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A portfolio analysis methodology to inform innovation policy and foresight

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ABSTRACT

This paper describes a new method for combining innovation foresight, country's innovation indices, and decision analysis to identify the best combination of investments to improve national innovation systems, using Brazil as the example. The sub-pillars for human factors for innovation of the Global Innovation Index (GII) (Cornell University, INSEAD, and WIPO, 2014) are used to develop a gap coverage matrix that is analysed using the Portman method (Chow et al., 2011), to enable the identification of an optimum portfolio of investments, taking into account the level of funding for each program and any interrelationships between them. The methodology could either be refined through a foresight exercise or provide inputs to a foresight study for innovation policy that would generate threshold values for the gaps and describe their relative importance. The latter could provide an explicit and quantitative guide to decision-makers in the implementation of the foresight results. The implications of the method for FTA practice are discussed.

1. Introduction

For many years innovation foresight (Georghiou, 2007) has been an exercise typically circumscribed to technology assessment areas. Foresight has evolved beyond technology-driven scenarios. More recently, its focus has shifted from specific future economic and technological targets to an in-depth understanding of the ways in which one can operate and interact in known and in unknown systems (Miller, 2007, 2011a, b; Loveridge, 2009). Hence, future-oriented discussions have been based on reframing the future in order to collectively identify and invent anticipatory assumptions and make choices in the present (Miller, 2007, 2011a, b).

Many are the challenges in attempting to characterize innovation ecosystems. Cagnin et al. (2012) highlighted the contributions that FTA might make to orient innovation systems towards grand challenges by considering structural and functional aspects of a ‘systems of innovation’ approach. This should be the departing point for any foresight exercise aimed at understanding the dynamics of a given innovation ecosystem and its associated indicators. In this paper, we propose a methodology that could generate inputs for any innovation foresight exercise. In order to bring abstraction down into an operational level, the proposal will look at such a foresight study that would address shortcomings of the Brazilian innovation ecosystem as a case study.

The Global Innovation Index, hereafter GII, considers the performance of a broad range of countries in seven areas (“pillars”) critical to building, maintaining and strengthening national innovation ecosystems. In this paper, we describe and execute an example application of a methodology to optimize a portfolio of investments to address a country's shortcomings in specific GII pillars and their 81 sub-pillars. The application example is Human Factors in Innovation, for which we apply our method to nine sub-pillars in Brazil. The portfolio of investments that we consider is restricted to fifteen programs of the Brazilian Ministry of Education for which we were able to obtain sufficient data for the analysis. Accordingly, the portfolio that we identify is optimized only within these possible investments, and does not include many likely important programs of other federal, state and local agencies and even those of the Ministry of Education for which we did not have sufficient data for analysis. Thus, we present these results solely as an illustration of the method and not with the intent to support investment decisions.

For a country aspiring to improve its ranking in the GII, its position in each pillar and sub-pillar illustrates shortcomings that need to be addressed in its innovation ecosystem. We treat these shortcomings in our method as “gaps” to be addressed by portfolio investments, and develop a supply-demand matrix in which the “supply” is the investments or programs aimed at improving the innovation ecosystem and the gaps are the “demand.” Following that, we show how to estimate the expected value for each investment or program that addresses each gap. We use the expected value matrix, together with estimates of the cost of each program and the number of individuals it benefits,

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to find an "optimum" portfolio for any given total investment, i.e., the portfolio of investments that provides the highest total expected value per individual benefitted. We then measure gaps either relative to some objective requirement or to the best value achieved by another country.

Every country, regardless of its GII ranking, will have its own characteristic innovation ecosystem, with its own specific shortcomings to be addressed. Foresight taking into account the current state of innovation and the country's aspirations is necessary to understand whether filling the gaps defined in terms of shortcomings of the GII pillars and sub-pillars will be sufficient to achieve these aspirations. Such foresight can also provide guidance on what constitutes adequate filling of each gap and in which areas new gaps need to be defined. Lacking such guidance, we have treated all the gaps as of equal importance and used as our objective function for portfolio optimization the total expected value across all gaps. However, the methodology was designed to be used with foresight approaches, and when applied as a support for decision-making will incorporate foresight tools and outputs to define appropriate thresholds for filling each gap as an integral part of its objective function for optimization.

The paper is organised as follows: the next section discusses the methodological approach, followed by a section on results, discussion and implications, including assumptions and limitations of the present work and future recommendations. The paper ends with a brief conclusion.

2. Methodological approach

The proposed methodology is depicted in Fig. 1. The PortMan decision-making process provides tools to optimize portfolios and fill in gaps (Chow et al., 2011), which was originally developed for Research and Development (R&D) projects. The novelty of the present work is to connect innovation indicators and educational programs within the PortMan framework. For the current work, gaps are shortcomings in the GII sub-pillars, i.e. innovation indicators. The process concludes with recommendations for a foresight exercise to establish thresholds for gaps and their relative importance based on future scenarios. As a result, one can design programs that will fill in gaps and inform decision makers on choices for a portfolio of programs to effectively execute a country's innovation strategy.

In order to select innovation indicators and identify countries of reference one should compare innovation studies to identify common metrics and countries that score consistently high irrespective of the metrics employed. It is not uncommon to find innovation indicators associated with GDP expenditures and these should be removed from the study, since it is a central government decision to define and achieve GDP targets, rather than objectives of the portfolio of programs under evaluation. Once indicators, i.e. gaps, have been identified, one should develop a method to rank or categorize their relative importance since they can be used as inputs for foresight studies.

2.1. Innovation indicators and countries of reference

We performed a brief comparison of innovation reports aiming at identifying reference countries and innovation indicators for Brazil, which is the country under study. The following reports were used: The Global Innovation Index, GII, (Cornell University, INSEAD, and WIPO, 2014), The Global Competitiveness Report, GCR, 2013–2014 (Schwab et al., 2013), The Global Innovation Policy Index, GIPI, 2012 (Atkinson et al., 2012) and the Innovation Union Scoreboard, IUS (European Commission, 2014). Two reports were selected due to their importance for organizations that address global issues: GII for World Intellectual Property Organization and CGI for the World Economic Forum. Europe has a number of representatives in the top innovative countries. This motivated the use of the IUS, which is widely adopted by the European Commission. The GIPI was used to broaden the spectrum of the assessment of innovation beyond competitiveness and usual indicators since it deals mostly with public policies for innovation.

The Global Innovation Index, hereafter GII, was the report selected for the present case study. The GII has continuously evolved since 2007, and in 2011, the World Intellectual Property Organization adopted it. It contains one of the most complete set of studies with data from 143 countries. It also includes trends, for example, sustainability, and paradigm changes such as creative outputs in the economy as part of the calculation of the overall innovation score. Another advantage of the GII is that most of its data are recent (2012 − 2013); only 37% comes from previous years (Cornell University, INSEAD, and WIPO, 2014). The GII defines pillars under which indicators are grouped and provides four indices: the input sub-index, the output sub-index, the efficiency ratio (output/input) and the overall GII score (simple average of input and output indices). It also contains a conceptual and statistical coherence analysis for its composite indicators (Cherchye et al., 2008).

Since the present study focuses on the proof-of-principle of a methodology, not all GII indicators were used. There were a couple of reasons for selecting only those related to human factors behind innovation. First, these are recommended by the GII and characterized by the following pillars: human capital & research, and business sophistication. Second, there is an on-going innovation ecosystem foresight exercise at CGEE that identified a number of functions that contribute to innovation

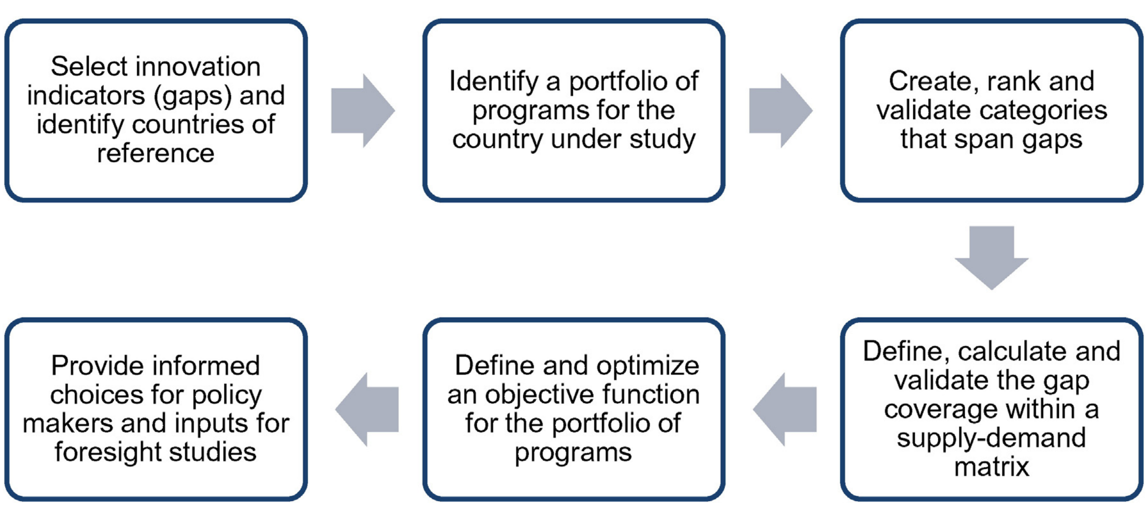

Fig. 1. High-level description of the proposed methodology.

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objectives. One of the most critical functions that emerged from the foresight exercise is the development and mobilization of human resources (i.e. human factors), and in fact this was the first to be analysed in depth. Third, (Izsák et al., 2013) indicates that there are two types of policies to enhance skills for innovation: support for human resources for R&D and innovation-related skills education, and an European study (Hollanders and Tarantola, 2011) views human resources as "enablers or drivers of innovation performance."

After comparing several innovation reports one can argue that the selected GII indicators do not constitute a comprehensive list (National Science Board, 2014). For example, for Europe other indicators have been discussed elsewhere (European Commission, 2014): the percentage youth aged 20–24 having attained at least upper secondary level education, percentage population having completed tertiary education, number of non-EU doctorate students, number of new doctorate graduates, number of international scientific co-publications per million population and scientific publications among the top 10% most-cited publications worldwide as a percentage of total scientific publications of the country. Other studies use higher education R&D performance as a share of GDP and high-skill immigration (Atkinson et al., 2012) and include the quality of the educational system, the quality of math and science education, Internet access in schools, tertiary education enrolment, availability of research and training services, extent of staff training, quality of scientific research institutions and availability of scientists and engineers (Schwab et al., 2013). These differences are not a problem for our methodology, since it assumes a given set of indicators as a pre-condition for the analysis and it is the foresight exercise at the end of the process that verifies the adequacy of the chosen set for a future scenario.

2.2. Gaps, categories and programs

The innovation indicators (gaps) used for this study are described in Table 1.

In order to estimate the impact of programs in filling gaps we use the gap coverage method (Chow et al., 2011). In this approach, gaps inhabit a space that can be described by a mutually exclusive set of categories representing the dimensions of the gap space. The choice of categories is central to the methodology and should involve literature research and discussion with experts, since it is possible that policy makers may not clearly define the problem that a particular policy is trying to solve, but rather focus on the solution. Once identified and validated, one should rank categories so that programs can be given appropriate weights in the portfolio.

For the present work there are nine gaps (Table 1), each representing an innovation indicator (sub-pillar of the GII). These gaps are spanned by the following categories defined after literature research and discussions with public policy experts: (1) parents' education; (2) resources and logistic support for students; (3) teacher resources and training; (4) demand for qualified jobs; (5) international standards for research and education; and (6) infrastructure for research and education.

Programs are connected to gaps through the gap-space coverage matrix. To develop this matrix one must estimate which dimensions of the space (i.e. categories) are covered by each program and how well a program addresses each gap–its technical potential to fill in a gap (Chow et al., 2011). The expected values for the gap coverage matrix are then calculated as depicted in Eq. (1) in the Results section. Following that one defines an objective function based on total expected value (weighted by the number of individuals benefitted) that should be maximized with the total budget of the portfolio as a constraint.

The selection of a portfolio of programs is complex for several reasons. Programs that impact innovation may come from different branches of government spanning federal, state and local initiatives. Developing a comprehensive list of programs, plus quantifying their costs and number of beneficiaries over a carefully selected time period, may be difficult because of unavailable or incomplete data. In addition, it is possible that the legislator(s) behind these programs may not have designed them to impact directly the innovation gaps of interest. However, our proposed methodology allows one to provide informed options for policy makers even in the absence of a comprehensive list of programs. There is a caveat that the quantitative analysis that emerges from this work is not to be viewed as a recommendation to

Table 1
Innovation indicators used as gaps for this study with their data source, data collection year and descriptions extracted from the The Global Innovation Index, GII, (Cornell University, INSEAD, and WIPO, 2014), and UNESCO online database (UNESCO 2012–2014).

ID	Gap	Description	Data source years
1	School life expectancy	Total number of years of schooling that a child of a certain age can expect to receive in the future, assuming that the probability of his or her being enrolled in school at any particular age is equal to the current enrollment ratio for that age.	UNESCO 2012–2014
2	Assessment in reading mathematics and science	Program for International Student Assessment (PISA) develops three yearly surveys that examine 15-year old students' performance in reading, mathematics, and science. The scores are calculated in each year so that the mean is 500 and the standard deviation 100. The scores for China come from Shanghai; those for India from Himachal Pradesh and Tamil Nadu (average); those for the United Arab Emirates from Dubai; and those for the Bolivarian Republic of Venezuela from Miranda. These scores are those from the GII 2013 report.	OECD, 2010–2012
3	Pupil-teacher ratio, secondary	The number of pupils enrolled in secondary school divided by the number of secondary school teachers (regardless of their teaching assignment). Where the data are missing for some countries, the ratios for upper secondary are reported; if these are also missing, the ratios for lower-secondary are reported instead.	UNESCO 2013–2014
4	Tertiary enrollment	The ratio of total tertiary enrollment, regardless of age, to the population of the age group that officially corresponds to the tertiary level of education. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.	UNESCO 2012–2014
5	Graduates in science and engineering	The share of all tertiary graduates in manufacturing, engineering, and construction over all tertiary graduates.	UNESCO 2012–2014
6	Tertiary inbound mobility	The number of students from abroad studying in a given country, as a percentage of the total tertiary enrollment in that country.	UNESCO 2013–2014
7	Researchers	Researchers per million population, head counts. Researchers in R&D are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students (ISCED97 level 6) engaged in R&D are included. The series with full-time equivalents (FTE) also exists, but has lower country coverage.	UNESCO 2012–2014
8	Average score of top 3 universities at the QS world ranking	Average score of the top three universities per country. If fewer than three universities are listed in the QS ranking of the global top 700 universities, the sum of the scores of the listed universities is divided by three, thus implying a score of zero for the non-listed universities.	QS 2013–2014
9	Firms offering formal training	The percentage of firms offering formal training programs for their permanent, full-time employees.	IFC-W/B 2005–2013

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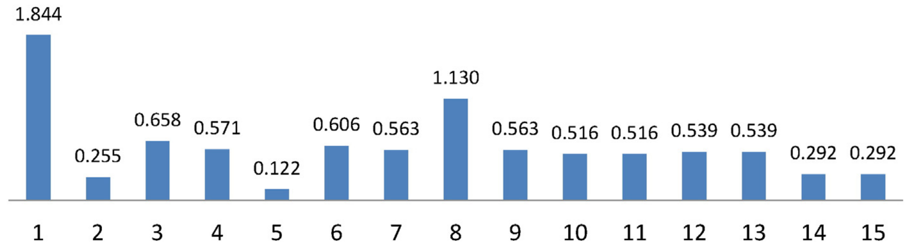

Fig. 2. Expected value for all fifteen programs of the portfolio.

policy makers, but as a set of alternatives that have to be considered together with results from other methods.

3. Results, discussion and implications

As described previously six categories were used as surrogates for the impact of programs on gaps; these were defined independently of programs and should represent an orthogonal set necessary to cover all gaps. These were input to an analysis that used the PortMan method (Chow et al., 2011) to obtain the expected value for each program, as shown in Eq. (1). The expected value for each program, EV_i, quantified its relative importance within the portfolio and was normalized for each gap as described in the Appendix A.

Fig. 2 shows a graph of the expected value of each of the fifteen programs from the Ministry of Education classified in the following way: programs from 1 to 6 focus on higher education, programs 7 to 9 are mostly devoted to vocational and professional education and programs from 10 to 15 are dedicated to basic education. The programs contain a mix of policies that are inherent to the needs of Brazil, which include among others, support for transportation to school for students from rural areas, access to school for those with disabilities and support for students under vulnerable conditions. After careful analysis it became clear that one cannot simply evaluate programs without considering the number of people impacted and the cost incurred. These issues will be addressed later in the paper.

The impact of the portfolio can be also quantified with respect to the gaps as depicted in Fig. 3. It appears that there is redundancy in addressing gaps 1, 2 and 4, while other gaps are not sufficiently covered to address the human factors for innovation. The policy maker should be aware that this quantitative information is informed input rather than a recommendation on where to invest. For example, the programs that contributed to gap 1 include important elements of the Brazilian ecosystem that would have an impact on the school life expectation such as: improvements in infrastructure; distribution of books to students; access for people with disabilities and in vulnerable conditions. This example highlights the difficulty in correlating programs that are not directly designed for developing human capital for innovation, but have importance in establishing a healthy ecosystem for that purpose.

In order to understand the importance of these gaps, we identified the 25 most innovative countries by comparing results from the innovation reports previously cited as shown in Table A3 of the Appendix A. Then we identified for each gap (i.e a sub-pillar of the Global Innovation Index) the 25 countries that have the highest score for that particular gap. Following that, we asked how many of the 25 most innovative countries are among those with the 25 highest scores for that particular gap. These countries were used to build an undirected network of countries and gaps as nodes. The results are the eigenvector centralities indicated in Table 3 showing the relative importance of the gaps. Fig. 4 indicates the number of gaps covered by each country considering only the indicators used for this study (see Tables 1 and 3). A priori there is no recipe for the number of gaps that a portfolio must cover, but the present portfolio clearly addresses three (gaps 1, 2 and 4) of the top six most important gaps (see Fig. 2): school life expectancy, assessment in reading mathematics and science and tertiary enrolment.

The next step of the analysis involved assigning values to the number of beneficiaries and the cost incurred per program according to Table 4.

These are preliminary values. They include a combination of planned budgets and actual spending that did not necessarily cover all years for all programs. One infers the number of beneficiaries by estimating the number of institutions that benefited from that program rather than counting the actual number of individuals impacted by the program. For the current paper this is not an issue for the final results, because we are only assessing the relevance of the methodology.

Table 5 shows expected values weighted by cost and number of beneficiaries. Programs 2, 10, 11 and 12 are those whose ratio of beneficiary to cost is more favourable. However, when one uses this to weight the expected value (total expected value/cost), programs 8, 12,

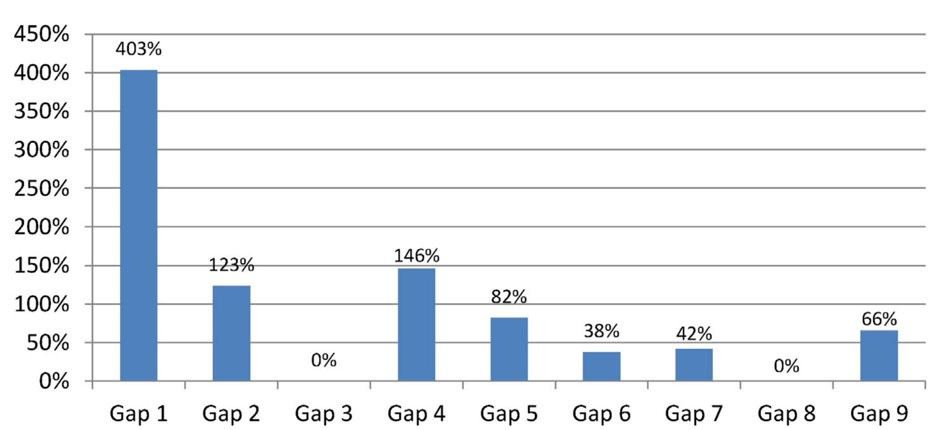

Fig. 3. Percentage within which the portfolio of programs addresses each gap.

Table 3
Relative importance of gaps considering top 25 innovative countries for each gap.

Gap	Description	Position (ranked by importance)	Eigenvector centrality
8	Average score of top 3 universities at the QS world ranking	1	1.00
7	Researchers	2	0.99
2	Assessment in reading mathematics and science	3	0.98
1	School life expectancy	4	0.88
6	Tertiary inbound mobility	5	0.79
4	Tertiary enrolment	6	0.77
5	Graduates in science and engineering	7	0.40
3	Pupil-teacher ratio. secondary	8	0.21
9	Firms offering formal training	9	0.11

Table 4
Weights used for the correction of the expected values for each program based on cost and number of beneficiaries in Brazilian Reais (BRL).

Cost		Beneficiaries	
Weight	Value	Weight	Value
3	More than 1 billion BRL	1	Less than 100 thousand
2	From 100 million to 1 billion BRL	2	From 100 thousand to 1 million
1	Less than 100 million BRL	3	More than 1 million

10 and 11 appear to be the most relevant, while programs 5 and 14 are the least relevant.

The number of beneficiaries weighted each program and this quantity, the total expected value (TEV), was maximized taking into account budget constraints. The objective function (OF) was defined as:

$$\text{OF} = \sum_{j=1}^{n} TEV_j \cdot P_j, \quad (2)$$

where TEV_j is the sum of the expected value for the program P_j across all gaps, weighted by the number of beneficiaries, n is the total number of programs and P_j is equal to one when the program is included in the portfolio or zero otherwise. The maximization was performed using an evolutionary algorithm for linear programming where the constraint was given by Eq. (3):

$$\sum_{j=1}^{n} C_j < Total \;\; Portfolio \;\; Cost, \quad (3)$$

where C_j is the total cost estimated for program P_j taking the middle value for each of the three ranges displayed in Table 4. The inclusion of programs in a portfolio that is limited to a maximum budget may vary according to their relative importance as the budget increases. In order to test that, we maximized the objective function and created eighteen cost scenarios (S1 to S18) with increasing order of costs and total expected value. The results shown in Table 6 suggest that for lower budget scenarios this portfolio should contain more small programs.

The methodology allows identification of programs, such as P13, that could be excluded from the portfolio in medium budget scenarios but may be included in low and high budget scenarios, thus interpreted not as a highest priority program. From the numerical analysis one could also remove programs P14 and P15 from the portfolio as they are only justified when high budgets are available. Programs P12, P11 and P10 appear to have a favourable cost benefit ratio since once included in the portfolio, they remain part of the portfolio for all subsequent budget scenarios.

Another visualization of the results of portfolio optimization is provided in Fig. 5, which indicates that for up to a total expected value of 7, programs can be included with marginal effect on the total budget. After that, there is a sequence of high-cost programs that have an important contribution to the total expected value, such as P8 and P3.

3.1. Discussions and implications

This paper connects innovation indicators and programs from the Ministry of Education aiming at assessing the development of skilled workforce for innovation in Brazil. Even though this study case presents a proof-of-concept, the method is generalizable to other components of an innovation index for Brazil or any other country. The method is generalizable; it only requires an attainable objective with identifiable gaps that ought to be filled. To this end, one identifies a portfolio of programs that can affect these gaps through carefully designed categories. The choice of categories is the key element in the process. There are no restrictions in applying this decision analysis method to any portfolio of investments (e.g. R&D projects, other innovation indicators) designed to identify alternative sets of investment options within a given financial constraint.

It is worth mentioning that there are important caveats to the proposed methodology:

- programs should not be analysed individually, since stronger statements can be made about the portfolio of programs due to their interconnectedness in the analysis;
- our quantitative analysis does not remove the subjectivity from

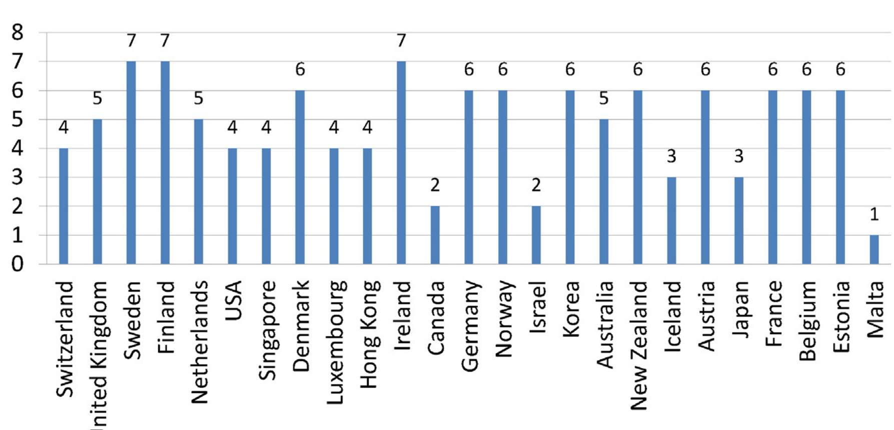

Fig. 4. Number of gaps covered by innovative countries for the indicators used in this work.

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Table 5
Expected values for each program based on cost and number of beneficiaries.

	EV	Cost	Beneficiary	Beneficiary/cost	EV/Cost	TEV (EV × Beneficiary)	TEV/cost
P1	1.844	3	1	0.3	0.615	1.844	0.615
P2	0.255	1	2	2.0	0.255	0.511	0.511
P3	0.658	3	3	1.0	0.219	1.973	0.658
P4	0.571	3	2	0.7	0.190	1.141	0.380
P5	0.122	1	1	1.0	0.122	0.122	0.122
P6	0.606	2	1	0.5	0.303	0.606	0.303
P7	0.563	1	1	1.0	0.563	0.563	0.563
P8	1.130	3	3	1.0	0.377	3.389	1.130
P9	0.563	2	1	0.5	0.281	0.563	0.281
P10	0.516	2	3	1.5	0.258	1.548	0.774
P11	0.516	2	3	1.5	0.258	1.548	0.774
P12	0.539	2	3	1.5	0.269	1.616	0.808
P13	0.539	3	3	1.0	0.180	1.616	0.539
P14	0.292	3	2	0.7	0.097	0.584	0.195
P15	0.292	3	3	1.0	0.097	0.876	0.292

Table 6
Results from maximizing the total expected value, weighted by the number of beneficiaries for each program, using total cost as constraint. For details see text.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	TEV
S1							0.56									0.56
S2		0.51					0.56									1.07
S3		0.51			0.12		0.56									1.20
S4												1.62				1.62
S5		0.51			0.12		0.56					1.62				2.81
S6												1.62	1.62			3.23
S7		0.51			0.12		0.56					1.62	1.62			4.43
S8										1.55	1.55	1.62				4.71
S9		0.51			0.12		0.56			1.55	1.55	1.62				5.91
S10		0.51			0.12	0.61	0.56			1.55	1.55	1.62				6.51
S11		0.51			0.12	0.61	0.56		0.56	1.55	1.55	1.62				7.08
S12		0.51			0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62				10.46
S13		0.51	1.97		0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62				12.44
S14	1.84	0.51	1.97		0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62				14.28
S15	1.84	0.51	1.97		0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62	1.62			15.90
S16	1.84	0.51	1.97	1.14	0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62	1.62			17.04
S17	1.84	0.51	1.97	1.14	0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62	1.62		0.88	17.91
S18	1.84	0.51	1.97	1.14	0.12	0.61	0.56	3.39	0.56	1.55	1.55	1.62	1.62	0.58	0.88	18.50

innovation indicators, but aims at minimizing additional subjectivity through the use of validated expert judgement;

- our method is sensitive to changes in technical potential of programs, but relies on proper definition and characterization of the categories that impact gaps.

The results discussed in this paper could be an important contribution to a foresight exercise for the innovation ecosystem of any given country, especially in the diagnosis phase.[1] Using Brazil as an example, the main questions that would normally drive an innovation foresight exercise are outlined in Table 7.

However, by analysing the results from this paper in detail, Table 8 highlights additional questions that should also be answered for a better understanding of the current state of the art of the Brazilian NSTIS as well as of its comparison, both at present and in the future (i.e. through scenarios or visions), with benchmark countries.

In this context, Portman functions as a due diligence tool (Loveridge and Cagnin).[2] Thus, it helps to identify important questions that ought to be investigated for a more complete and systemic understanding of any given NSTIS. In addition, the modification to the PortMan method implemented in this paper allowed it to become a key asset in providing a benchmark of a country's innovation capacity. This is an important input for any foresight study associated with innovation policy. Combining these results with those of a trend analysis and exploratory scenarios or visions would allow the definition of a set of capabilities necessary to enable a particular NSTIS that can cope with current and future challenges.

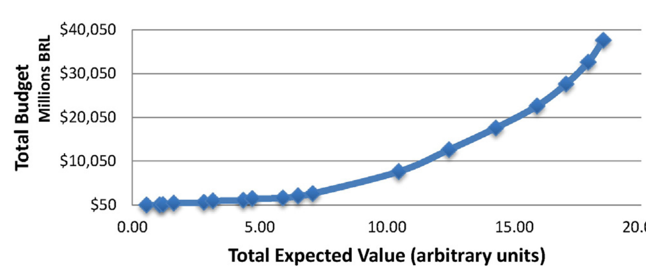

Fig. 5. Total expected value for the portfolio of programs based on a total budget constraint after maximization of the objective function. For details see text.

[1] A foresight exercise can be typically divided into three main phases: diagnosis, exploration and prescription (Cagnin and Könnölä, 2014 - Futures 59 (2014) 27–38).

[2] Loveridge, D and Cagnin, C (forthcoming). FTA as Due Diligence for an Era of Accelerated Interdiction by an Algorithm-Big Data Duo. Springer.

Table 7
Phases and main questions that drive the innovation ecosystem continual foresight exercise at CGEE.

Diagnosis	Exploration	Prescription
▪ Which are the system functions that represent the National STI System (NSTIS)? ▪ Which are the STI activities developed by each system actor in interaction and what system functions relate to these? ▪ Which are the important functions and/or relationships between actors missing or weakly developed and why?	▪ What is the future of innovation and of NSTIS? ▪ How can such future NSTIS be measured in terms of performance? ▪ In which ways can future NSTIS be organised? ▪ How can the current NSTIS evolve towards these different possibilities? ▪ Which actors should play what roles?	▪ Which criteria should be used to prioritize the NSTIS organization, performance measuring and roles of actors? ▪ Which policies are required to enable the NSTIS to evolve towards the desired direction? ▪ Which other actions (e.g. funding, research, etc.) are required and how to place these in time considering interrelationships and interdependency (i.e. roadmap)?

Table 8
New questions for the innovation ecosystem foresight exercise at CGEE derived from the results of this paper.

Diagnosis	Exploration	Prescription
▪ What is the current state of the Brazilian innovation system and how does it compare with benchmark countries? ▪ To what extent do the identified gaps and existing programs meet the requirements for human factors for innovation?	▪ What are the aspirations for the Brazilian innovation system? ▪ Which factors from benchmark countries can be adapted to meet these aspirations? ▪ What are the relevant gaps to improve human factors for innovation in the Brazilian ecosystem? ▪ Which are the appropriate possible thresholds that can be applied for the gap coverage analysis?	▪ How to combine aspirations and benchmark countries to define a vision for the future of the Brazilian innovation system? ▪ Which gaps, gap thresholds and programs are more appropriate to support this vision?

Another possibility of using Portman results as input for an innovation foresight study is to define the categories of a Portman method through a foresight exercise. In this direction, once a project team is able to define the gaps and identify which programs to analyse, a few panels could be used to debate which categories should be used to cover such gaps. For instance, several workshops could be held separately with representatives of the Ministry of Industry, Ministry of Education, Ministry of Innovation, among others, to define which categories are appropriate for the challenge at hand. The next step would be to run the Portman exercise. Finally, a workshop would be organised for a joint assessment of results so that different Ministries would understand their different viewpoints and possibly arrive at either a consensus or a compromise towards which programs to prioritize. In case a compromise is not attainable, the group would then be able to refine the gaps to rerun Portman and further engage in a discussion concerning prioritization.

Hence, the work depicted here should be perceived as an initial step towards a new methodology for innovation foresight aimed at improving a country's innovation capacity.

3.2. Future developments

The following are recommendations for future developments:

- expand the present analysis to include the largest possible set of indicators from the GII;
- combine data from different innovation reports;
- include programs from different branches of government;
- include budget estimates and not actual spent funds on programs;
- improve the cost analysis and characterize budgets over a period of at least five to seven years, a typical average duration of policy measures (this would allow incorporation of multi-year costs as an additional constraint);
- Include a broad set of specialists to validate all categories, gaps and programs;
- improve portfolio optimization by using Monte Carlo approaches to deal with uncertainties (e.g., see Chow et al., 2011);
- develop adequate tools for the foresight exercise;
- add new dimensions of analysis to account for the special characteristics of Brazil such as:
  - o regional aspects of indicators, since reduction of inequalities is of uttermost importance for a continental country such as Brazil;
  - o inequalities between public and private educational institutions;
  - o vulnerability, gender and ethnic background aspects where applicable.

4. Conclusions

This paper describes a case study for a new method for combining innovation foresight, international innovation indices, and decision analysis to identify the best combination of investments to improve national innovation systems, using Brazil as the example. The implications of the method for FTA practice and evaluation and improvement of other national innovation systems are: (i) one can rank a non-comprehensive list of programs and evaluate their impact on innovation indicators, (ii) one can inform policy makers of potential uncovered gaps in innovation strategies and (iii) one can provide inputs to foresight studies aimed at improving a country's innovation ecosystem.

The main result of this paper is the proof-of-concept of a new methodology. Further work is required to provide a better assessment of how programs in Brazil are or are not adequate to fill the gaps proposed. Specialists in the areas of interest should validate the gap analysis matrices and the work should be expanded to include all indicators from the Global Innovation Index and potentially others from additional studies.

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Appendix A

A.1. Calculation of the expected value

The expected value for each program, EV_i, quantified its relative importance within the portfolio and was normalized for each gap as described by Eq. (A1). The sum of all expected values that contributed to a gap could be larger than one and that would imply that the portfolio may be “overinvesting” in that gap.

$$EV_i = \sum_{k=1}^{ngaps} \frac{\sum_{n=1}^{ncat} C_{kn} \cdot T_{kn} \cdot CE_n \cdot P_{in}}{\sum_{m=1}^{ncat} CE_{km}}, \tag{A1}$$

where i corresponds to the program number, k to the gap number and m to the category number. The total number of gaps and categories are characterized by *ngaps* and *ncat*, respectively. If a program contributes to a gap via a category n then P_{in} assumes a value of one, and is zero otherwise. If a program affects gap k via category n then C_{kn} assumes a value of one, and is zero otherwise. The technical potential T_{kn} measures the potential impact of a program in addressing a gap though a given category and it can assume three values, low (0.33), medium (0.67) or high (1). The relative importance of the categories was obtained using an undirected bipartite network of categories and gaps, without considering the programs. The resulting centrality eigenvectors were summed to produce the normalization for each gap. Thus the sum of CE_{km} includes only categories relevant to a given gap and not all six categories as shown in Table A1. The value of CE_n in the numerator uses the same eigenvectors as weights for categories contributing to a gap.

The results depicted in Table A1 were used in Eq. (A1) to obtain the gap coverage, i.e., how many gaps were filled with the portfolio of programs. Table A2 shows, for each program, how a category contributes (green) or not (red) to fill a gap. Note that a single program can address more than one gap. The expected values per program are shown under the program number and the highlighted numbers (yellow) indicate categories that are deemed important to fill in that gap. Since we only considered the direct impact of programs through categories, all indirect impacts were ignored in the calculation. A clear example of that can be seen in gaps 3 and 8 (see Table A2), which were not directly covered by any of our programs. This does not come as a surprise since the portfolio of programs from the Brazilian Ministry of Education was not chosen because it satisfies the gaps identified as innovation sub-pillars in the Global Innovation Index. Rather the choice was dictated by their potential improvements on education in Brazil, while considering the country's idiosyncrasies and not necessarily comparisons with other countries. It was through the present methodology that one brought these elements to a direct comparison.

A.2. Identification of the most innovative countries

The following are the 25 most innovative countries according to the following reports: The Global Innovation Index, GII, (Cornell University, INSEAD, and WIPO, 2014), The Global Competitiveness Report, GCI, 2013–2014 (Schwab et al., 2013), The Global Innovation Policy Index, GIPI, 2012 (Atkinson et al., 2012) and the Innovation Union Scoreboard, IUS, (European Commission, 2014).

The GII and GCI present countries ranked by number, so the comparison is straightforward. The GCI also divides the countries into four groups according to their stages of development: innovation driven (stage 3), transition from stage 2 to stage 3, efficiency-driven (stage 2), transition from stage 1 to stage 2 and factor-driven (stage 1). The GIPI divides the group of countries into classes: upper tier, upper-mid tier, lower-mid tier and lower tier. There are 33 countries in the top two categories. The Innovation Union Scoreboard ranks European Countries as: leaders, followers, moderate and modest innovators. In addition, the report ranks the following countries: Australia, Brazil, China, India, Japan, South Africa, South Korea and the USA. The rationale for create a list of top 25 most innovative countries is the consistency of their rankings when comparing the reports. The paragraphs provide detailed explanation for the choice of countries for this report.

There are 8 countries that appear in the top 25 of the GII and the GCI, in the upper tier of the GIPI and are perceived as leaders by the IUS. These are in our list: Switzerland, Sweden, Finland, USA, Denmark, Germany, South Korea and Japan, There are 5 countries that appear in the top 25 of the GII and the GCI, in the upper tier of the GIPI and are perceived as followers by the IUS. These are in our list: United Kingdom, The Netherlands, Canada, Austria and France. South Korea is the only country that appear in the top 25 of the GII and the GCI, in the upper-mid tier of the GIPI and is perceived as leader by the IUS. There are 2 countries that appear in the top 25 of the GII and the GCI, in the upper-mid tier of the GIPI and are perceived as followers by the IUS. These are in our list: Luxembourg and Belgium.

The remaining 9 countries need additional justification to appear in our list, these are: Australia, Estonia, Hong Kong (China), Iceland, Ireland, Israel, Malta, New Zealand, Norway, Singapore.

The IUS does not evaluate Australia, Singapore and Hong Kong (China) and evaluates Norway as moderate innovator. However, these countries appear on the top 25 for GII, GCI and GIPI and for that reason they are in our list. Iceland (31), Ireland (28), Israel (27), Estonia (32) and Malta (41), are not within the top 25 in the Global Competitiveness Index. Since all, but Estonia belong to the innovation-driven economies as defined by the CGI, we decided to keep them in our final list. Although Malta appears in 41st place it is also on the top 15 for the GCI when one considers the education indicators. In addition, according to the IUS, is “has experienced the fastest growth of all Member States for most cited publications, public-private co-publications and Small medium enterprises introducing product or process innovations. High growth is also observed for new doctorate graduates” (European Commission,

Table A1
Eigenvector centrality weights for each gap k and category m and their corresponding normalizations CE_{km}, based on the number of relevant categories.

		Gap k								
		1	2	3	4	5	6	7	8	9
Category m	1. 1	0.293	0.293							
	2. 2	0.920	0.920		0.920	0.920	0.920		0.920	
	3. 3	0.379	0.379	0.379						
	4. 4	0.560			0.560	0.560				0.560
	5. 5					0.574	0.574	0.574	0.574	
	6. 6	1.000		1.000	1.000	1.000	1.000	1.000	1.000	
ΣCE_{km}		3.152	1.592	1.379	2.48	3.054	2.494	1.574	2.494	0.56
Number of relevant categories		5	3	2	3	4	3	2	3	1

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Table A2
Programs and categories that address (green = y) or not (red = n) a gap. The expected values per program are shown under the program number. Highlighted (yellow) numbers indicate categories that are deemed important to fill that gap.

		GAP 1						GAP 2						GAP 3						GAP 4						GAP 5						GAP 6						GAP 7						GAP 8						GAP 9					
		categories						categories						categories						categories						categories						categories						categories						categories						categories					
		1	**2**	**3**	**4**	5	**6**	1	**2**	**3**	4	5	6	1	2	**3**	4	5	**6**	1	**2**	3	**4**	5	**6**	1	**2**	3	**4**	5	**6**	1	**2**	3	4	5	**6**	1	2	3	4	5	**6**	1	**2**	3	4	**5**	**6**	1	2	3	**4**	5	6
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P1	M	n	n	n	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	y	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n
1.84	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P2	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.26	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P3	M	n	y	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.66	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P4	M	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.57	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P5	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.12	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P6	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.61	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P7	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.56	H	y	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P8	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	y	n	n
1.13	H	n	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P9	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.56	H	y	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P10	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.52	H	n	n	y	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P11	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.52	H	n	n	y	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P12	M	n	n	n	n	n	n	n	y	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.54	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P3	M	n	n	n	n	n	n	n	y	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.54	H	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P14	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.29	H	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	L	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
P15	M	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
0.29	H	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n

2014). Estonia is kept in our list because it is at position 24 for the GII, it is considered a follower by the IUS, is in the upper-mid tier for the GIPI and ranks 23 in higher education and training for the GCI.

For completeness, it is important to note that within the top 25 of the GCI there were 5 countries not added to our list: Taiwan, China (12), Quatar (13), United Arab Emirates (19), Saudi Arabia (20) and Malaysia (24). The rationale is the following. None of them were evaluated by the GIPI except Malaysia that appeared in the low-mid Tier list. For the GCI they occupied the following positions: Taiwan, China (29), Quatar (47), United Arab Emirates (36), Saudi Arabia (38) and Malaysia (33), which shows a large discrepancy when compared to the GII.

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Table A3
The 25 most innovative countries. Numbers indicate the position in the rank for the GII (Cornell University, INSEAD, and WIPO, 2014) and GCI (Schwab et al., 2013). The GIPI (Atkinson et al., 2012) divides the group of countries into classes: upper tier, upper-mid tier, lower-mid tier and lower tier. The Innovation Union Scoreboard (European Commission, 2014) ranks European Countries as: leaders, followers, moderate and modest innovators.

Country	Global Innovation Index	Innovation Union Scoreboard	Global Innovation Policy Index	Global Competitiveness Index
Switzerland	1	Leader	Upper tier	1
United Kingdom	2	Follower	Upper tier	10
Sweden	3	Leader	Upper tier	6
Finland	4	Leader	Upper tier	3
Netherlands	5	Follower	Upper tier	8
United States of America	6	Leader	Upper tier	5
Singapore	7	n/a	Upper tier	2
Denmark	8	Leader	Upper tier	15
Luxembourg	9	Follower	Upper-mid tier	22
Hong Kong (China)	10	n/a	Upper tier	7
Ireland	11	Follower	Upper-mid tier	28
Canada	12	Follower	Upper tier	14
Germany	13	Leader	Upper tier	4
Norway	14	Moderate	Upper tier	11
Israel	15	n/a	Upper-mid tier	27
Korea, Republic of	16	Leader	Upper-mid tier	25
Australia	17	Moderate	Upper tier	21
New Zealand	18	n/a	Upper tier	18
Iceland	19	Follower	Upper-mid tier	31
Austria	20	Follower	Upper tier	16
Japan	21	Leader	Upper tier	9
France	22	Follower	Upper tier	23
Belgium	23	Follower	Upper-mid tier	17
Estonia	24	Follower	Upper-mid tier	32
Malta	25	Moderate	Upper-mid tier	41

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