager can be involved in multiple projects or complex projects (2-grams 'multiple project' and 'complex project').
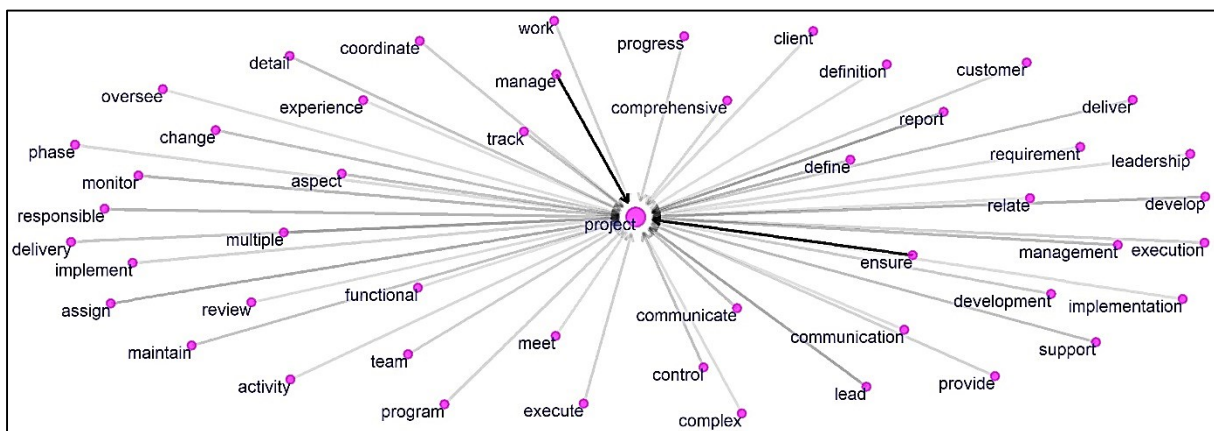
Figure 6. 2-grams with 'project' as the second word.
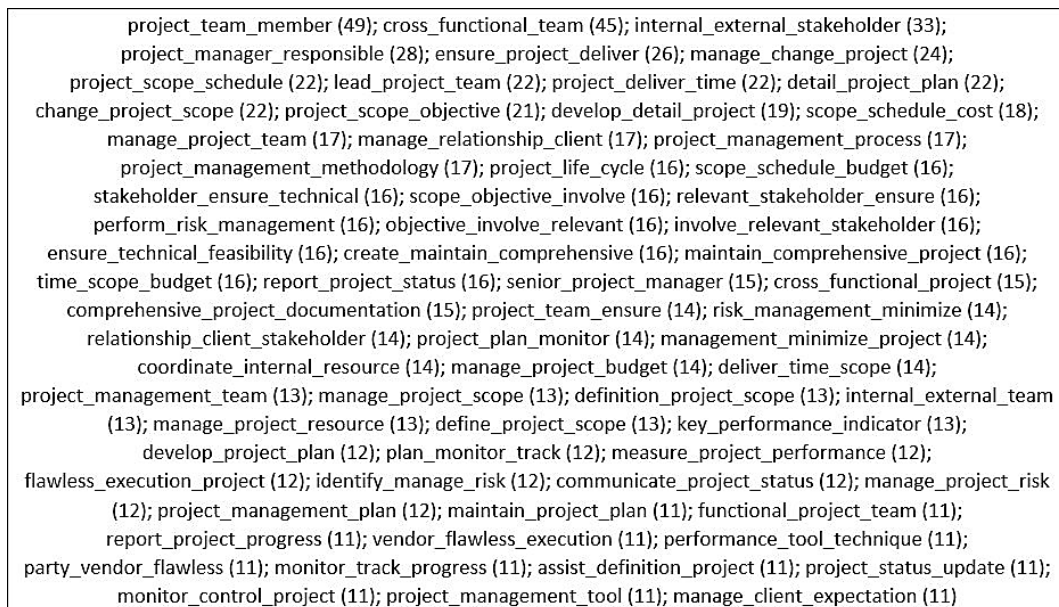
Figure 7. The most used 3-grams.

```
ensure_project_deliver_time (22); manage_change_project_scope (21); develop_detail_project_plan (18);
        stakeholder_ensure_technical_feasibility (16); scope_objective_involve_relevant (16);
            project_scope_objective_involve (16); involve_relevant_stakeholder_ensure (16);
            change_project_scope_schedule (16); relevant_stakeholder_ensure_technical (15);
            project_scope_schedule_cost (15); objective_involve_relevant_stakeholder (15);
        maintain_comprehensive_project_documentation (15); risk_management_minimize_project (14);
        perform_risk_management_minimize (14); manage_relationship_client_stakeholder (14);
    create_maintain_comprehensive_project (14); project_deliver_time_scope (13); deliver_time_scope_budget (12);
        cross_functional_project_team (11); party_vendor_flawless_execution (11); detail_project_plan_monitor (11);
            definition_project_scope_objective (11); assist_definition_project_scope (11);
        vendor_flawless_execution_project (10); project_plan_monitor_track (10); plan_monitor_track_progress (10);
            scope_schedule_cost_verification (9); schedule_cost_verification_technique (9);
            project_performance_tool_technique (9); measure_project_performance_tool (9);
            ensure_resource_availability_allocation (9); clarify_specific_requirement_project (6);
        work_cross_functional_team (6); order_clarify_specific_requirement (5); detail_order_clarify_specific (5);
            develop_maintain_project_plan (5); relationship_internal_external_stakeholder (5);
    strength_skill_experience_level (5); member_individual_strength_skill (5); individual_strength_skill_experience (5);
    scope_cost_schedule_contractual (5); develop_project_management_plan (5); define_project_scope_objective (5);
        ensure_project_complete_time (5); member_cross_functional_team (5); project_scope_goal_deliverable (5)
```

Figure 8. The most used 4-grams.

Figure 7 shows 69 most common 3-grams that occurred at least 11 times. Figure 8 shows 46 4-grams that occurred at least five times. Analysis of the most popular 3-grams and 4-grams confirms previous conclusions. The project manager manages client and project stakeholder relationships (for example, n-grams 'relationship internal external stakeholder', 'manage relationship client stakeholder', 'relationship client stakeholder', or 'manage client expectation'). They manage the project team (for example, 3-grams 'manage project team', 'lead project team'), but can also be part of (internal and external) project teams (for example, n-grams 'internal external team' or 'member cross functional team'). They also control the budget, scope, objective, risk, resources, and time of project execution (for example, n-grams 'time scope budget', 'deliver time scope budget', 'definition project scope objective', 'project scope schedule cost', 'manage project risk', 'perform risk management minimize', 'manage project resource', and 'ensure resource availability allocation'). They set the project plan and monitor and report the progress (for example, n-grams 'develop project plan', 'project plan monitor track', 'report project progress', and 'report project status').

Figure 10 shows topics generated with the LDA algorithm. Their objective was also to identify the scope of responsibilities and most common tasks of the project manager. Each topic contains six words with the highest beta value. It represents the probability of word j occurring in topic i.

The number of topics to be generated by the LDA algorithm was a pivot decision. Four metrics were calculated as described in (Arun, Suresh, Veni Madhavan, & Narasimha Murthy, 2010; Cao, Xia, Li, Zhang, & Tang, 2009; Deveaud, SanJuan, & Bellot, 2014; Griffiths & Steyvers, 2004) with function FindTopicsNumber from R package ldatuning (Nikita & Chaney, 2020). The metrics were computed by training several LDA models with topics ranging from 2 to 50. The results in Figure 9 suggest that the optimum number of topics in light of these metrics was from 17 to 50 topics. The number of topics was also determined via a manual inspection of a variety of topic sets trained using several different numbers of topics. The final number of topics was set to 21.
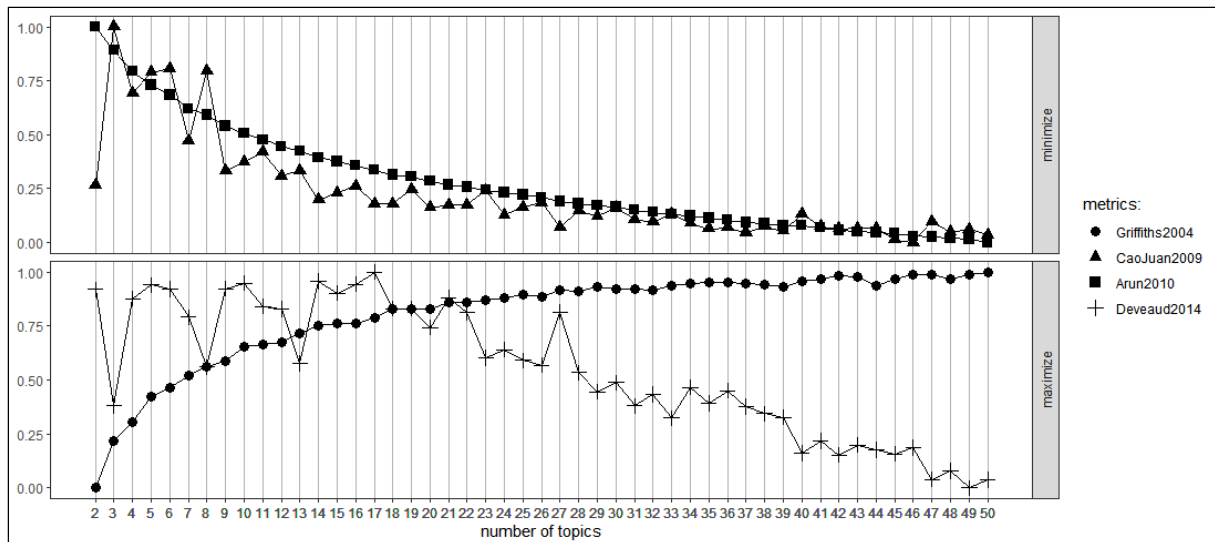
Figure 9. The selection of the number of topics in topic modelling using four metrics.

The topics generated by LDA (Fig. 10) also suggest the most common duties and responsibilities of the project manager. Those previously identified have been confirmed. The project manager performs actions related to project management (topic 12), determines the plan, scope, and resources needed for the project (topic 17), manages project risk by identifying its sources and potential impact (topic 20), manages costs and communication within the project (topic 11), monitors and ensures project quality (topic 2), leads the project team, manages and coordinates its operations (topics 5 and 18), manages project clients and stakeholders (topics 1, 6, and 9), monitors and reports project progress (topics 4 and 19), and supports partners involved in the project (topic 7). The project manager identifies new opportunities and helps with the development of the organisation's business strategy (topic 14). They are the guardian of current standards and procedures (topic 10). Topics 8, 13, and 16 may suggest activities related to the execution of specific types of projects, for example, software development, specific technical solutions or structures.
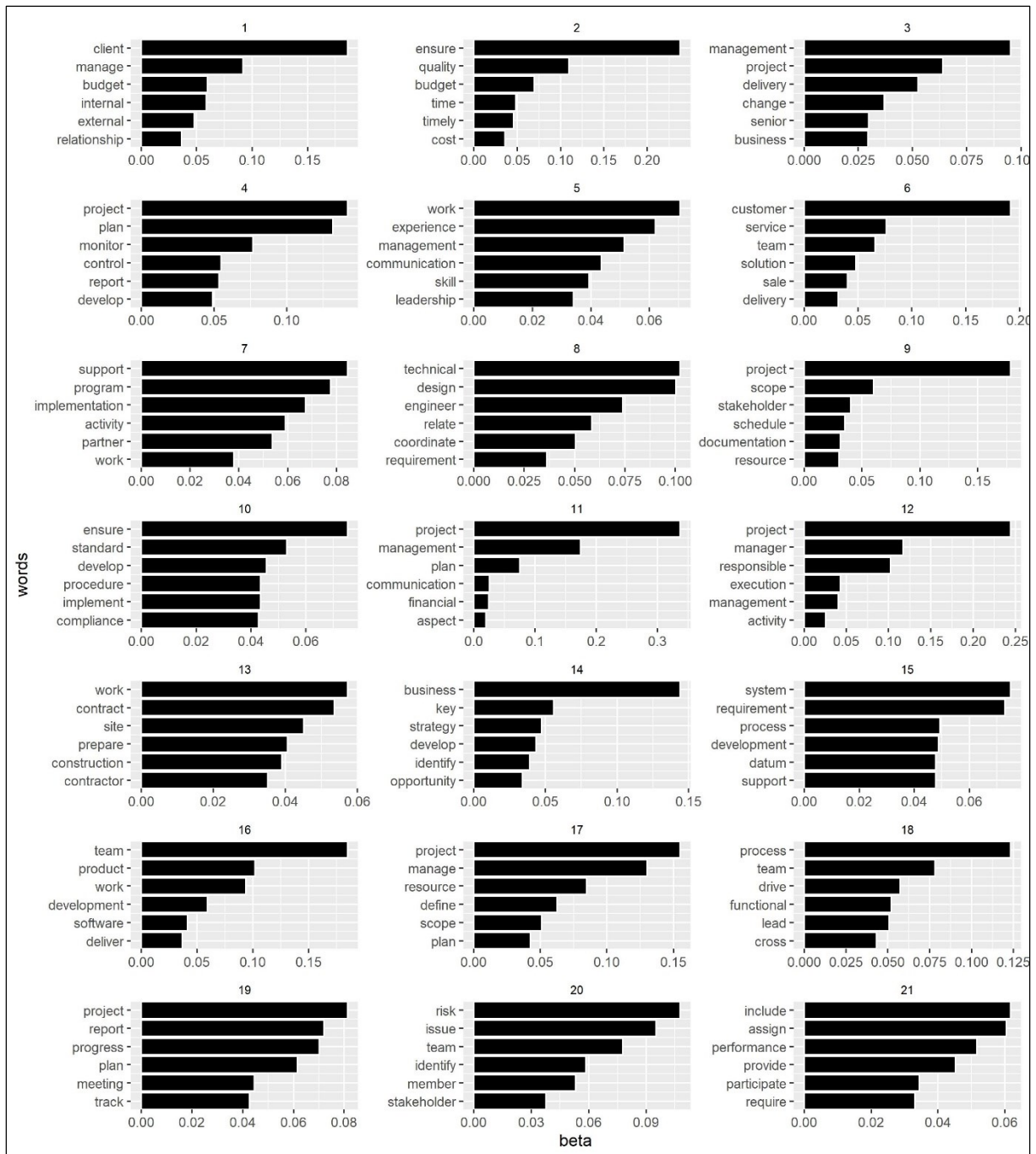
Figure 10. The topics generated with LDA.

5. Discussion and conclusions

The analysis of the most frequent words, n-grams, and topics identified with LDA exhibited the following responsibilities of project managers:

- various general tasks relevant to project management,
- resolving day-to-day problems to ensure project progress,

- drawing up a plan, schedule, budget, and documentation for the project,
- project scope and resources necessary,
- managing project risk, identifying its sources and potential effects,
- managing costs and communication for the project,
- monitoring and ensuring project quality,
- leading the project team, managing and coordinating its work,
- managing project client and stakeholder relations,
- monitoring project progress,
- reporting project progress,
- identifying new opportunities and aiding the development of the organisation's business strategy.

The scope of responsibilities and duties identified in the paper is consistent with other authors' previous research. Primary duties of the project manager include planning activities, organising work, leading the team, and monitoring and controlling progress (Pawlak, 2006; Wachowiak et al., 2004). The project manager acts as a problem solver, finding the best options to achieve project objectives (Ahmed et al., 2013). Their primary responsibility is to ensure that the project is properly planned, executed, and completed (Mantel et al., 2011), that all work is completed on time, within budget and scope and at the right level of performance (Heagney, 2016). They often report on the project progress, are accountable to stakeholders and guard such main goals as representing the interests of the project, ensuring that project goals are achieved, leading the project team, representing the project to appropriate environments, and supervising the preparation of project documentation (Gareis, 2005). The duties and responsibilities of the project manager identified by the author also partly correspond to those listed by Crawford et al. (Crawford et al., 2008)

The present study has certain limitations. Only job advertisements in English were analysed. Therefore the number of advertisements from countries where English is not an official language was reduced. The advertisements were downloaded for a period of six days only. The attempt to automatically identify the section with duties and responsibilities did not succeed. Therefore, the identification was done manually for random advertisements. It reduced the number of documents analysed. The content of the job advertisements was not analysed by country/area, although results in Figures 1 and 2 suggest certain differences among them.

Future research could focus on the following matters:

- to develop a tool/solution to automatically identify a specific section in a job advertisement, such as requirements, job description, company overview, which would facilitate analysing all downloaded job advertisements,

- to compare responsibilities of project managers:
  - by project type,
  - be economy sector,
  - by country, continent, official language, country size, or population size,
- job advertisement categorisation using text clustering (for example K-means text clustering),
- analysis of job advertisements in languages other than English following machine translation into English.

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