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Validation of the Innovation Radar assessment framework

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Title Validation of the Innovation Radar assessment framework

Abstract
In this report we provide an assessment of the statistical methodology behind the Innovation Radar. In particular we analyse to what extent the Innovation potential index and the Innovator capacity index are analytically and statistically sound and transparent. The aim of this report is to evaluate to what extent variables that have been included in these composite indicators make sense from a statistical point of view. Overall, the Innovation potential index is found to be statistically sound with particularly room for improvement of the market potential dimension. The Innovator capacity index is conceptually sound but can be improved statistically.

Table of contents

Foreword

This report is prepared in the context of the three-year research project on Research on Innovation, Start-up Europe and Standardisation (RISES), jointly launched in 2017 by JRC and DG CONNECT of the European Commission. The JRC provides evidence-based support to policies in the domain of digital innovation and start-ups. In particular:

- Innovation with the focus on maximising the innovation output of EC funded research projects, notably building on the Innovation Radar;
- Start-ups and scale-ups – providing support to Start-up Europe; and
- Standardisation and IPR policy aims under the Digital Single Market priorities.

This research builds on the work and expertise gathered within the EURIPIDIS project.

In this report we provide an assessment of the statistical methodology behind the Innovation Radar. In particular we analyse to what extent the Innovation potential index and the Innovator capacity index are analytically and statistically sound and transparent. The aim of this report is to evaluate to what extent variables that have been included in these composite indicators make sense from a statistical and conceptual point of view. It is supposed to serve as a basis for a discussion on potential changes to the questionnaire and the framework.

Executive summary

The European Commission's (EC) Framework Programme (FP) constitutes an important share in R&D expenditures in Europe. Many EC-funded research projects produce cutting-edge technologies. However, there is a feeling that not all of them reach the market. The question is why? Launched in 2014, **the Innovation Radar is a joint DG CNECT-JRC initiative to identify high-potential innovations and innovators in EC-funded research projects** and guide project consortia in terms of the appropriate steps to reach the market. Its objective is to maximise the outcomes of public money spent on research. Following its successful launch, the Innovation Radar is becoming the main source of actionable intelligence on innovation in publically-funded research projects in Europe.

Data of the Innovation Radar stem from a survey developed by DG CNECT which is conducted during periodic reviews of FP projects with an ICT theme. Two indices have been built using the Innovation Radar data:

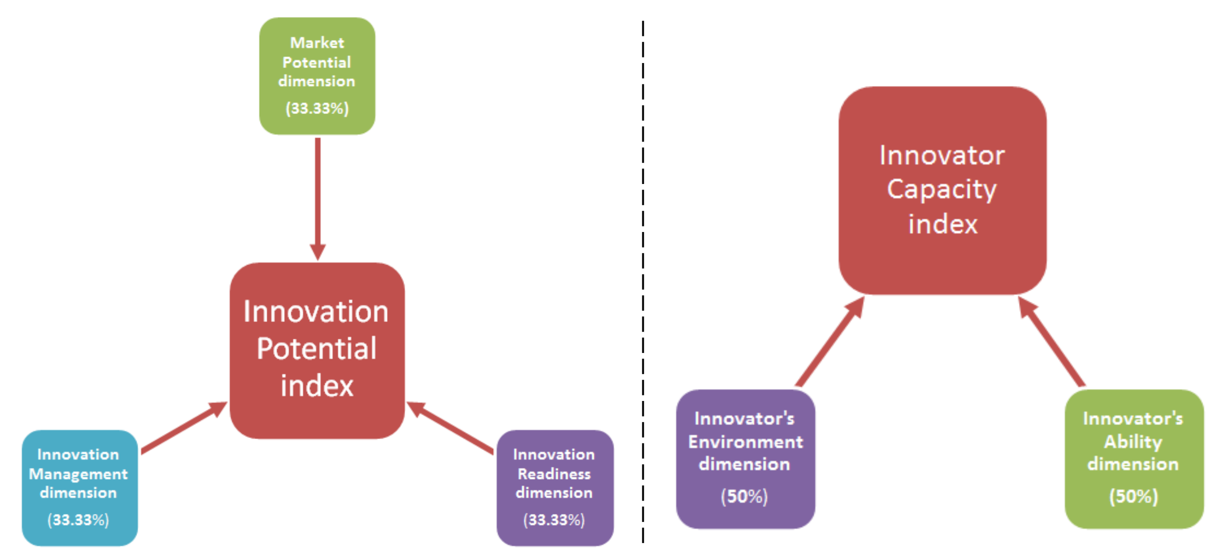
- **Innovation potential index**: it aims at measuring FP project's innovation development towards commercialisation;
- **Innovator capacity index**: it aims at capturing the innovation capacity of innovators that are behind these innovations.

The Innovation potential index captures information about three dimensions that are essential in the innovation development process: innovation readiness, innovation management and market potential. The Innovator capacity index captures information about the innovator's ability and innovator's environment to determine the capacity of innovators in developing successful innovations. Both indices are constructed as arithmetic aggregates of their respective dimensions as indicated in Figure 1.

In this report we analyse to what extent the Innovation potential index and the Innovator capacity index are analytically and statistically sound. We follow the methodology of the OECD/JRC handbook for constructing composite indicators and perform an evaluation of the following items:

- **Input:** questionnaire and the scoring system used for the indices;
- **Process:** statistical process to construct the indices;
- **Output:** statistical soundness of the indices.

Figure 1: The Innovation potential index and Innovator capacity index



Source: European Commission JRC

The main findings of the current report on the validation of the Innovation Radar assessment framework can be summarised in the following way:

Input

- Questionnaire: slight adjustments could be considered as to maximise a clear alignment of reviewers on how to interpret questions;
- Scoring system: slight adjustments could be considered as to accentuate project differences.

Process

- **Innovation potential index: statistically sound**;
  - The innovation management and innovation readiness dimensions are statistically well-balanced and show a good internal consistency;
  - More room for improvement is observed for the market potential dimension.
- **Innovator capacity index: conceptually sound but can be improved statistically**;
  - The index would benefit from a more balanced contribution of indicators;
  - Hence, the collection of indicators that fit better together from a statistical perspective could be considered.

Output

- Adjustments to the conceptual framework of both indices could be considered as to account for differences in the innovation process across innovation types and research partners.

Section 6 provides more detailed summary tables that synthesize the main findings of the assessment of the Innovation Radar framework that has been conducted in this report.

1 Introduction

The Innovation Radar (IR) is an initiative supported by the European Commission focussing on the identification of high potential innovations and the key innovators behind them in FP7, CIP and Horizon2020 projects with an ICT theme (De Prato et al., 2015). The IR serves as a monitoring tool for policy makers and project officers at the European Commission as it provides up-to-date information on the innovative output of these projects. The IR allows them to characterise innovations with respect to their technical readiness, innovation management and market potential. For innovators, it can deliver information on their individual performance and ongoing needs and the environment in which they innovate. Both the information about the innovation potential and innovator capacity has been summarised in two indices called respectively Innovation potential index and Innovator capacity index.

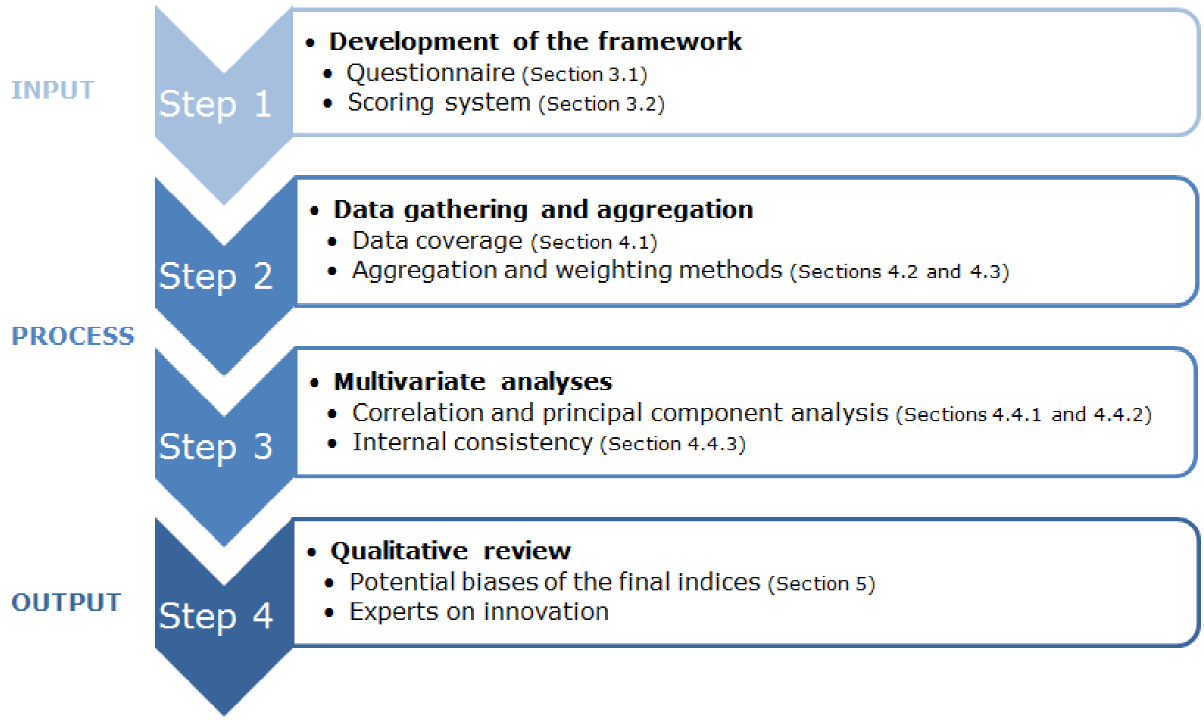
A business intelligence dashboard has been developed for EU policy makers to help them make use of the Innovation Radar data sets for policy development and to empower a more data-driven approach to managing the Horizon 2020 programme. While pilot editions have been conducted for a limited number of Framework Programme projects, the dashboard has been deployed to all projects with an ICT theme.

The deployment of the dashboard to cover all collaborative projects launched under the ICT theme calls for a formal validation of the Innovation Radar methodology. In this report we provide an assessment of the statistical methodology behind the Innovation Radar. In particular **we analyse to what extent the Innovation potential index and the Innovator capacity index are analytically and statistically sound and transparent.** The aim of this report is to evaluate to what extent variables that have been included in these composite indicators make sense from a statistical and conceptual point of view. This assessment consists of a statistical evaluation of the following items:

- **Input**: relates to the questionnaire and the scoring system that provide the input data that feeds the indices of the Innovation Radar;
- **Process**: relates to the statistical process to construct the indices of the Innovation Radar;
- **Output**: relates to the statistical soundness of the final indices of the Innovation Radar.

The three items that are presented in this report closely follow the different methodological steps suggested by the OECD/JRC handbook for constructing composite indicators (OECD & JRC, 2008). The construction of indices should ideally be guided by the following steps: 1. the development of a framework defining the concept and the dimensionality of what is meant to be measured; 2. the gathering of data accompanied with general data checks (e.g., data coverage, and choice of aggregation and weighting methods); 3 the statistical choices to ensure the coherence and robustness of the composite indicator (e.g. multivariate analyses); and eventually 4. a quality assessment from expert bodies in order to get suggestions and reviews about the decisions undertaken in the previous stages of analysis. The sequence for the construction procedure is depicted in Figure 2.

Figure 2: Methodological steps for the construction of the Innovation Radar



Source: Based on the OECD/JRC handbook on constructing composite indicators (OECD & JRC, 2008).

We use these sequential steps as guide for the structure of this report. Section 2 provides a brief overview of the Innovation Radar methodology and presents the data that is included in the dashboard and that is employed for the statistical assessment of the Innovation potential index and Innovator capacity index in the current report. Section 3 focuses on the framework of the Innovation Radar. Instead of focusing on the theoretical arguments for the different dimensions in both indices that has been analysed in De Prato et al. (2015), we provide an assessment of the framework from a statistical point of view, i.e. measuring to what extent the scoring system is adequate in measuring the underlying constructs, and providing some insights about the questionnaire that feeds the data for the composite indicators.

Section 4 provides an in-depth assessment of the current construction of the indices and evaluates to what extent the various steps to construct a composite indicator have been followed. While this section is mainly focused on the process of obtaining the indices, section 5 focuses more on the assessment of the final indices in terms of their results and potential biases they may have due to methodological choices made during their construction.

Finally, section 6 summarises the practical recommendations concerning the construction of the framework and composite indicators. This way, it is supposed to serve as a basis for a discussion on potential changes to the questionnaire and the framework.

2 Innovation radar: in a nutshell

The Innovation Radar (IR) is an EC support initiative that aims to assess the potential of innovations developed within FP research projects and to identify the bottlenecks to their commercialisation (De Prato et al., 2015). Data of the Innovation Radar stem from a questionnaire developed by DG CONNECT. The questionnaire is conducted by external experts commissioned by DG CONNECT during periodic reviews of the research projects. The Innovation Radar monitors the ICT research actions and the e-infrastructures activity under the seventh Framework Programme 2007-2013 (under cooperation and capacities themes), the policy support actions carried out under the competitiveness and innovation framework policy support programme (CIP ICT PSP) and the ICT-related projects in Horizon 2020 (EC, 2014).

Among others, the Innovation Radar aims to identify high potential innovations and the key innovators behind them in FP projects. This information is delivered by means of two indices. The first index provides a holistic view of the innovation potential of FP7 projects, while the second one is capturing the innovator's capacity in conducting high-potential innovation activities. Both indices are respectively called Innovation potential index and the Innovator capacity index. The conceptual framework and scoring systems behind these two indices was originally developed as pilot editions in 2015 (De Prato et al., 2015) and subsequently revised in 2016 (Pesole and Nepelski, 2016).

A business intelligence dashboard has been developed for EU policy makers to help them make use of these data sets for policy development and to empower a more data-driven approach to managing the Horizon 2020 programme. While the pilot editions related to a limited number of reviews conducted between October 2014 and December 2016, the dashboard has been deployed to all projects with an ICT theme and contains information from January 2016 onwards. The dashboard has automatized the processing of data and uses the most recent approach in terms of scoring system and questionnaire version to construct the two indices. Both the questionnaire and the scoring system to construct the indices are presented in appendix.

Table 1: Overview of innovation projects and organisation types

Review period	January 2016 – November 2017
Number of reviewed projects	643
Number of innovations	1777
Number of key organisations	1398
Universities	23%
Research centers	13%
SMEs	37%
Large firms	23%
Government/others	4%

Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The indicator in the database that identifies whether a firm categorises as a SME or a large firm contained 92 missing values. In the table above, these missing values have been treated as large firms.

Data from the dashboard has been used for the statistical assessment of both indices of the Innovation Radar. Table 1 provides an overview of the sample of innovation projects and innovators that we have used for assessment in the current report. Between January 2016 and November 2017, 643 EU-funded collaborative research projects were reveiwed. As a result, 1,777 innovations were identified. This means that, on average, every project produces nearly 3 innovations. The number of distinct key organisations active in these projects amounted to 1,398. We distinguished six types of organisations, including universities, research centres, small –and medium-sized enterprises (SMEs), large firms, governmental institutions and others. SMEs represent the highest share of organisations with 37 percent. Universities and large firms both account for 23 percent each of the organisations, while the percentage of research centers is lower amounting to 13 percent. The percentage of both the governmental institutions and other types of organisations amounts to 4% together.

3 Input: development of the framework

This section provides an assessment of the questionnaire and scoring systems that feed the data for the composite indicators. In particular, it aims to identify some pitfalls and drawbacks in the current questionnaire and scoring system and provides some recommendations for improvement.

3.1 Questionnaire

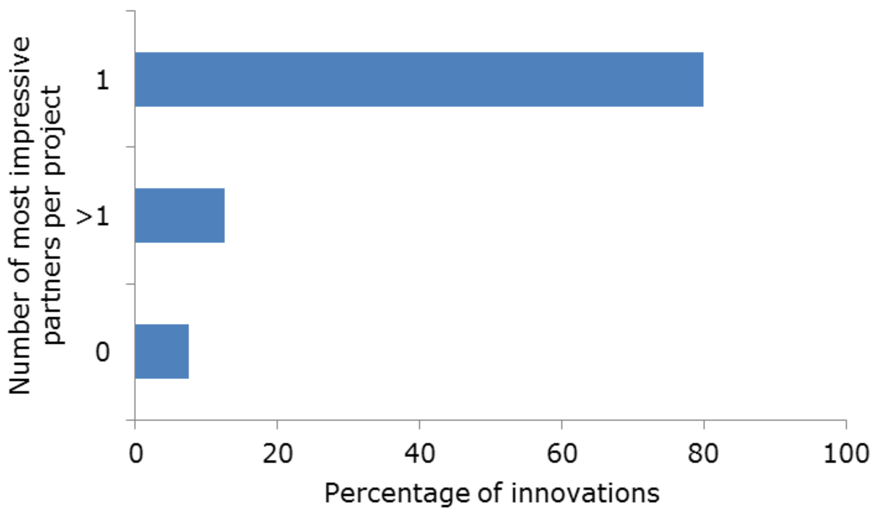
Concept

In survey sampling, one of the main issues of survey designers is limiting respondent errors. Several reasons can lead respondents to provide incorrect or biased information. It can be due to a misunderstanding of the question by the respondent or alternatively it can be caused by a misunderstanding of the response by the surveyor. In any case, **survey questions should be designed in such a way as to minimise possible bias from misunderstanding**.

Assessment outcome

The question about the most impressive partner in terms of innovation potential is clearly stating that reviewers should highlight one particular partner in each project. Hence, this question calls for one partner name per FP project. However, statistics are telling the opposite as observed in Figure 3. From the 1777 innovations identified in the actual dashboard, 13 percent of them report several most impressive partner at the overall project-level.

Figure 3: Number of most impressive partner per project



Calculations: European Commission JRC
Data: European Commission DG Connect

Recommendation

The assessment outcome calls for a clear alignment across reviewers on how to interpret questions.

3.2 Scoring system

Concept

A scoring system has been developed to allow for the classification of projects along their level of innovation potential and innovators along their capacity to develop high-potential innovations. The scoring systems that have been used as indicators for both the Innovation potential index and the Innovator capacity index are presented in the appendix. These scoring systems are in line with other types of scoreboards that have been used in the scientific literature as a ranking systems of technology development projects (see e.g. Cooper, 2007).

In general all the questions relevant to measure each dimension captured in the two indices is used as input in the scoring system. Each answer is then allocated a certain score as defined in appendix in order to determine the innovation potential and innovator capacity.

Although the scoring systems aims to aggregate data from the questionnaire to reduce the dimensionality of the concept measured, in some cases **it can be beneficial to apply a more diversified rating score in order to accentuate project differences**. This would improve the accuracy of identification of the indices in the Innovation Radar.

Assessment outcome

Maximisation of the diversity in rating score is not always applied. The question about the partners' commitment to exploit their innovation outlines 6 levels of reviewer assessment, while the scoring system reduces this information to 3 levels. As illustrated in Table 2, an additional scoring level for the projects' commitment would reward almost one fourth of the innovation sample.

Table 2: Change of scoring system for partners' commitment

	Frequency	Percent
Low	157	8.8
Average	443	24.9
High	1177	66.2
Total	1777	100

⇨

	Frequency	Percent
Low	157	8.8
Average	443	24.9
High	746	42.0
Very high	431	24.3
Total	1777	100

Calculations: European Commission JRC
Data: European Commission DG Connect

Recommendation

Consider changing rating scores to accentuate project differences.

3.3 Duplication

Concept

In general, statisticians discourage the use of an ‘index within an index’ on two main grounds: the distorting effect of the use of different computing methodologies and the risk of duplicating variables (Saisana et al., 2017). The former issue is not a major problem when similar computing methodologies have been used as is the case for the Innovation Radar indices. However, **the risk of duplicating indicators when using an 'index within an index' remains a major issue**.

Assessment outcome

The Innovator capacity index contains the Innovation potential index as one of its indicators. However, it also includes two indicators that were already included in the Innovation potential index. This leads to the duplication and double counting of the following indicators in the Innovator capacity index:

- End-user engagement
- Commitment to innovate

Recommendations

- Recalculation of the Innovation potential index without the two duplicate indicators and insertion of this revised index in the Innovator capacity index;
- Collection of other indicators of innovator's environment.

4 Process: construction of the composite indicators

This section provides an assessment of the current methodology of the Innovation Radar. In particular, we assess to what extent the methodology follows the various methodological steps highlighted by the OECD/JRC handbook on composite indicators (OECD and JRC, 2008). This section extensively builds on the expertise of the Competence Centre on Composite Indicators and Scoreboards of the Joint Research Centre in Ispra.[1]

In particular, the construction of indices can be outlined in the following key steps:

- Data coverage: quality assessment of the raw data in terms of data availability and data imputation decisions;
- Choice of aggregation method: selection of a suitable aggregation method allowing or not for compensability among indicators;
- Choice of weighting method: selection of a suitable weighting method favouring equal weighting or not;
- Multivariate analyses: assessment of the statistical coherence in terms of the underlying importance of indicators and sub-dimensions.

In general the process of construction a composite indicator includes additional steps of outlier treatment and normalisation. Outlier treatment relates to the identification and replacement of outliers in the raw data. The normalisation step requires the selection of a suitable normalisation method in order to adjust the raw data to a notionally common scale. These both steps are not relevant for the Innovation Radar as the data is based on a survey and hence do not contain outliers in the data. Normalisation is also not needed as indicators are comparable to each other giving the scoring system that has been developed. All other steps will be discussed in detail in the following paragraphs.

4.1 Data coverage

Concept

A representative data coverage is key to create a sound and transparent composite indicator. A low data coverage for some indicators could bias the final outcome of an index. **As a rule of thumb, a data coverage of at least 75 percent per indicator should be available** to include an indicator in a composite index. In this section we assess the data coverage for each dimension for both indices of the Innovation Radar.

4.1.1 Innovation potential index

Assessment outcome

Figure 4, Figure 5 and Figure 6 presents the percentages of missing values for the various indicators populating the Innovation potential index.

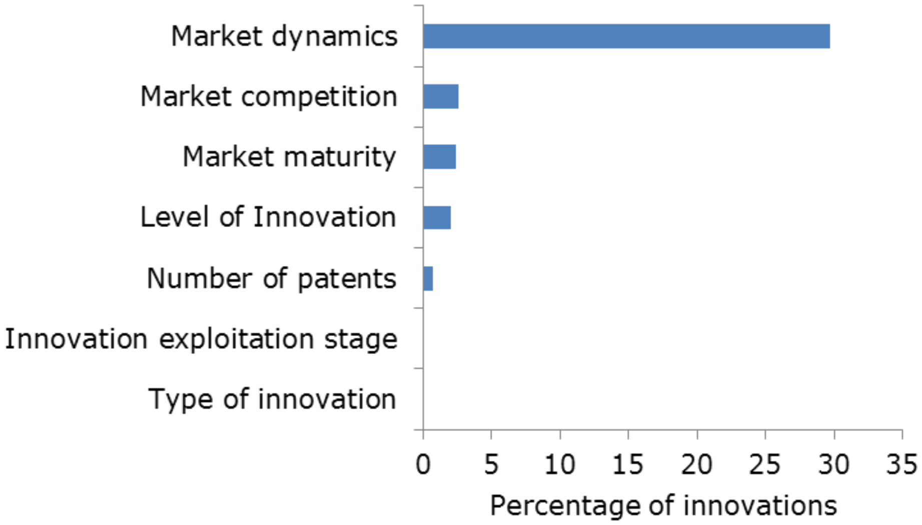
Market potential

The **indicators of market potential are relatively well covered**, where the percentages of missing values remain below 3 percent for most indicators. **Market dynamics is the only indicator with a problematic data coverage**. Data for this indicator is missing in nearly one third of the cases. This large number of missing values may indicate a difficulty of reviewers in responding to questions about the market

[1] For more information about the construction and audit of composite indicators, we refer to the Competence Centre on Composite Indicators and Scoreboards: https://ec.europa.eu/jrc/en/coin.

conditions (e.g. in comparison, the question on market size has a missing rate of 44 percent).

Figure 4: Overview of missing data for the dimension of market potential

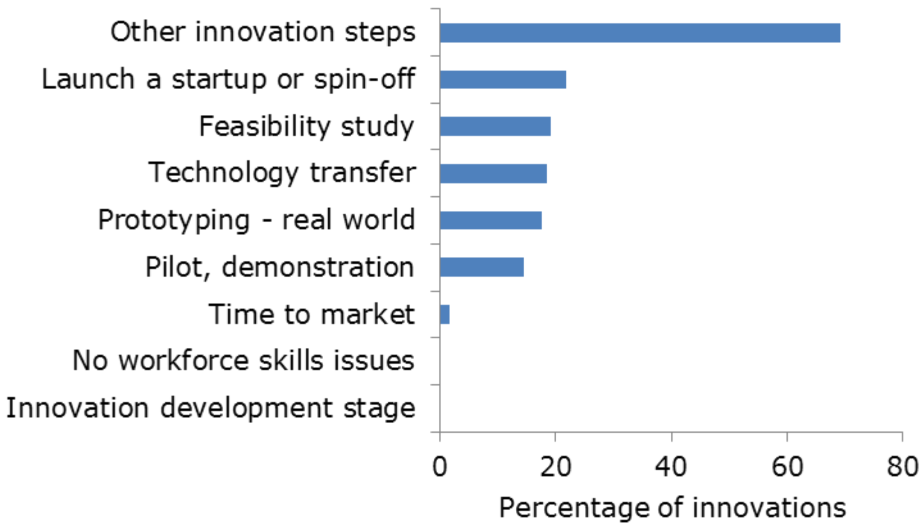


Calculations: European Commission JRC
Data: European Commission DG Connect

Innovation readiness

In general, we observe a low data coverage for all innovation steps that project consortia have undertaken to develop and commercialise their innovations on the market. All indicators in the innovation readiness dimension that capture innovation steps reflect missing rates between 14 and 24 percent. The indicator called "others" that provide the possibility to reviewers to indicate a particular type of innovation step (i.e. not listed in the questionnaire) is even lacking in nearly 70 percent of the cases.

Figure 5: Overview of missing data for the dimension of innovation readiness

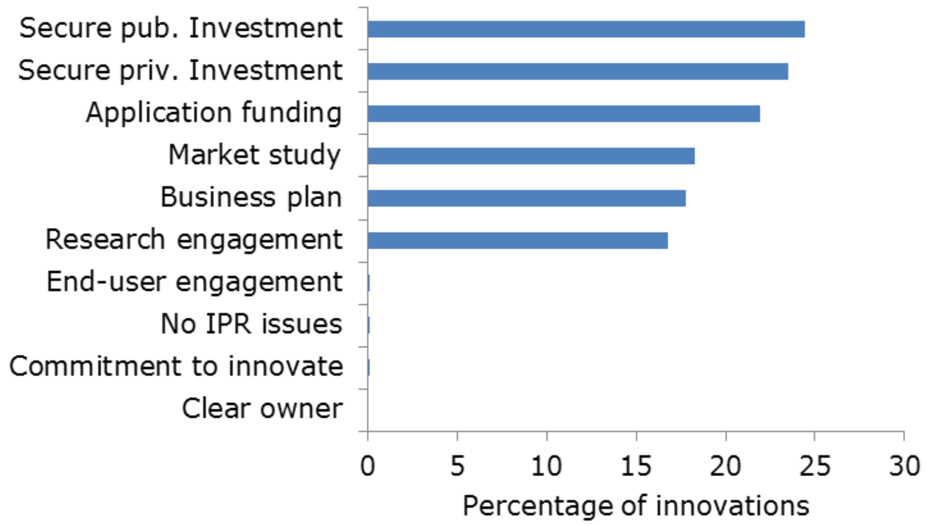


Calculations: European Commission JRC
Data: European Commission DG Connect

Innovation management

A similar pattern is observed in Figure 6 for the dimension of innovation management: all indicators related to innovations steps are missing in 17 to 24 percent of the cases. Other indicators have almost no missing values.

Figure 6: Overview of missing data for the dimension of innovation management



Calculations: European Commission JRC
Data: European Commission DG Connect

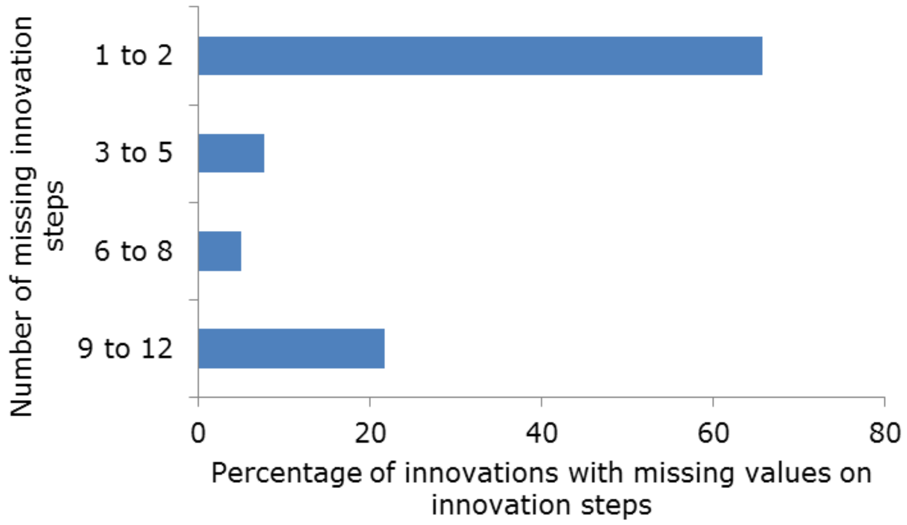
Missing values for innovation steps

Since the lower data coverage on innovation steps seems to be a general phenomenon **we evaluate in more detail the pattern of missing innovation steps in each innovation**. To this purpose, we select those innovations that have at least one missing innovation step and analyse their missing patterns across the twelve innovation steps that are surveyed in the questionnaire. We group them in four different categories according to their number of missing innovation steps: 1) 1 to 2, 2) 3 to 5, 3) 6 to 8 and 4) 9 to 12. The distribution of innovations along these groups is presented in Figure 7. From the population of innovations that have at least on missing innovation step, we observe the following:

- The large majority (66 percent) only lacks information for 1 or 2 innovation steps;
- Around 8 percent lacks information for up to 12 innovation steps;
- Almost 22 percent of innovations lacks information for 9 to 12 innovation steps.

Translating this last point to the full sample of innovations, we observe that **12 percent of innovations do not have any information about innovation steps.**

Figure 7: Distribution of the number of missing innovation steps



Calculations: European Commission JRC
Data: European Commission DG Connect

Twelve percent of innovations for which almost no information is available about the innovation steps is not a negligible number given that they constitute a relatively large part of the Innovation potential index. **Two main reasons can be put forward to explain the low data coverage for innovation steps:**

- It may reflect the difficulty of reviewers to fill this type of question.
- Innovation steps may be left blank because they are most applicable for product innovations and less relevant for other types of innovations, such as process or service innovations and new marketing and organisational methods.

To address this latter issue, **we analyse the distribution of innovations for which none of the innovation steps have been filled in and compare them across different innovation types** (see Figure 8). The figure represents the percentage of innovations per innovation type for which none of the innovation steps have been filled in by the reviewers. Following patterns are observed:

- Organisational/marketing methods and service innovations have highest percentages of complete lack of information on the innovation steps;
- Percentages for product and process innovations for which no information is available is relatively low.

Figure 8: Missing data on all innovation steps across innovation types

Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The different innovation types are defined in the following way: 1) Marketing/organisational method includes both new and significantly improved methods, 2) Service innovation and others: new and significantly improved services, consulting services and others, 3) Product innovations: new and significantly improved products, 4) Process innovations: new and significantly improved process innovations. Percentages are calculated per innovation type, i.e. relative to the total number of innovations in each innovation type.

Recommendations

We have the following recommendations for each dimension of the Innovation potential index:

Market potential

- Consider exclusion of market dynamics.

Innovation management

- Consider exclusion of "other" innovation steps.

Innovation readiness

- Consider hands-on support or training of reviewers.
- Based on the low data coverage for all innovation steps: different types of innovations may require different types of innovation trajectories that are actually not included in the conceptual framework of the Innovation Radar. The questionnaire and conceptual framework could be adjusted to account for these differences.

4.1.2 Innovator capacity index

Assessment outcome

The indicators of the Innovator's ability have no missing values. The innovator's environment has only a few missing values for the indicators of end-user engagement and commitment to innovate as indicated in previous section. Hence, we have no particular recommendations concerning the data coverage of the Innovator capacity index.

Recommendations

Given the excellent data coverage we do not have particular recommendations for the innovator capacity index.

4.2 Choice of the aggregation method

Concept

Every ranking score in composite indicators depends on subjective modelling choices. One of them is the choice to use arithmetic averages when aggregating data into the overall index. In this paragraph, we evaluate how rankings differ if we use another aggregation method such as the geometric average.

4.2.1 Innovation potential index

Assessment outcome

We evaluate another aggregation method because we observe a **low diversity in the ranking scores when using arithmetic averages**:

- Only 60 out of the 1777 innovations (only 3 percent!) have a unique value for the Innovation potential Index;
- A large majority of innovations have Innovation potential indices that appear twice and up to 23 times in the database.

So far arithmetic averages have been used to aggregate indicators into dimensions and indices. It is used in wide range of well-known indices as it has the virtue of being simple and easy to interpret (Saisana and Saltelli, 2014).

However, **arithmetic averages provide low diversity in ranking scores caused by the following problems** related to this method:

- Perfect substitutability: i.e. a poor performance in one indicator can be fully compensated by a good performance in another;
- It does not reward balanced achievement in all indicators;
- No impact of poor performance: it does not consider that the lower the performance in a particular indicator, the more urgent it becomes to improve achievements in that indicator.

To overcome these shortcomings other aggregation methods such as the geometric mean have been advanced by practitioners (Munda, 2008). This average method is a partially compensatory approach that rewards projects with balanced profiles and motivates them to improve in the dimensions in which they perform poorly, and not just in any dimension.

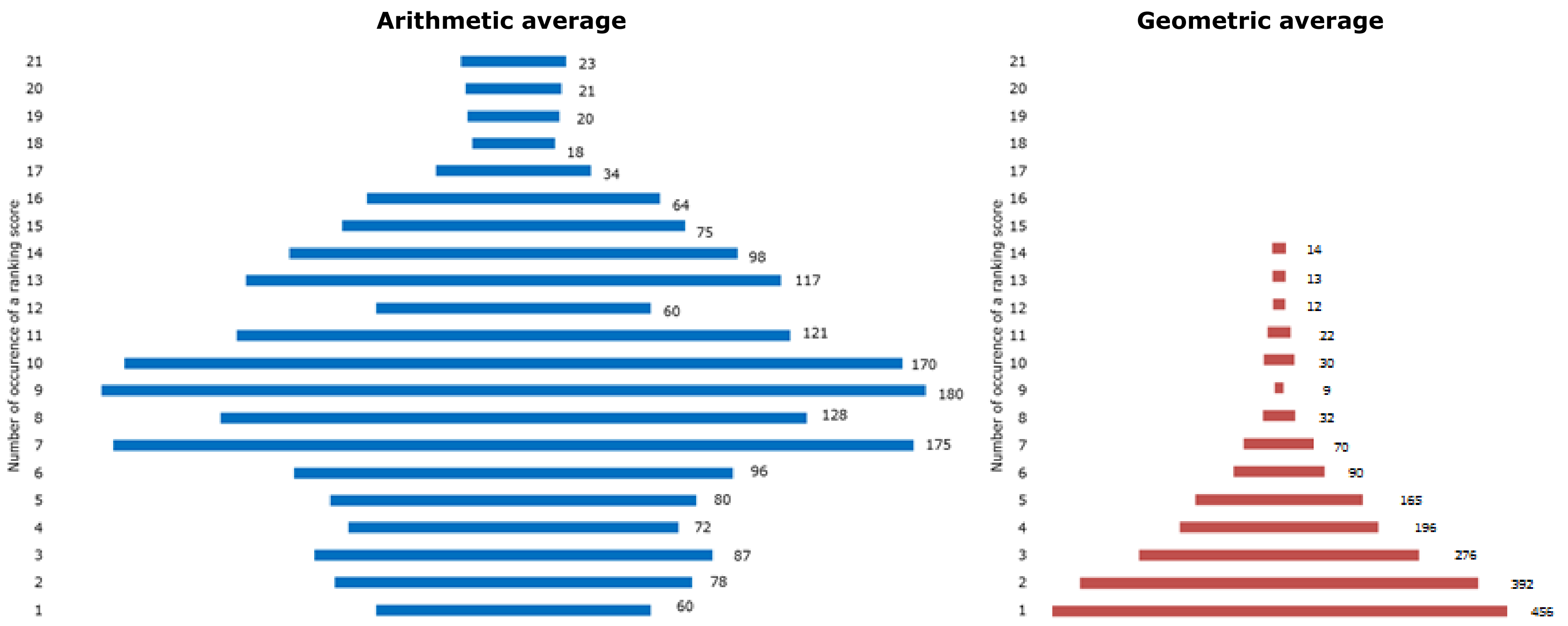
In addition to these advantages, **geometric averages accentuate project differences and provide more diversity in the rankings scores**. This is exactly what we should aim at with the Innovation potential index as ideally an index should only have unique rankings scores that fully capture the project differences.

This is well illustrated in Figure 9 that presents the distribution of similarity in ranking scores of innovations across the two types of aggregation: arithmetic and geometric. The figure present for both aggregation methods how often an identical ranking score appears in the database. The fact that the Innovation potential index has a majority of identical ranking scores is not only caused by the restricted scoring system of the Innovation Radar, but is further accentuated by the use of arithmetic averages. The figures should be read as a pyramid where the base is the ideal situation, representing the number of ranking scores that appear only once in the database. Hence, these are the rankings that allow to differentiate projects in their innovation potential. Each layer above represents the number of occurrences that a same ranking score appears. For instance, the second layer represents the number of rankings that appear twice in the database, while the third layer represents the number of rankings that appear three times in the database, etc.

Based on both figures we can make the following conclusions:

- The number of unique ranking scores when using geometric averages is significantly higher than for arithmetic averages;
- The number of ranking scores that appear twice, three times, etc. in the database is gradually decreasing for the geometric average, while increases for arithmetic averages;
- The number of occurrences that a ranking score appears in the database is significantly lower for geometric averages.

Figure 9: Arithmetic versus geometric aggregation for the Innovation potential index

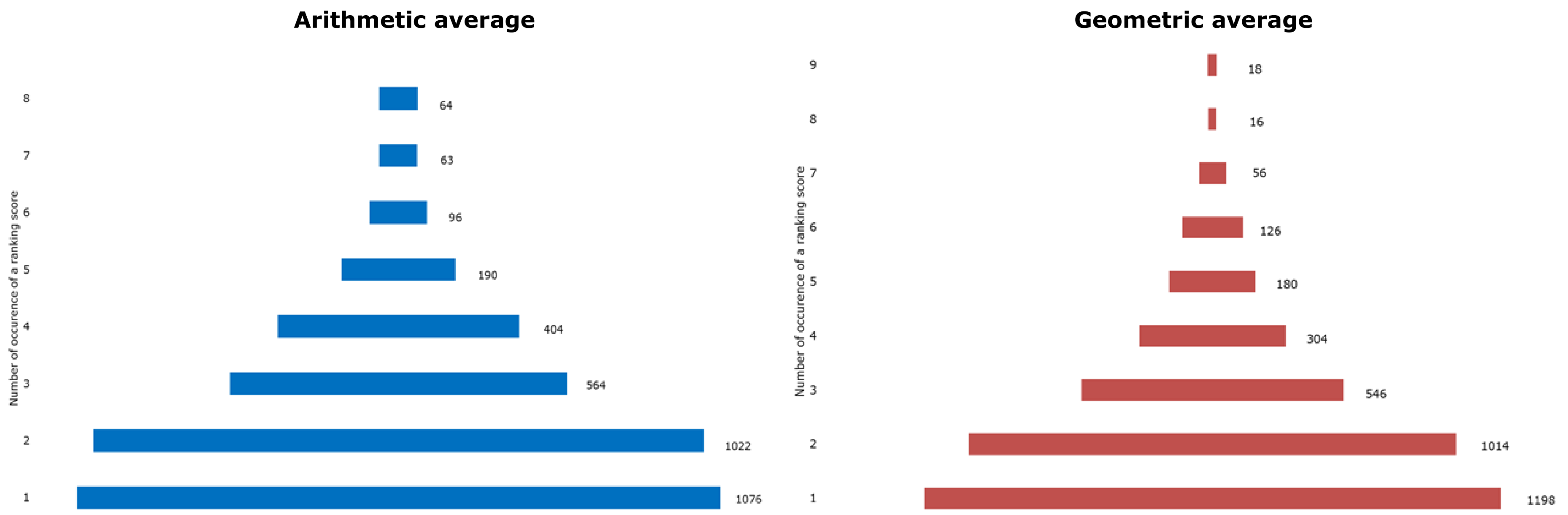


Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The figures present the distribution of ranking scores along their number of occurrences in the database. Ranking score distributions are calculated when using arithmetic and geometric aggregation. The base of the pyramids represents the number of unique ranking scores, while the second layer are ranking scores that appear twice, etc. The labels at the bars represent the number of ranking scores that appear in each layer of the pyramid.

Figure 10: Arithmetic versus geometric aggregation for the Innovator capacity index



Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The figures present the distribution of ranking scores along their number of occurrences in the database. Ranking score distributions are calculated when using arithmetic and geometric aggregation. The base of the pyramids represents the number of unique ranking scores, while the second layer are ranking scores that appear twice, etc. The labels at the bars represent the number of ranking scores that appear in each layer of the pyramid.

4.2.2 Innovator capacity index

Assessment outcome

Using a similar pyramid comparison as for the Innovation potential index, Figure 10 presents a comparison of the rankings for arithmetic and geometric averages for the Innovator capacity index. Aggregation using geometric averages still accentuates project differences, though results are less pronounced than for the Innovation potential index.

Recommendations for both indices

Based on the assessment outcome of the choice of aggregation method for both indices **it is recommended to use geometric averages rather than arithmetic ones**. In the particular case of the Innovation Radar, ranking scores lack diversity due to the restricted scoring system. However, this lack of diversity is further accentuated by the use of arithmetic averages to aggregate the dimensions of market potential, innovation readiness and innovation management into the Innovation potential index. In Table 3 we recall the characteristics of the different aggregation methods for the Innovation Radar.

Table 3: Comparison of aggregation method

	Arithmetic average	Geometric average
Simplicity	+	-
Diversity in ranking scores	Less	More
Penalising poor performances	No	Yes
Rewarding balanced profiles	No	Yes

Note: Based on Munda (2008) and the assessment outcome of the Innovation Radar.

4.3 Choice of weighting method

Concept

The results of principal component analyses (see section 3.4) are often used to determine appropriate weights when aggregating indicators into dimensions. Important to notice is that these weights are then used to correct for overlapping information between two or more correlated indicators and are not a measure of the theoretical importance of the associated indicator. If no correlation between indicators is found – which is the case for the Innovation Radar – then weights cannot be estimated with this method.

Given the difficulty of obtaining appropriate weights from the principal component analyses, **aggregation of the dimensions in the current version of the Innovation Radar is done using equal weights.**

4.3.1 Innovation potential index

Assessment outcome

We have analysed the scientific literature that investigates which factors are important in innovation processes. Many of these papers classify important indicators in relatively similar dimensions that have been used in the Innovation Radar. Balachandra and Friar (1997) proposes four major categories on market, technology, environment, and organisational related characteristics. These categories have been widely recognised and adopted by many scholars in the field of technology commercialisation of R&D projects (Astebro, 2004; Linton et al., 2002). Alternatively, Heslop et al. (2001) use factor analyses to group more than fifty variables related to the technology commercialisation process into four dimensions of market readiness, technology readiness, commercial readiness, and management readiness. However, there is no clear evidence of which dimension is more important in the innovation process.

Due to a lack of convergence in the scientific literature to determine which factors are most important, **it is justified to follow a conservative approach and to opt for equally weighting the three dimensions of market potential, innovation readiness and innovation management**. With this approach we follow the perspective of scholars claiming that successful development and commercialisation of a new technology is a matter of competence in all factors and of balance and coordination between them and not doing one or two things brilliantly well (Conceição et al., 2012; Cooper and Kleinschmidt, 1988; Rothwell, 1992).

4.3.2 Innovator capacity index

Assessment outcome

A similar argumentation applies as for the Innovation potential index: there is no clear convergence in the scientific literature of which indicators are important to determine innovator capacity.

Recommendations for both indices

At the moment, the Innovation Radar can continue using equal weighting in both the Innovation potential index and the Innovator capacity index.

4.4 Multivariate analyses

In order to assess the statistical and conceptual coherence of the structure of the data in the indices of the Innovation Radar, we conduct a series of multivariate analyses that are commonly used in the scientific literature of composite indicators (OECD and JRC, 2008). In particular, we conducted following analyses:

- Correlation analyses: it provides insights about the statistical dimensionality and the grouping of indicators into the three dimensions;
- Principal Component Analysis (PCA): it is used to assess to what extent the conceptual framework behind the indices of the Innovation Radar is confirmed by statistical approaches and to identify eventual pitfalls.
- Cronbach Alpha Coefficient: it estimates the internal consistency in each dimension of the innovation potential index.

All the analyses in this section complement each other and aim to **evaluate to what extent indicators that are fitting well in their respective dimensions**.

4.4.1 Correlation analyses

Concept

Correlation analyses allow investigating the linear statistical relationships across indicators in each dimension and their respective relationship with the final index. **Overall, indicators need to be significantly and positively correlated but not excessively (above 0.95) to have a statistical justification to aggregate them together**.

4.4.1.1 Innovation potential index

Assessment outcome

Correlations within and across dimensions are presented in Table 4. We discuss the correlation matrices for each dimension of market potential, innovation readiness and innovation management and conclude with the analyses of the correlations across these two dimensions and the Innovation potential index.

Market potential

We observe relatively low levels of correlations across indicators in the market potential dimension. **Indicators in the market potential dimension do not correlate with each other because they measure a wide range of different phenomena**. The conceptual framework that provides a theoretical justification for the various items that are measured in the market potential dimension (see De Prato et al., 2015) highlights a large variety of phenomena that determine the market potential of an innovation. Market potential relates in essence to a wide range of technical and market characteristics that aim to capture the type, level, exploitation stage and patentability of an innovation as well as market conditions with respect to the level of maturity, competition and dynamics.

Although these items are relevant to determine the market potential of an innovation they do not easily fit well in an aggregated measure as they measure different phenomena. This is difficulty is reflected in the correlation results.

Concretely, the correlation matrix of the market potential dimension reveals the following:

- Correlations across indicators are close to zero and in the best case elevate up to 0.40.
- Skewed contribution of the indicators to the aggregated measure of market potential.

The market potential measure seems to be mainly explained by the indicators on innovation exploitation stage and market maturity. The relevance and contribution of the other indicators is significantly lower. In particular, the indicator on market competition does not seem to contribute to the aggregated measure of market potential. This is not surprising as market competition seems to negatively correlate with other indicators in this pillar.

Innovation readiness

The correlation matrix of the innovation readiness dimension provide a more balanced picture. Correlations across indicators are higher and almost all positive significant, suggesting that many indicators in this aggregated measure are capturing related phenomena. By consequence, **the contribution of the indicators to the aggregated measure is more balanced as well**. The indicator on the innovation development stage as well as the indicators measuring the various innovation steps in the development process (i.e. prototyping, pilot, demonstration, technology transfer and feasibility study) are capturing between 37 and 59 percent of the aggregated measure of innovation readiness. **The only two innovation steps that contribute less to the innovation readiness dimension are the launch of a startup or spinoff and other innovation steps.** These are also the two indicators with the lowest data coverage.

Innovation management

Also the correlation matrix of the innovation management dimension is relatively well balanced. All correlations are positive and significant. The indicator of a clear owner of the innovation and the indicator revealing no problems of IPR issues within the project consortium are the only two exceptions. Both indicators do not correlate with other indicators, while they correlate positively with each other. The fact that both indicators do not statistically fit with the other indicators is also reflected in their contribution to the aggregated measure of innovation readiness. Both indicators only explain 10 to 13 percent of the variance of the innovation readiness dimension, while other indicators have a significantly higher contribution (between 25 and 60 percent).

Correlations across the Innovation potential index and its three dimensions

Analysing the correlations across the Innovation potential index and its three dimensions, **we find considerably strong linear relationships between the three dimensions and the index.** This suggests that the three dimensions provide meaningful information on the variation of the index score. The contributions of innovation readiness and innovation management are strongly balanced and capture each 65 percent of the index variance. The contribution of the market potential is slightly lower, elevating at 41 percent.

Table 4: Correlations within and across dimension and the Innovation potential index

Correlations within dimensions

Dimension and indicators	1	2	3	4	5	6	7
1 Market potential	**1.00**						
2 Type of innovation	**0.29**	1.00					
3 Innovation exploitation stage	**0.69**	0.19	1.00				
4 Market maturity	**0.79**	-0.05	0.15	1.00			
5 Market dynamics	**0.37**	0.06	0.02	0.39	1.00		
6 Level of Innovation	**0.35**	0.12	0.13	0.12	0.28	1.00	
7 Market competition	**0.05**	0.14	-0.13	-0.31	0.04	-0.07	1.00
8 Number of patents	**0.27**	-0.01	0.02	0.00	0.09	0.15	-0.09

Dimension and indicators	1	2	3	4	5	6	7	8	9
1 Innovation readiness	**1.00**								
2 Innovation development stage	**0.67**	1.00							
3 Technology transfer	**0.63**	0.31	1.00						
4 Prototyping - real world	**0.76**	0.41	0.41	1.00					
5 Pilot, demonstration	**0.77**	0.45	0.44	0.73	1.00				
6 Feasibility study	**0.61**	0.22	0.28	0.43	0.42	1.00			
7 Launch a startup or spin-off	**0.53**	0.30	0.32	0.33	0.30	0.26	1.00		
8 Other	**0.33**	0.13	0.07	0.17	0.24	-0.04	0.50	1.00	
9 Time to market	**0.52**	0.54	0.33	0.42	0.38	0.24	0.30	0.07	1.00
10 No workforce skills issues	**0.39**	0.05	0.11	0.12	0.12	0.23	-0.05	-0.09	0.04

Dimension and indicators	1	2	3	4	5	6	7	8	9	10
1 Innovation management	**1.00**									
2 Clear owner	**0.37**	1.00								
3 Research engagement	**0.68**	-0.09	1.00							
4 Business plan	**0.78**	-0.04	0.58	1.00						
5 Market study	**0.77**	-0.13	0.57	0.85	1.00					
6 Application funding	**0.61**	-0.09	0.31	0.36	0.39	1.00				
7 Secure priv. Investment	**0.68**	-0.09	0.39	0.43	0.40	0.77	1.00			
8 Secure pub. Investment	**0.59**	-0.12	0.23	0.40	0.34	0.81	0.85	1.00		
9 No IPR issues	**0.32**	0.22	-0.03	-0.09	0.01	-0.02	-0.01	-0.08	1.00	
10 End-user engagement	**0.50**	0.04	0.29	0.38	0.35	0.05	0.05	0.01	-0.16	1.00
11 Commitment to innovate	**0.57**	0.05	0.33	0.36	0.37	0.17	0.30	0.18	0.10	0.29

Correlations across dimensions and index

Index and dimensions	1	2	3
1 Innovation potential index	**1.00**		
2 Market potential	**0.64**	1.00	
3 Innovation readiness	**0.81**	0.23	1.00
4 Innovation management	**0.81**	0.30	0.55

Calculations: European Commission JRC

Data: European Commission DG Connect

Note: Correlations between indicators and pillars or pillars and the innovation potential index are indicated in bold. All correlations are significant, except for those indicated in red that represent correlations with a significance level below 5 percent.

Recommendations

We have the following recommendations for each dimension of the Innovation potential index:

Market potential

- Consider exclusion of market competition and number of patents.

Innovation management

- Consider exclusion of Other innovation steps and No workforce skills issues.

Innovation readiness

- Consider exclusion of Clear owner and No IPR issues.

4.4.1.2 Innovator capacity index

Assessment outcome

Correlations within and across dimensions are presented in Table 5. We discuss the correlation matrices for each dimension of innovator ability and innovator environment and conclude with the analyses of the correlations across these two dimensions and the Innovator capacity index.

Innovator ability

We observe relatively low levels of correlations across indicators in the innovator ability dimension. Correlations across indicators are below 0.2, which leads to a very skewed contribution of indicators to the aggregated dimension. **Only the indicators of Most impressive partner and Owner of the innovation contribute significantly to the innovator ability dimension**, while the impact of the other indicators is relatively low.

Innovator environment

The indicators of Project performance and Commitment to innovate are relatively strongly correlated, while correlation with the End-user engagement is lower to inexistent. However, all indicators seem to contribute to the aggregated measure of innovator environment. The correlation between the dimension of innovator environment and the indicator Commitment to innovate is so high that only using that single indicator as measure for the innovator environment would yield a similar result.

Correlations across the Innovator capacity index and its two dimensions

Analysing the correlations across the Innovator capacity index and its two dimensions, **we find considerably strong linear relationships between the two dimensions and the index.** This suggests that the two dimensions provide meaningful information on the variation of the index score. The contributions of the innovator ability and innovator environment are relatively balanced, with a slightly higher contribution of the latter dimension. The higher contribution of innovator environment is mainly caused by the very imbalanced structure of the innovator ability dimension that seems to regroup indicators that do not statistically relate to each other.

Table 5: Correlations within and across dimension and the Innovator capacity index

Correlations within dimensions

Dimension and indicators	1	2	3	4	5
1 Innovator ability	**1.00**				
2 Number of times key organisation	**0.38**	1.00			
3 Innovation potential index	**0.25**	0.12	1.00		
4 Most impressive partner	**0.80**	0.20	0.05	1.00	
5 Owner of innovation	**0.79**	-0.03	0.15	0.25	1.00
6 Needs of organisation	**0.33**	-0.02	-0.08	-0.14	-0.01

Dimension and indicators	1	2	3
1 Innovator environment	**1.00**		
2 End-user engagement	**0.75**	1.00	
3 Project performance	**0.79**	-0.03	1.00
4 Commitment to innovate	**0.91**	0.26	0.58

Correlations across pillars and index

Index and dimensions	1	2
1 Innovator capacity index	**1.00**	
2 Innovator ability	**0.65**	1.00
3 Innovator environment	**0.86**	0.14

Calculations: European Commission JRC

Data: European Commission DG Connect

Note: Correlations between indicators and pillars or pillars and the innovation potential index are indicated in bold. All correlations are significant, except for those indicated in red that represent correlations with a significance level below 5 percent.

Recommendations

We have the following recommendations for each dimension of the Innovator capacity index:

Innovator ability

- Consider collection of other indicators of innovator's ability that fit better together from a statistical point of view.

Innovator environment

- Consider collection of other indicators of innovator's environment that fit better together from a statistical point of view.

4.4.2 Principal component analyses

Concept

Principal component analysis (PCA) is a statistical procedure to reveal the internal structure of the data in a way that best explains the variance in the data. PCA performs an orthogonal transformation to convert the different sets of correlated indicators into linearly uncorrelated indicators. In layman's words, **principal component analysis provides insights about the underlying structure of the data in each dimension and identify which indicators statistically belong to each other.**[2] Ideally, all indicators that have been categorised in one dimension based on theoretical/conceptual arguments, should show a similar structure from a statistical point of view. In this ideal case, PCA would find only one statistical structure per dimension, which would suggest that all the indicators included in one dimension are relatively highly correlated with each other and have similar statistical patterns. In more general terms, this would mean that the conceptual framework constructed on theoretical groundings would coincide with the statistical structure of the underlying data. This is needed to have a statistical justification to aggregate the data as outlined in the conceptual framework.

Given the relatively low correlations found in previous section, it is expected that the PCA will reveal more than one structure per dimension. In a sense, this is not surprising given the complex nature of the innovation process that contains many different steps that do not necessarily relate to each other. Nevertheless, it is important to analyse the data structure found by the PCA to see if it makes sense from a theoretical perspective as it can then be used to further improve the conceptual framework of the inidces of the Innovation Radar.

To summarise, conducting a PCA is relevant for two reasons:

- To provide statistical confirmation of the conceptual framework;
- To provide new insights on data structures that can be used to revise the conceptual framework.

In the following sections we present that the results of the PCA for the Innovation potential index and the Innovator capacity index.

4.4.2.1 Innovation potential index

Assessment outcome

Table 6 presents the different structures obtained after PCA on each dimension. The different structures are presented in the columns and the red values indicate which indicators belong to the respective structures.[3] Below we discuss in more detail the different structures that have been found for each dimension of the Innovation potential index.

Market potential

For the market potential, PCA identifies four statistical structures that respectively contain the following indicators:

- Market maturity and market dynamics;
- Market competition;

[2] In this report we only highlight the intuition behind PCA without going into detail concerning the mathematical calculations of principal component analyses. For more detailed discussions about this particular method, we refer to studies of OECD-JRC (2008) and Jolliffe (1986).

[3] A threshold value of 0.45 (absolute value) on the principal component loadings has been used to allocate indicators to their specific structure. These values are highlighted in red in the tables.

- Type of innovation and Innovation exploitation stage;
- Number of patents.

This result highlights that the indicators of the market potential capture a wide range of distinct phenomena.

The first structure identifies indicators that relate to **market conditions**. Market maturity and market dynamics are market-related characteristics that are important to determine the market orientation and market potential of an innovation, but they seem not to relate the other indicators in this dimension.

The second structure identifies **market competition** as a single indicator. This is not surprising given the very low – and even negative – correlation that this indicator has with all the other indicators in this dimension. Market competition acts as a silent indicator, meaning that its inclusion can be important from a conceptual point of view, but statistically it does not contribute to the market potential dimension.

The third structure identifies indicators that relate to the **technology** of the innovation. It includes indicators on the type of innovation and its exploitation stage. The PCA outcome is however not clear-cut about the level of innovation, which is theoretically also a technological-related aspect. Statistically that indicator does not seem to be categorised in any particular structure, but according to the PCA it tend to fit better in the fourth structure.

The fourth structure contains the indicator on number of patents which provides a measure of the **patentability** of the innovation. Hence, it is not surprising that the level of innovation seems to fit best in this structure as both aspects are undeniably related. A more innovative invention that satisfies a well-known market need is probably more patented.

To summarise, the PCA of the market potential highlights both market and technology-related aspects of innovations and reveals that indicators in each of these dimensions relate to each other but that both aspects are distinct phenomena. This is in line with the scientific literature that identifies market and technology as two of the most relevant factors in the innovation process (Balachandra and Friar, 1997; Astebro, 2004).

The finding of the PCA for the market potential has two important implications:

- It provides reliability for the indicators that are included in the dimension of market potential as indicators that are theoretically related seem also to be statistically related;
- The distinction between market and technology related characteristics in the market potential dimension should be further emphasized in the conceptual framework.

Innovation readiness

For the innovation readiness, PCA identifies three statistical structures that respectively contain the following indicators:

- Innovation development stage and time to market;
- Feasibility study and No workforce skills issues;
- Launch a startup or spin-off and Other.

The first structure identifies indicators that relate to **commercialisation**. It relates to the overall development stage of an innovation and the timing to market. This reveals consistency in the underlying data as an innovation that is more advanced in its development stage should generally exhibit a shorter time to commercialisation.

The second structure identifies indicators that relate to the **feasibility** of an innovation. It identifies both Feasibility study and No workforce skills issues in the same latent structure. This is justified from the fact that the feasibility of an innovation is directly affected by the lack of appropriate workforce skills in the project consortium. Hence, also this structure provides evidence for the consistency of responses to the questionnaires.

The third structure is less comprehensible and hence we label it as **other**. PCA regroups the indicators of Launch a startup or spin-off and Other innovation step in one latent structure. This may mean that both indicator share a statistical pattern. However, so far, the answers of the "Other innovation steps" indicator have not been explored in detail. Text-mining analyses on this indicator could shed more light on the type of answers that it contains and could potentially unravel correlation patterns with the indicator of startup/spinoff launch.

Other innovation steps inserted in this dimension – i.e. technology transfer, pilot, demonstration and prototyping – are not allocated to any particular structure. This means that statistically all these innovation steps appear as being distinct aspects of the innovation process that do not relate to each other. To better assess the reliability of the data for all these innovation steps the PCA of this dimension should be complemented with an analysis of the internal consistency (which is done in next section).

Innovation management

For the innovation readiness, PCA identifies three statistical structures that respectively contain the following indicators:

- Business plan, Market study and End-user engagement;
- Application funding, Secure private investment, Secure public investment;
- Clear owner, No IPR issues.

The first structure identifies indicators that relate to the **business proposal.** It contains the indicators of market study, business plan and user-engagement.

The second structure identifies indicators that relate to the financial **funding** of innovations. It regroups all the indicators that measure applications and actual attraction of financial investments from public or private sources that are needed to develop an innovation.

The final structure identifies indicators that relate to aspects concerning **ownership**. The fact that the indicator of clear ownership and no apparent IPR issues in the consortium is identified to be in one structure is not surprising but at the same time identifies a weakness of the conceptual framework. Even if both indicators are measured at a different level (innovation versus project), innovations with a clear ownership may be in projects where there are no IPR issues in the research consortium. The scoring system may penalise projects with only multiple owners.

Table 6: Statistical structure within the dimensions of the Innovation potential index

Market potential

	Market conditions	Market competition	Technology	Patentability
Type of innovation	0.04	0.33	0.66	-0.03
Innovation exploitation stage	-0.09	-0.30	0.71	-0.04
Market maturity	0.52	-0.44	0.00	-0.21
Market dynamics	0.75	0.13	-0.06	0.00
Level of Innovation	0.38	0.08	0.24	0.41
Market competition	0.08	0.76	-0.03	-0.11
Number of patents	-0.04	-0.06	-0.05	0.88
Explained variance	1.46	1.32	1.24	1.08
Cumulative	0.21	0.40	0.58	0.73

Innovation readiness

	Commercialisation	Feasibility	Other
Innovation development stage	0.56	-0.13	-0.06
Technology transfer	0.27	0.21	0.07
Prototyping - real world	0.32	0.29	0.12
Pilot, demonstration	0.31	0.29	0.15
Feasibility study	0.08	0.54	0.00
Launch a startup or spin-off	0.10	0.02	0.60
Other	-0.11	-0.08	0.75
Time to market	0.58	-0.14	-0.12
No workforce skills issues	-0.21	0.67	-0.12
Explained variance	2.52	1.64	1.61
Cumulative	0.28	0.46	0.64

Innovation management

	Business proposal	Funding	Ownership
Clear owner	0.02	-0.08	0.62
Research engagement	0.43	0.04	-0.02
Business plan	0.49	0.07	-0.04
Market study	0.48	0.07	-0.02
Application funding	0.01	0.55	0.00
Secure priv. Investment	0.05	0.54	0.04
Secure pub. Investment	-0.03	0.58	-0.05
No IPR issues	-0.05	0.05	0.72
End-user engagement	0.46	-0.22	-0.10
Commitment to innovate	0.36	0.01	0.29
Explained variance	2.81	2.72	1.26
Cumulative	0.28	0.55	0.68

Calculations: European Commission JRC

Data: European Commission DG Connect

Note: This table presents component loadings of a polychoric principal component analysis conducted on each pillar. Loadings greater than 0.45 (absolute values) are highlighted in red. Varimax rotation has been applied.

Recommendations

In general the results of the principal component analysis confirm the findings of the correlation analysis. Hence, similar recommendations apply for the PCA. Based on the PCA results, following additional recommendations can be made for the following dimensions of the Innovation potential index:

Market potential

Based on the statistical structure found in the PCA, consider creating three sub-dimensions of market potential, including:

- Market conditions (market maturity, market dynamics);
- Technology (type of innovation and innovation exploitation stage);
- Market orientation (level of innovation).

As previous recommendations on the market potential suggested exclusion of a couple of indicators, this dimension may benefit from the inclusion of indicators related to bottlenecks of innovation. As such, this dimension would not only account for positive indicators towards commercialisation but would also account for phenomena that hamper the innovation process. Inclusion of the following indicators could be considered:

- Bottlenecks to innovation such as standardisation, trade and regulation.

Innovation readiness

Given the fact that Other innovation steps and Launch a startup/spin-off are statistically grouped together by the PCA, text-mining analyses on Other innovation steps could shed more light on the type of answers that it contains and could potentially unravel correlation patterns with the indicator of startup/spinoff launch.

Innovation management

There are no additional recommendations for innovation management.

4.4.2.2 Innovator capacity index

Assessment outcome

Table 7 presents the different structures obtained after PCA on each dimension. The different structures are presented in the columns and the red values indicate which indicators belong to the respective structures.[4] Below we discuss in more detail the different structures that have been found for each dimension of the Innovation potential index.

Innovator ability

For the innovator ability, PCA identifies three statistical structures that respectively contain the following indicators:

- Number of times key organisation;
- Owner of innovation;
- Needs of organisation.

All the structures of this dimension contain only one indicator. In addition, two indicators on Most impressive partner and the Innovation potential index do not fit in any of these structures. The indicator of Most impressive partner is at the threshold of being included together with the Owner of innovation, which is in line with the correlation analyses as both indicator recorded the highest correlation in this dimension. However, overall the PCA reveals that **none of the indicators in the innovator ability dimension are related to each other from a statistical perspective**.

[4] A threshold value of 0.45 (absolute value) on the principal component loadings has been used to allocate indicators to their specific structure. These values are highlighted in red in the tables.

Innovator environment

For the innovator environment, PCA identifies two statistical structures that respectively contain the following indicators:

- End-user engagement;
- Project performance and Commitment to innovate.

In line with the correlation analysis Project performance and Commitment to innovate are grouped together in one structure. These are also the two most influential indicators in the dimension and explain a large part of the variance of the aggregated measure of innovator environment.

Recommendations

The results of the principal component analysis confirm the findings of the correlation analysis. Hence, following recommendations apply for the Innovator capacity index:

Innovator ability

- Consider collection of other indicators of innovator's ability that fit better together from a statistical point of view.

Innovator environment

- Consider collection of other indicators of innovator's environment that fit better together from a statistical point of view.

Table 7: Statistical structure within the dimensions of the Innovator capacity index

Innovator ability

	Ownership	Key organisation	Innovation needs
Number of times key organisation	-0.12	0.87	0.03
Innovation potential index	0.34	0.38	0.12
Most impressive partner	0.44	0.27	-0.35
Owner of innovation	0.82	-0.17	0.09
Needs of organisation	0.05	0.04	0.93
Explained variance	1.24	1.14	1.05
Cumulative	0.24	0.47	0.68

Innovator environment

	Commitment	End-user engagement
End-user engagement	-0.01	0.95
Project performance	0.74	-0.20
Commitment to innovate	0.67	0.23
Explained variance	1.57	1.07
Cumulative	0.52	0.88

Calculations: European Commission JRC

Data: European Commission DG Connect

Note: This table presents component loadings of a polychoric principal component analysis conducted on each pillar. Loadings greater than 0.45 (absolute values) are highlighted in red. Varimax rotation has been applied.

4.4.3 Internal consistency

Concept

In this section we measure the internal consistency of the various indicators included in each dimension. This is typically measured with the Cronbach Alpha Coefficient which is **a measure of reliability that indicators that propose to measure a similar concept also provide similar scores**.[5] A high Cronbach Alpha Coefficient indicates that the indicators of a dimension are measuring the same underlying construct. Important to keep in mind is that the Cronbach Alpha Coefficient should not be strictly interpreted as a measure of uni-dimensionality. In this respect, the Handbook to construct composite indicators mentions that "(…) *a set of individual indicators can have a high alpha and still be multi-dimensional. This happens when there are separate clusters of individual indicators (separate dimensions) which intercorrelate highly, even though the clusters themselves are not highly correlated* (…)" (OECD and JRC, 2008).

Many scholars have debated on how large the Cronbach Alpha Coefficient should be to be acceptable. According to Nunnally (1978) and Hair et al. (1998), the generally accepted lower limit for Cronbach's alpha is 0.7, although this may decrease to 0.6 in exploratory research. Below, we evaluate the internal consistency in both indices of the Innovation Radar.

4.4.3.1 Innovation potential index

Assessment outcome

Market potential

The Cronbach Alpha Coefficient for the market potential dimension is 0.08, which is very poor. This reflects the results of the principal component analysis and the correlation matrix of this dimension. Most indicators in this pillar capture different phenomena, including technological and market related characteristics that are important for the development and commercialisation of innovations.

Innovation readiness

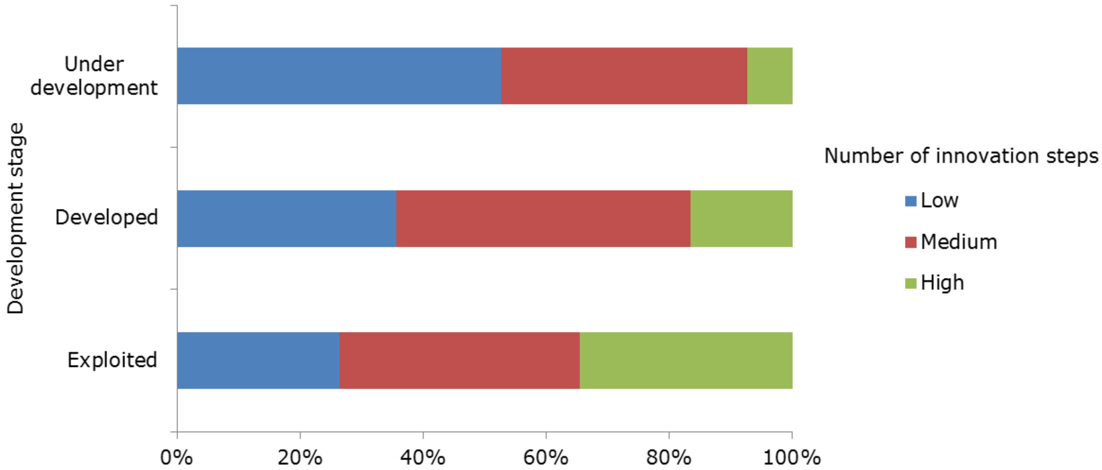
In contrast to market potential, the Cronbach Alpha Coefficient for innovation readiness is close to the acceptable reliability threshold, elevating at 0.66. When looking how the value of the Cronbach Alpha Coefficient changes after deleting one individual indicator at a time, we observe that the coefficient would decrease in most of the cases. This means that **almost all indicators contribute to enhance the internal consistency of innovation readiness**. The only exception is the indicator capturing no workforce skill issues, where deletion of this indicator would increase the internal consistency of the dimension. Based on this observation and in line with the recommendations from the correlation analysis, exclusion of this indicator could be considered.

Even if the results of PCA in previous section may suggest that there is limited internal consistency in this dimension as many indicators of the innovation steps are not categorised in a particular structure, a more detailed investigation is needed. To gain further insights on the internal consistency of the innovation readiness, **we analyse the number of innovation steps that have been undertaken and compare them across the different development stages of an innovation.** Hence, we combine information from the first indicator of this dimension with all the indicators measuring innovation steps towards innovation readiness. We do this to measure the consistency in respondents' replies and to ensure that the conceptual framework is in line with the underlying data.

[5] We refer to studies of Cronbach (1951) and Streiner (2003) for more details about the mathematical construction of this coefficient.

We proceed in the following way. First, we count the number of innovation steps that have been undertaken per innovation and regroup them in three ordinal categories (low, medium and high). Then we calculate the frequencies of these three groups across the different development stages. Figure 11 presents the percentages of the three categories of innovations steps per development stage. In line with the expectations, we observe that **the majority of innovations that are still under development have undertaken a limited number of innovation steps,** as the share of the lowest group of innovation steps is the highest. Analysing the innovations that have been developed and are being exploited, we observe that the highest percentages gradually shift towards groups with more innovation steps. These results provide important evidence for the consistency of reviewers' replies to the questionnaire with respect to indicators related to the innovation readiness.

Figure 11: Number of innovation steps across innovation development stages



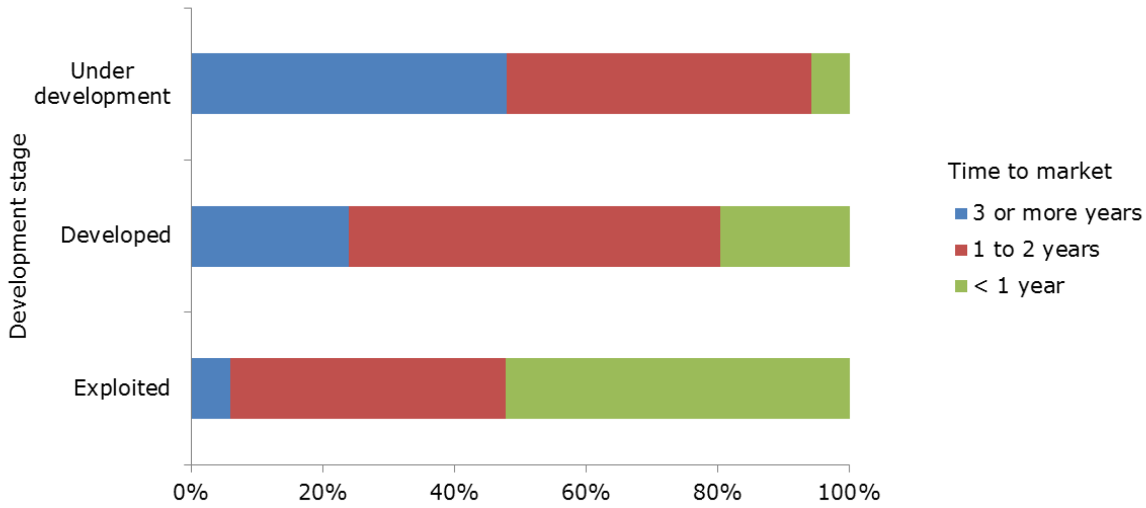
Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The number of innovation steps in this figure is based on the following indicators: technology transfer, prototyping – real world, pilot, demonstration, feasibility study, launch a startup or spinoff and other. The scores of the indicators have been summed up and grouped in three categories: low (score 0-1.5), medium (score 2-3.5) and high (score 4-6). The figure presents percentages of these categories across different innovation development stages.

Similarly, **we analyse the time needed to bring an innovation on the market and compare it across the different development stages of an innovation**. As both indicators (i.e. innovation development stage and time to market) aim to capture a similar latent construct – namely innovation readiness – we expect them to follow a similar pattern. In particular, innovations that are exploited should be close to commercialisation and hence report a shorter time to market, while the opposite is expected for innovation that are still in the development stage. Figure 12 presents the frequency distribution of the time to market across the different development stages of innovations and confirms our expectations.

Figure 12: Time to market across innovation development stages



Calculations: European Commission JRC

Data: European Commission DG Connect

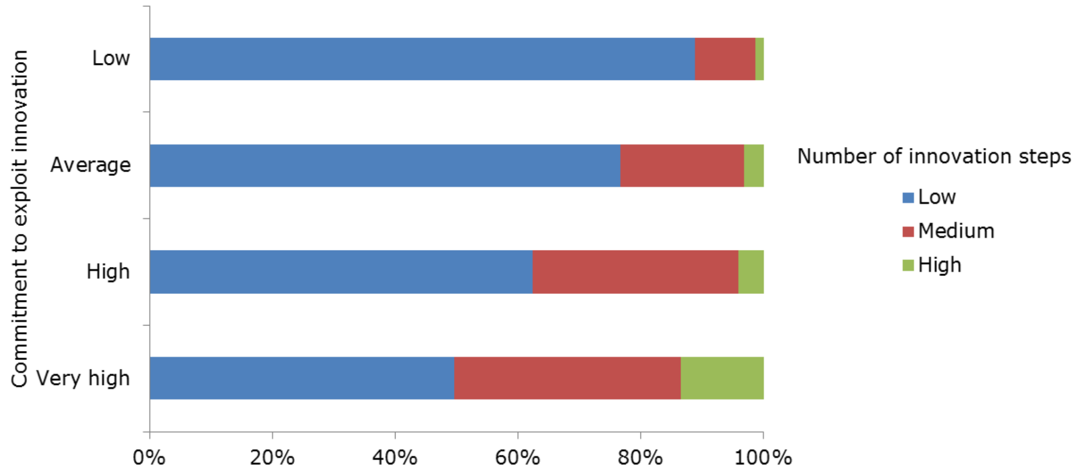
Note: The figure presents frequency distributions of time to market across different innovation development stages. Time to market is grouped in three categories that represent the time needed to bring an innovation on the market: 3 or more years, between 1 and 2 years and less than 1 year.

Innovation management

The Cronbach Alpha Coefficient of the innovation management is also relatively close to the acceptable threshold and elevates at 0.63. Similar to the previous pillar, exclusion of individual indicators would yield the coefficient to decrease, which means that **almost all indicators contribute to the internal consistency of innovation management**. Only two indicators have a positive impact on the Cronbach Alpha when being excluded: clear owner and no IPR issues. This result is in line with the observations from the correlation matrix and the principal component analysis. Both indicator seem not to belong to this dimension and could be considered to be excluded. Exclusion of the clear owner indicator would for instance increase the Cronbach Alpha Coefficient up to 0.68.

To gain further insights on the internal consistency of the innovation management, **we analyse the number of innovation steps that have been undertaken and compare them across various levels of commitment of the relevant partners to exploit their innovation**. Hence, we combine information from the indicator 'commitment to innovate' with all the pillar indicators measuring innovation steps that rely on an effective innovation management. Similar to the previous dimension, we do this to measure consistency in respondents' replies and to ensure that the conceptual framework of this dimension is in line with the underlying data. We calculate the number of innovation steps in this pillar that have been undertaken and regroup them in three categories (low, medium and high). Figure 13 presents the percentages of each group for different levels of partner commitment to exploit an innovation. The figure shows that innovations with a research consortium that is more committed to exploit an innovation has been undertaking more innovation steps in terms of business propositions, fund raising and research engagement.

Figure 13: Number of innovation steps across partner commitment



Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The number of innovation steps in this figure is based on the following indicators: research engagement, business plan, market study, application funding, secure private and public investment. The scores of the indicators have been summed up and grouped in three categories: low (score 0-1.5), medium (score 2-3.5) and high (score 4-6). The figure presents percentages of these categories across different levels of partner commitment to exploit an innovation.

Recommendations

We have the following recommendations for each dimension of the Innovation potential index:

Market potential

- Similar recommendations apply as in the correlation and principal component analysis.

Innovation management

- Internal consistency analysis provides evidence of the reliability of the answers of the questionnaire, which enhances the validity of the Innovation potential index.

Innovation readiness

- Internal consistency analysis provides evidence of the reliability of the answers of the questionnaire, which enhances the validity of the Innovation potential index.

4.4.3.2 Innovator capacity index

Assessment outcome

Innovator ability

The Cronbach Alpha Coefficient for the innovator ability dimension is 0.24, which is very poor. This reflects the results of the principal component analysis and the correlation matrix of this dimension.

Innovator environment

The Cronbach Alpha Coefficient for the innovator ability dimension is 0.42, which is also relatively poor. This result reflects the fact that this dimension contains three indicators from which only two fit well together from a statistical perspective. Exclusion of the end-user engagement indicator would increase the internal consistency of this dimension.

Recommendations

The results of the internal consistency analysis confirm the findings of the correlation and principal component analysis. Hence, following recommendations apply for the Innovator capacity index:

Innovator ability

- Consider collection of other indicators of innovator's ability that fit better together from a statistical point of view.

Innovator environment

- Consider collection of other indicators of innovator's environment that fit better together from a statistical point of view.

5 Output: assessment of the final indices

In this section we assess the output of the current version of the Innovation potential index and Innovator capacity index. In particular, we assess to what extent the indices show biases towards certain types of innovations or types of research collaborations.

5.1 Innovation potential index across innovation types

Concept

Innovation is a complex and uncertain process that involves a wide range of stakeholders. Most innovations are messy and the innovation process is characterised by feed-back loops, dead-ends and dynamic interactions. Simple and linear innovation models have the advantages to be conceptually easy to understand but lack the capacity to draw attention on the complex ways in which innovations actually evolve over time. The Innovation Radar methodology aims to approach the innovation process from a holistic point of view and attempts to synthesize the technological, organisational and commercial aspects of the innovation process. We refer to Tidd et al. (2005) for a detailed overview of the characteristics of innovation models and their evolvement over time.

One of the **problems of holistic approaches of innovation models as the Innovation Radar is that they may not be suitable of all types of innovations**. The various innovation steps as included in the innovation readiness and innovation management pillars of the Innovation Radar may be more relevant for product innovations than for other types of innovations, such as new services or processes and organisational/marketing methods.

Assessment outcome

To control for a **potential bias of the innovation potential across innovation types**, Figure 14 presents the distribution of the innovation potential index across different types of innovations. The figure shows that:

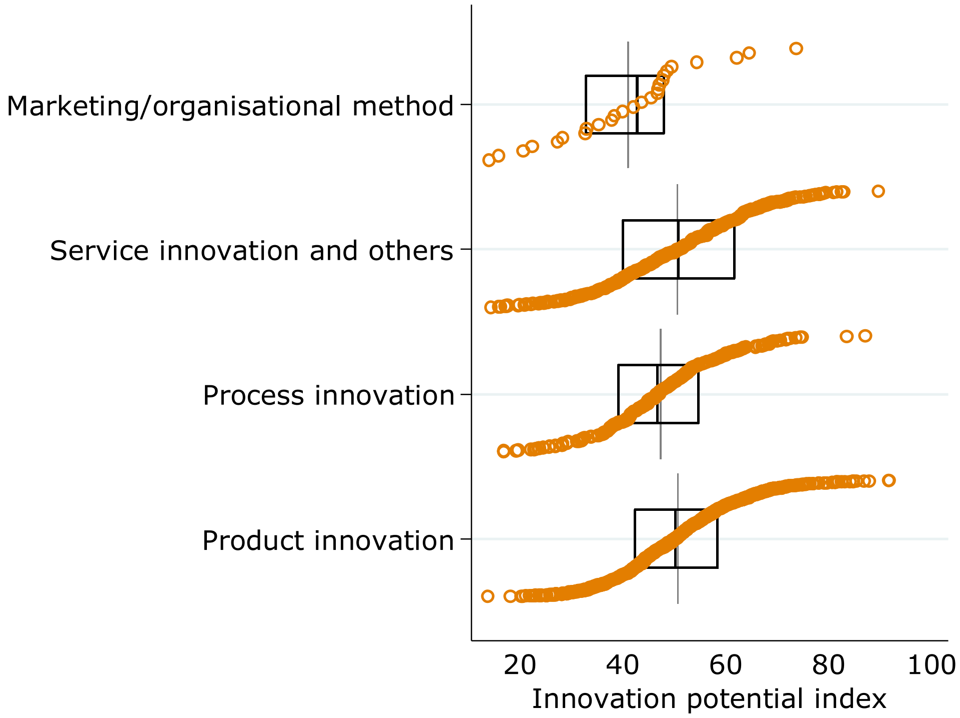
- The distribution and mean values of the innovation potential for product and service innovations are similar;
- The average innovation potential of process innovations and marketing/organisational methods is systematically lower.

Recommendation

The actual version of the Innovation potential index is strongly based on innovation models for product development. It may not be optimal to evaluate the innovation process of other innovation types such as process and marketing/organisational methods.

- Revision of the conceptual framework and adjustment of the questionnaire could be considered to account for differences in innovation processes across innovation types.

Figure 14: Distribution of the Innovation potential index across innovation types



Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The figure presents the distribution of the innovation potential index across different types of innovations. The different innovation types are defined in the following way: 1) Marketing/organisational method includes both new and significantly improved methods, 2) Service innovation and others: new and significantly improved services, consulting services and others, 3) Product innovations: new and significantly improved products, 4) Process innovations: new and significantly improved process innovations. The box plots present the quartiles of the distribution (25% - 50% and 75%) while the reference lines represents the mean.

5.2 Innovation potential index across research partners

Concept

The Innovation Radar aims to capture those innovations that have the potential to be brought on the market in the near future. As the various partners of a research consortium may follow different trajectories towards commercialisation, this may be reflected on their innovation potential. **The innovation potential of innovations from consortia with private partners (firms) may be higher than those with only public partners (universities/research centers)** for the following reasons.

Firms may have a strong strategic alignment with FP projects and explicit goals related to innovation outputs such as developing a prototype, a patentable technology, or a complementary technology that will directly enhance their competitiveness. They focus on projects with an applied orientation and engage only in cooperative agreements that are likely to yield tangible benefits and guarantee their immediate survival and growth. In this sense, the innovation process as measured by the Innovation potential index follows well the various steps that private partners would undertake in the development of an innovation.

Universities and public research centres, on the other hand, may primarily participate to FP projects to advance their research and may follow a different development path towards innovation that is not accounted for by the actual version of the Innovation potential index.

Related to this issue, the role of organisational diversity on the innovation potential has been analysed by Nepelski and Piroli (2017) and Nepelski et al. (2018) in other studies related to the Innovation Radar.

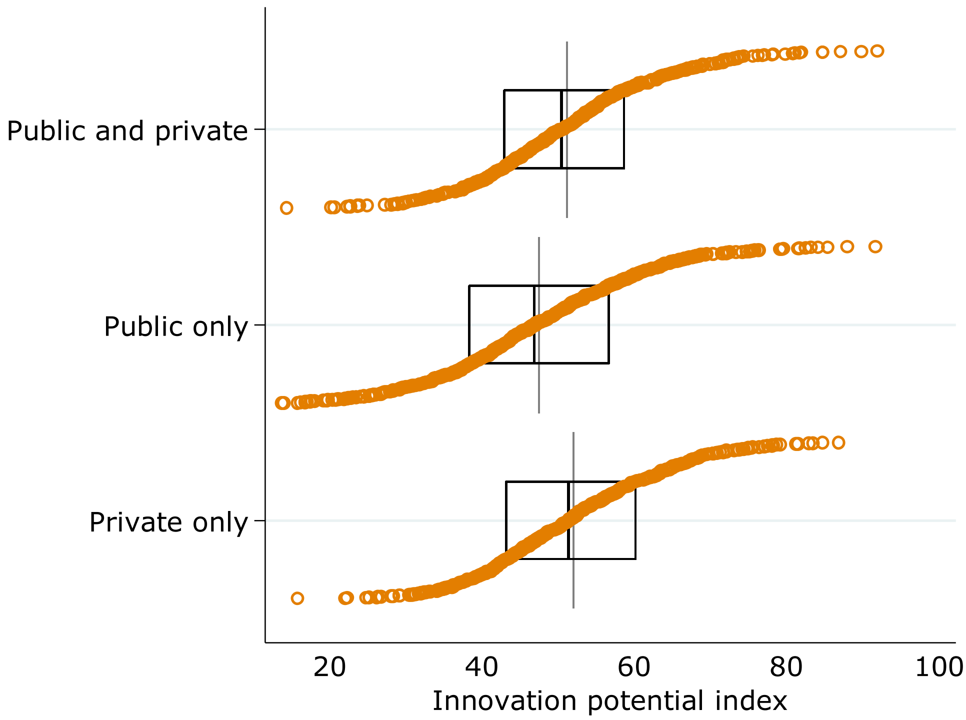
Assessment outcome

Figure 15 presents the distribution of the Innovation potential index across collaboration types, accounting for collaborations that include only private, only public or public and private partners. The figure shows that:

- Innovations with only public research partners score systematically less on innovation potential than innovations from consortia including private partners.

This result may be caused by the fact that projects including only public key organisations are penalised by the actual scoring system in case they following different paths study to develop an innovation.

Figure 15: Distribution of the Innovation potential index across collaboration types



Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The figure presents the distribution of the innovation potential index across different collaboration types. The different collaboration types are defined in the following way: 1) private only: innovations with only firms as key organisations, 2) public only: innovations with only universities, research centres, governmental institutions or other types as key organisations, 3) public and private: innovations with a combination of public and private key organisations. The box plots present the quartiles of the distribution (25% - 50% and 75%) while the reference lines represents the mean.

Recommendation

The conceptual framework to measure the innovation potential of FP projects could be adjusted to account for different innovation development paths of public organisations such as universities, research centers or governmental institutions.

5.3 Innovator capacity index across organisation types

Concept

Similarly as for the Innovation potential index, we test to what extent the Innovator capacity index varies across organisation types. **The innovator capacity of SMEs may be higher than the one of other organisation types and large firms in particular** for the following reason.

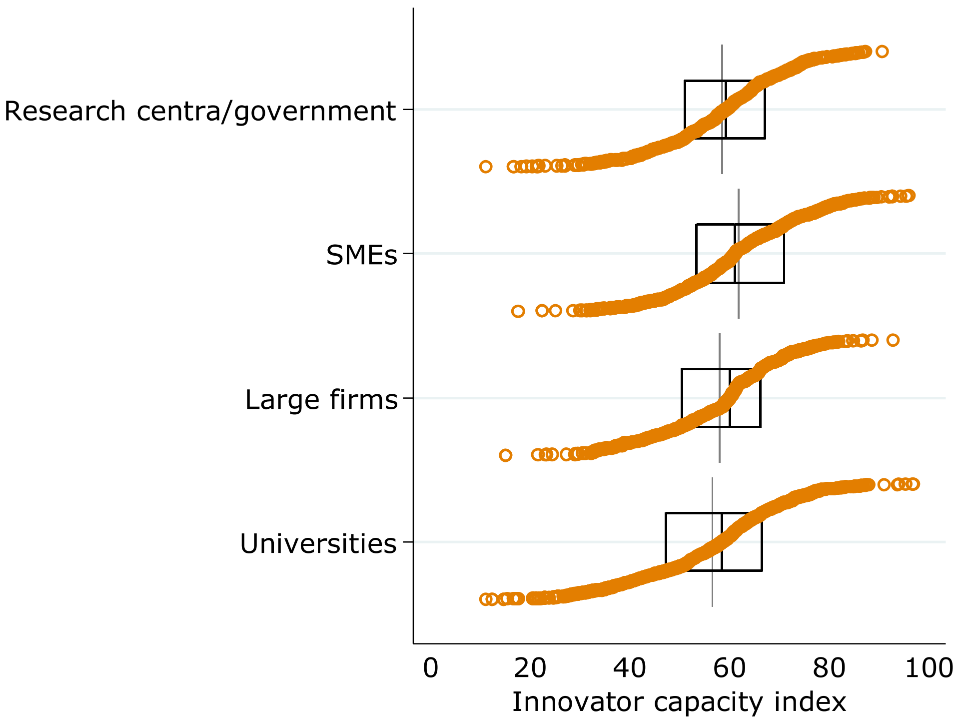
It may be due that SMEs benefit from the advantage of being more selected as most impressive partner as this question excludes large firms.

Assessment outcome

Figure 15 presents the distribution of the Innovator capacity index across organisation types, accounting for universities, SMEs, large firms and other organisations (i.e. governmental institutions, research centers and others). The figure shows that:

- On average, SMEs have the highest innovator capacity, while large firms are lagging behind

Figure 16: Distribution of the Innovator capacity index across organisation types



Calculations: European Commission JRC

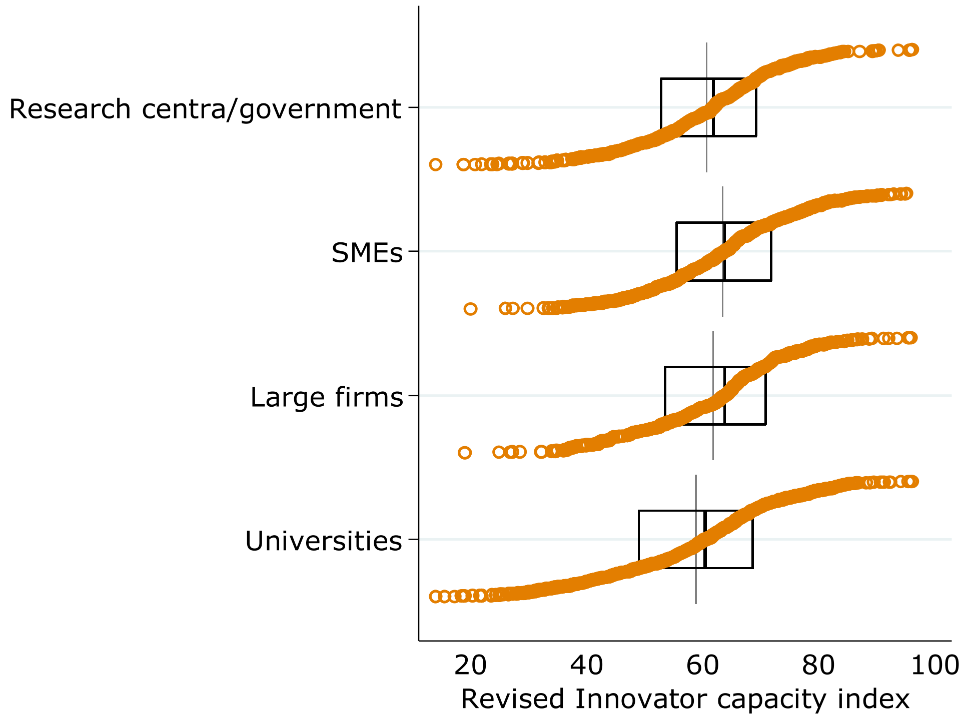
Data: European Commission DG Connect

Note: The figure presents the distribution of the innovator capacity index across different collaboration types. The box plots present the quartiles of the distribution (25% - 50% and 75%) while the reference lines represents the mean.

This result may be caused by the fact that SMEs scores systematically higher as most impressive partner compared to large firms. However, when observing the means of all the indicators included in the Innovator capacity index, it seems that SMEs are on average scoring higher on all the indicators compared to large firms. This may suggest that the difference of the Innovator capacity index between SMEs and large firms may remain even when the question about most impressive partner is not taken into account.

To evaluate this proposition, we calculated a revised version of the Innovator capacity index without the question about the most impressive partner and plotted the distribution of this revised index across organisation types in Figure 17. The difference between SMEs and large firms remain, but is however less pronounced.

Figure 17: Distribution of the revised Innovator capacity index across organisation types



Calculations: European Commission JRC

Data: European Commission DG Connect

Note: The figure presents the distribution of the innovator capacity index across different collaboration types. The box plots present the quartiles of the distribution (25% - 50% and 75%) while the reference lines represents the mean.

Recommendation

The exclusion of large firms as most impressive partners in that particular question of the questionnaire seems to accentuate difference of the Innovator capacity index across SMEs and large firms. However, even after exclusion of that particular indicator from the Innovator capacity index, a difference between large firms and SMEs – although less pronounced – seems to remain. This seems to reveal that SMEs are the innovators with the strongest innovators' capacity.

It is recommended to leave the question open to all organisation types in order to see whether SMEs would really be pointed as Most impressive partner. At least it would lower the probability of a biased answer and would yield a stronger result if more SMEs are chosen as Most impressive.

6 Synthesis of the assessment

In this section we provide some tables that summarise the results of the assessment of the Innovation Radar presented in this report.

The summary tables follow the structure of the report and are grouped in the following order:

- **Input**: relates to the questionnaire and the scoring system that provide the input data that feeds the indices of the Innovation Radar (Table 8);
- **Process**: relates to the statistical process to construct the indices of the Innovation Radar (Table 9 to Table 11);
- **Output**: relates to the statistical soundness of the final indices of the Innovation Radar (Table 12).

Overall, the main findings of the current report on the validation of the Innovation Radar assessment framework can be summarised in the following way:

Input

- Questionnaire: slight adjustments could be considered as to maximise a clear alignment of reviewers on how to interpret questions;
- Scoring system: slight adjustments could be considered as to accentuate project differences.

Process

- Innovation potential index: statistically sound;
    - The innovation management and innovation readiness dimensions are statistically well-balanced and show a good internal consistency;
    - More room for improvement is observed for the market potential dimension.
- Innovator capacity index: conceptually sound but can be improved statistically;
    - The index would benefit from a more balanced contribution of indicators;
    - Hence, the collection of indicators that fit better together from a statistical perspective could be considered.

Output

- Adjustments to the conceptual framework of both indices could be considered as to account for differences in the innovation process across innovation types and research partners.

Table 8: Synthesis table of the input: questionnaire and scoring system

Assessment	Outcome	Potential reason	Recommendation
Questionnaire	Lack of consistency in reviewers' assessment	Reviewers may misunderstand questions	Need for a clear alignment among reviewers on how to interpret questions
Scoring system	Lack of spread in scores for some indicators	Assessment levels of the scoring system are too narrow and do not exploit all the assessment levels of the questionnaire	Change rating scores to increase accuracy of identification and accentuate project differences
Duplications	Duplication of information in the Innovator capacity index	Double counting of end-user engagement and commitment to innovate	Recalculate the Innovation potential index without indicators on End-user engagement and Commitment to innovate and insert this revised index in the Innovator capacity index
			Consider collection of other indicators of innovator's environment

Note: The table provides a synthesis of the findings when analyzing the statistical coherence of the questionnaire and scoring system behind the Innovation Radar. Data used in this assessment is owned by European Commission DG Connect.

Table 9: Synthesis table of the process: construction of the composite indicators

Assessment	Dimension	Outcome	Potential reason	Recommendation
Data coverage	Market potential	Low data coverage for Market dynamics	Difficulty for reviewers to evaluate Market dynamics	Consider exclusion of Market dynamics
	Innovation readiness and innovation management	Relatively low data coverage on question about innovation steps, which is mostly apparent for marketing/organisational methods and service innovations.	Difficulty of reviewers to answer to this question	Consider hands-on support or training of reviewers
			Innovation steps are less relevant for marketing/organisational methods and service innovations	Consider adjustment of the questionnaire to take into account specific innovation steps for marketing/organisational methods and service innovations
	Innovator ability and innovator environment	Good data coverage		No particular recommendations
Weighting method		Equal weighting method is used		Equal weighting is justified and can be continued
Aggregation method		Arithmetic average is used as aggregation method but provides low diversity in ranking scores	Arithmetic average suffers from drawbacks that can be solved by geometric averages: - a poor performance in one indicator can be fully compensated by a good performance in another; - does not reward balanced achievement in all indicators.	Consider using geometric averages as aggregation method

Note: The table provides a synthesis of the findings when analyzing the statistical coherence of the construction method to produce the indices of the Innovation Radar. Data used in this assessment is owned by European Commission DG Connect.

Table 10: Synthesis table of the process: construction of the composite indicators (cont.)

Assessment	Dimension	Outcome	Potential reason	Recommendation
Multivariate analyses	Market potential	Market competition and number of patent enrich the conceptual framework, but do not contribute to the market potential dimension	Low correlations among all indicators in this dimension	Consider exclusion of market competition and number of patents
		Three distinct structures related to market conditions, technology and market orientation	Dimension includes a wide range of distinct phenomena	Consider create three sub-dimensions of market potential: 1) Market conditions (market maturity, market dynamics) 2) Technology (type of innovation and innovation exploitation stage) 3) Market orientation (level of innovation)
				Consider inclusion of bottlenecks to innovation such as standardisation, trade and regulation
	Innovation readiness	Relatively balanced dimension	Balanced contribution of all indicators, except Other innovation steps and No workforce skills issues	Consider exclusion of Other innovation steps and No workforce skills issues
		Good internal consistency		Internal consistency analysis provides evidence for reliability of answers to the questionnaire in this dimension

Note: The table provides a synthesis of the findings when analyzing the statistical coherence of the construction method to produce the indices of the Innovation Radar. Data used in this assessment is owned by European Commission DG Connect.

Table 11: Synthesis table of the process: construction of the composite indicators (cont.)

Assessment	Dimension	Outcome	Potential reason	Recommendation
Multivariate analyses	Innovation management	Relatively balanced dimension	Balanced contribution of all indicators, except Clear owner and No IPR issues	Consider exclusion of Clear owner and No IPR issues
		Good internal consistency		Internal consistency analysis provides evidence for reliability of answers to the questionnaire in this dimension
	Innovator ability	Dimension mostly driven by Most impressive partner and Owner of innovation	Unbalanced contribution of indicators	Consider collection of other indicators of innovator's ability that fit better together from a statistical point of view
	Innovator environment	Dimension mostly driven by Project performance and Commitment to innovate	Unbalanced contribution of indicators	Consider collection of other indicators of innovator's ability that fit better together from a statistical point of view

Note: The table provides a synthesis of the findings when analyzing the statistical coherence of the construction method to produce the indices of the Innovation Radar. Data used in this assessment is owned by European Commission DG Connect.

Table 12: Synthesis table of the output: assessment of the final indices

Assessment	Outcome	Potential reason	Recommendation
Innovation potential index across innovation types	Average innovation potential of marketing/organisational methods and service innovations is lower than that of product or process innovations	Marketing/organisational methods and process innovations may be penalised by the actual framework	Consider revision of the conceptual framework and adjustment of the questionnaire to account for differences in innovation processes across innovation types.
Innovation potential index across research partners	Average innovation potential of innovations from consortia with private partners (firms) is higher than that of only public partners (universities/research centers)	Consortia with only public partners may be penalised by the actual framework	Consider revision of the conceptual framework and adjustment of the questionnaire to account for differences in innovation processes across research partners.
Innovator capacity index across organisation types	On average, SMEs have the highest innovator capacity, while large firms are lagging behind. This points at the fact that SMEs may be favoured by the actual framework as Most impressive partner excludes large firms.	Difference between SMEs and large firms remain when constructing the Innovator capacity index without the question on Most impressive partner, although difference is less pronounced.	It is recommended to leave the question open to all organisation types.

Note: The table provides a synthesis of the findings of the quality assessment of the final indices of the Innovation Radar. Data used in this assessment is owned by European Commission DG Connect.

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List of figures

List of tables

Appendix

1. Innovation Radar Questionnaire

Innovation Radar Questionnaire by EC DG CONNECT

Note: the first 19 questions below are to be answered for **each** innovation the project develops (up to a maximum of 3 innovations).

1) **Title of the innovation**

2) **Describe the innovation (in less than 500 characters, spaces included):**

3) **Is the innovation developed within the project…:**
   a) Under development
   b) Already developed but not yet being exploited
   c) being exploited

4) **Characterise the type of innovation**

   a) Significantly improved product
   b) New product
   c) Significantly improved service (except consulting ones)
   d) New service (except consulting ones)
   e) Significantly improved process
   f) New process
   g) Significantly improved marketing method
   h) New marketing method
   i) Significantly improved organisational method
   j) New organisational method
   k) Consulting services
   l) Other

5) **If other, please specify:**

6) **Will the innovation be introduced to the market or deployed within a partner:**
   a) Introduced new to the market (commercial exploitation)
   b) Deployed within a partner (internal exploitation: Changes in organisation, new internal processes implemented, etc.)
   c) No exploitation planned

7) **If no exploitation planned, please explain why no exploitation is planned (answer only if 6(c) is selected)**

8) **Is there a clear owner of the innovation in the consortium or multiple owners?**
   a) A clear owner
   b) Multiple owners

9) **Indicate who is the "owner" of the innovation. Please use the exact name of the project partner as listed on the CORDIS project profile.**

10) **Indicate the step(s) already done (or are foreseen) in the project in order to bring the innovation to (or closer to) the market (answer only if 6(a) is selected)**

	Done	Planned in project	Not Planned	Desirable

1. Technology transfer				
2. Engagement of both research team and partner's business units in project activities				
3. Business plan				
4. Market study				
5. Prototyping				
6. Pilot, Demonstration or Testing activities				
7. Feasibility study				
8. Launch a start-up or spin-off				
9. Standardisation				
10. Application for private or public investment				
11. Securing private investment				
12. Securing public investment				
13. Other				

11) If other, please specify

12) Indicate which participant(s) (up to a maximum of 3) is/are the key organisation(s) in the project delivering this innovation. For each of these identify under the next question their needs to fulfil their market potential. Please use the exact name(s) of the project partner(s) as listed on the CORDIS project profile.

Filed 1: Organization1:
Filed 2: Organization 2:
Filed 3: Organization 3:

13) Indicate their needs to fulfil their market potential

	Investor readiness training	Investor introductions	Biz plan development	Expanding to more markets	Legal advice (IPR or other)	Mentoring	Partnership with other company (technology or other)	Incubation	Startup accelerator
Organization 1									
Organization 2									
Organization 3									

14) Market size: What is the market size for this innovation

a) < €25M
b) €25M - €100M
c) €100M - €250M
d) €250M - €500M
e) > €500M
f) Not known

15) Market maturity: The market for this innovation is...

a) Nonexistent: customers are not yet buying such products
b) Emerging: There is a growing demand and few offerings are available

c) Mature: The market is already supplied with many products of the type proposed

16) Market dynamics: is the market…

a) In decline
b) Holding steady
c) Growing

17) Level of innovation: What is the level of innovation

a) No innovation—other factors contribute to viability
b) Some distinct, probably minor, improvements over existing products
c) Innovative but could be difficult to convert customers
d) Obviously innovative and easily appreciated advantages to customer
e) Very innovative satisfies a well-known market need

18) Market competition: How strong is competition in the target market?

a) Patchy, no major players
b) Established competition but none with a proposition like the one under investigation
c) Several major players with strong competencies, infrastructure and offerings

19) When do you expect that such innovation could be commercialised? (answer only if 6(a) is selected)

a) Less than 1 year
b) Between 1 and 3 years
c) Between 3 and 5 years
d) More than 5 years

General Questions

(questions below are to be answered once in the project review, not for each innovation)

1) How does the consortium engage end-users?

- End user organisation in the consortium
- An end user organisation outside of the consortium is consulted
- No end user organisation in the consortium or consulted

2) Are there in the consortium internal IPR issues that could compromise the ability of a project partner to exploit new products/solutions/services, internally or in the market place?

- yes
- no

3) Please provide specifics of the IPR issues:

4) Which are the external bottlenecks that compromise the ability of project partners to exploit new products, solutions or services, internally or in the market place?

- IPR
- Standards
- Regulation
- Financing
- Workforce's skills
- Trade issues (between MS, globally)
- Others

5) If others, please specify:

6) Indicate how many patents have been applied for by the project: __________

7) Does the review panel consider the project performance in terms of innovation?

- Exceeding expectations
- Meeting expectations
- Performing below expectations

8) General observations of innovation expert on this project's innovation performance:

9) How would you rate the level of commitment of relevant partners to exploit the innovation?

- Very low
- Low
- Average
- High
- Very High
- None

10) Please indicate the 1 partner (excluding large enterprises) that the panel considers to be the most impressive in terms of innovation potential:

11) Please enter some tag words (comma separated) to represent what "innovation elements" are strong in the project:

12) Please enter some tag words (comma separated) to represent what "innovation elements" can be improved (or are absent) in the project:

2. Scoring system: matching survey questions with assessment criteria

2.1 Innovation potential assessment framework

Table 1: Innovation potential assessment framework: Market potential

Criteria & questions		**Scoring**
Market potential	**Question code***	**Max: 10**
Type of innovation:	Q4	
New product, process or service	b OR d OR f	1
Significantly improved product, process or service	a OR c OR e	0.75
New marketing or organizational method	h OR j	0.5
Significantly improved marketing or organizational method	g OR i	0.25
Consulting services, other	k OR l	0
Innovation exploitation:	Q6	
Commercial exploitation	a	2
Internal exploitation	b	1
No exploitation	c	0
Market maturity: The market for this innovation is…	Q15	
Nonexistent: customers are not yet buying such products	a	0
Emerging: There is a growing demand and few offerings are available	b	1
Mature: The market is already supplied with many products of the type proposed	c	0.5
Market dynamics: is the market…	Q16	
In decline	a	0
Holding steady	b	0.5
Growing	c	1
Level of innovation: What is the level of innovation	Q17	
No innovation—other factors contribute to viability	a	0
Some distinct, probably minor, improvements over existing products.	b	0.25
Innovative but could be difficult to convert customers.	c	0.5
Obviously innovative and easily appreciated advantages to customer	d	0.75
Very innovative satisfies a well-known market need.	e	1
Market competition: How strong is competition in the target market?	Q18	
Patchy, no major players	a	1
Established competition but none with a proposition like the one under investigation	b	0.5
Several major players with strong competencies and infrastructure	c	0
Number of patents have been applied for by the project	GQ6	
<2		0.5
≥2		1

Innovation potential assessment framework: Innovation readiness

Criteria & questions		Scoring
Innovation Readiness	**Question code***	**Max: 10**
Development phase	Q3	
Under development	a	0
Developed but not exploited	b	1
Being exploited	c	2
Technology transfer**	Q10.1	
Done		1
Planned		0.5
Prototyping**	Q10.5	
Done		1
Planned		0.5
Pilot, Demonstration or Testing activities**	Q10.6	
Done		1
Planned		0.5
Feasibility study**	Q10.7	
Done		1
Planned		0.5
Launch a start-up or spin-off**	Q10.8	
Done		1
Planned		0.5
Other**	Q10.13	
Done		1
Planned		0.5
Time to market	Q19	
Less than 1 year	a	1
Between 1 and 2 years	b	0.75
Between 3 and 5 years	c	0.5
More than 5 years	d	0.25
No workforce's skills issues that could compromise the ability of a project partner to exploit the innovation	GQ4e	1

Innovation potential assessment framework: Innovation Management

Criteria & questions		Scoring
Innovation Management	**Question code***	**Max: 10**
There is a clear owner of the innovation	Q8	1
Engagement of both research team and partner's business units in project activities** Done Planned	Q10.2	 1 0.5
Business plan**	Q10.3	
Done Planned		1 0.5
Market study**	Q10.4	
Done Planned		1 0.5
Application for private or public investment**	Q10.10	
Done Planned		1 0.5
Securing private investment**	Q10.11	
Done Planned		1 0.5
Securing public investment **	Q10.12	
Done Planned		1 0.5
No consortium internal IPR issues that could compromise the ability of a project partner to exploit the innovation	GQ2	1
End-user engagement End-user in the consortium End-user consulted No end-user in the consortium or consulted	GQ1	 1 0.5 0
Commitment of relevant partners to exploit innovation Above average Average Below average	GQ9	 1 0.5 0

*GQ – general questions
** - Steps **DONE** or **PLANNED** in the project in order to bring the innovation to the market.

2.1 Innovator capacity assessment framework

Table 2: Innovator capacity assessment framework

Criteria & questions		**Scoring**
Innovator's ability	**Question code***	**Max: 5**
Number of innovations in the project for which an organization is identified as a key organisation(s) in the project delivering this innovation 1 2 3	Q12	 0.5 0.75 1
Score of innovation for which an organization is identified as a key organisation(s) in the project delivering this innovation	Output of the innovation assessment framework	Score between 0-1
Organization is considered as the most impressive in terms of innovation potential	GQ10	1
Organization is the owner of the innovation	Q9	1
Total number of needs to fulfil the market potential of an innovation No needs Between 1 and 2 Between 3 and 4 Between 5 and 6 More than 6	Q13	 1 0.75 0.5 0.25 0
Innovator's environment	**Question code***	**Max: 3**
The engagement of end-users in the consortium End user organisation in the consortium An end user organisation outside of the consortium is consulted No end user organisation in the consortium or consulted	GQ1	 1 0.5 0
The project performance in terms of innovation Exceeding expectations Meeting expectations Performing below expectations	GQ7	 1 0.5 0
The level of commitment of relevant partners to exploit the innovation Very High or high Average Below average	GQ9	 1 0.5 0

*GQ – general questions

3. Construction of the indices

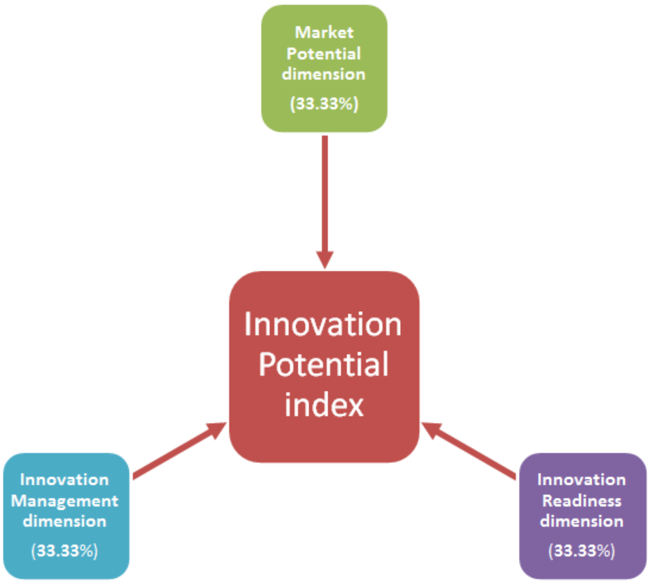
3.1 Innovation Potential

In order to observe and measure the relevant criteria, each of them was matched with relevant questions of the Innovation Radar Questionnaire. In this way, a composite sub-indicator for each assessment criteria was created:

- **Innovation Readiness Dimension** (IR) is an arithmetic aggregate of all relevant information in the domain of innovation readiness (see Table).
- **Innovation Management Dimension** (IM) is an arithmetic aggregate of all relevant information in the domain of innovation management (see Table).
- **Market Potential Dimension** (MP) is an arithmetic aggregate of all relevant information in the domain of innovation market potential (see Table).

In the second step, the **Innovation Potential index** (IPI) is constructed. IPI is an arithmetic composite indicator which aggregates the values of the three dimensions, i.e. MP, IR and IM. Equal weighting is applied. Figure visualizes this procedure.

Figure 1: Construction of the Innovation Potential index



Source: European Commission JRC

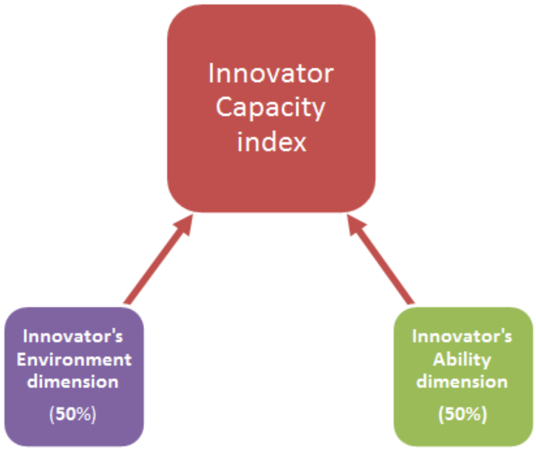
3.2 Innovator Capacity

In order to create a measure of innovator capacity, we proceed in two steps. In a first step, composite sub-indicators are created, one for each of the above defined criteria: Innovator's Ability and Innovator's Environment. This way, two intermediate sub-indicators are used in order to assess each innovation dimension, i.e.:

- **Innovator's Ability Dimension** (IA) is an arithmetic aggregate of all relevant information in the domain of innovator's ability (see Table).
- **Innovator's Environment Indicator** (IE) is an arithmetic aggregate of all relevant information in the domain of innovator's environment (see Table).

In the second step, the **Innovator Capacity Indicator** (ICI) is constructed. The ICI is an arithmetic composite indicator aggregating the values of the two earlier sub-indicators, i.e. IA and IE. Like in the case of innovation ranking, equal weighting is applied. Figure 2 visualizes this procedure.

Figure 2: Construction of the Innovation Capacity index



Source: European Commission JRC

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