



Vlaams Indicatorenboek 2021

WETENSCHAP – TECHNOLOGIE – INNOVATIE



Overzicht van de gemaakte selectie

Het Vlaams Indicatorenboek bevat een portfolio aan beleidsindicatoren die de ontwikkeling van het Vlaams potentieel inzake wetenschap, technologie en innovatie in kaart brengen.

Sinds 1999 wordt het boek om de twee jaar uitgegeven en vanaf 2017 wordt het Indicatorenboek een virtueel boek met een eigen website: <http://vlaamsindicatorenboek.be>. Het boek dat u nu in handen hebt is een selectie van hoofdstukken uit dit boek. Voor de volledige versie verwijzen we u graag naar de website.

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De website van het Indicatorenboek biedt u ook de mogelijkheid om een eigen selectie samen te stellen van hoofdstukken die voor u relevant zijn. Surf hiervoor naar: <http://vlaamsindicatorenboek.be/selectie>.

Wij wensen u alvast een informatieve zoektocht door het Vlaamse innovatielandschap!

Dankwoord

Wetenschap, technologie en innovatie zijn onmiskenbaar essentiële hefboomen tot welvaart en welzijn in onze maatschappij. De Vlaamse overheid heeft daarom veelzijdig en veelzijdig aandacht besteed aan de ontwikkeling van de kwaliteit en de slagkracht van het Vlaamse Wetenschaps-, Technologie- en Innovatiesysteem. Het brede spectrum van wetenschappelijk en technologisch onderzoek aan de Vlaamse kennisinstellingen is daarbij vervolledigd met maatregelen en instrumenten om het innovatievermogen van de in Vlaanderen opererende ondernemingen te verhogen, en daarbij ook de kleine en middelgrote ondernemingen steeds meer, gerichte innovatiekansen te bieden.

Het is dan ook nuttig en wenselijk om het geheel aan acties, en hun meetbare resultaten, in een coherent, regelmatig te verschijnen Indicatorenboek te bundelen. Het vernieuwde Vlaams Indicatorenboek Wetenschap, Technologie en Innovatie, dat de tijdsreeksen uit de vorige Indicatorenboeken actualiseert en uitbreidt, draagt daartoe bij. Zo is het mogelijk een robuust en internationaal vergelijkbaar overzicht te geven van de situatie in Vlaanderen op het vlak van de bestedingen voor en de resultaten van onderzoek, ontwikkeling en innovatie.

Het Indicatorenboek 2021 wordt net als de vorige editie uitsluitend in een interactieve bevragingmode elektronisch aangeboden.

Uiteraard bouwt dergelijk Indicatorenboek op de inspanningen van veel enthousiaste medewerkers. De redactie en het schrijven van dit boek kwamen dan ook tot stand onder impuls van een redactiegroep van experts behorend tot de verschillende beleidsactoren uit het Vlaams Innovatiesysteem, die de staf van het Expertisecentrum O&O-monitoring (ECOOM) van de Vlaamse overheid bijstonden in de opdracht dit Indicatorenboek te ontwikkelen. Elk van hen droeg bij tot de conceptie van dit werk. We willen hen dan ook van harte danken voor de constructieve samenwerking om onder de gebruikelijke tijdsdruk dit document af te werken:

De Heer Paul De Hondt van het Kabinet van de Vlaamse Minister voor Economie, Wetenschap en Innovatie en tevens voorzitter van het Beheersorgaan van het Expertisecentrum O&O-Monitoring,

Mevrouw Linda De Kock van de Administratie Hoger Onderwijs,

De Heer Peter Viaene en Mevrouw Monica Van Langehove van het Departement Economie, Wetenschap en Innovatie (EWI),

De Heren Eric Sleenckx en Maarten Sileghem van het Vlaams Agentschap Innoveren en Ondernemen (VLAIO),

Mevrouw Danielle Gilliot van de Vlaamse Interuniversitaire Raad (VLIR),

Mevrouw Daniëlle Raspoet en Mevrouw Kristien Vercoetere en Mevrouw Annelies Wastyn van de Vlaamse Raad voor Innoveren en Ondernemen (VARIO),

De Heer Hans Willems van het FWO,

De collega's Tim Engels, Raf Guns, (ECOOM-Antwerpen), Katia Levecque en Noëmi Debacker (ECOOM-Gent), en Wolfgang Glänzel, Bart Thijs, Machteld Hoskens, Wytse Joosten, Laura Verheyden, Julie Callaert, Sarah Heeffe, Veronique Adriaenssens en Mariëtte Du Plessis (ECOOM-Leuven), en het ganse ECOOM-Leuven team dat de realisatie van deze digitale versie in goede banen heeft geleid,

die samen de nodige expert-inzichten en inbreng geleverd hebben bij het tot stand komen van de Vlaamse O&O gegevens.

Daarnaast danken we tevens van harte alle auteurs die op basis van de inbreng van de redactiegroep, de verschillende hoofdstukken en dossiers hebben uitgewerkt, geschreven en gedocumenteerd met relevant en betrouwbaar cijfermateriaal.

Zonder hun gezamenlijke inspanning was dit tiende Vlaams Indicatorenboek WTI nooit tot stand kunnen komen!

Van harte dank!

Prof. Koenraad Debackere en Prof. Reinhilde Veugeliers
Redacteurs Vlaams Indicatorenboek Wetenschap, Technologie en Innovatie
Leuven, september 2021

Woord van de ministers

Na een moeilijke periode die getekend werd door de coronacrisis toont Vlaanderen veel veerkracht.

De pandemie heeft ons dynamische wetenschapslandschap niet kunnen temmen. Anders dan aanvankelijk werd gevreesd, is de innovatie in het bedrijfsleven niet teruggeduikt, en ook de kmo's worden steeds meer betrokken bij de noodzakelijke innovatie. De samenwerking tussen bedrijfsleven en kennisinstellingen, onder meer via de speerpuntclusters, verloopt nog steeds uitstekend en ook het fundamenteel onderzoek ondersteund door het FWO bleef productief.

De relance na de coronacrisis kan steunen op een heel stevige basis. Voor het eerst heeft Vlaanderen de norm van 3% van het bbp aan onderzoek en ontwikkeling doorbroken. In 2019 hebben alle bedrijven, overheden en kennisinstellingen in Vlaanderen samen 3,35% van het bbp geïnvesteerd in onderzoek en ontwikkeling, zo bleek uit de 3% nota 2021 van ECOOM. Dat is een belangrijke mijlpaal. Uit andere internationale rapporten komende nog positieve elementen naar voor. Zowel België als land, als Vlaanderen als regio, komen voor het eerst in de kopgroep van 'innovatieleiders' in Europa op een respectievelijke 4de (European Innovation Scoreboard) en 27e plaats (Regional Innovation Scoreboard).

Zoals blijkt uit de tiende editie van het indicatorenboek zet Vlaanderen met succes in op de ontwikkeling van haar talentbasis via hoger onderwijs en toenemende mobiliteit van studenten en onderzoekers binnen Vlaanderen maar ook internationaal, op de sterke aanwezigheid in Europese onderzoeks- en innovatieprogramma's, en op de ontwikkeling van significante posities inzake intellectuele eigendom zowel bij het bedrijfsleven als bij de kennisinstellingen. Ook de institutionele versterking van het innovatieweefsel met een portfolio van complementaire kennisinstellingen trekt investeringen in het Vlaamse WTI-weefsel aan.

Ook de toekomst ziet er goed uit. De Vlaamse Regering maakte 4,3 miljard vrij voor haar relanceplan, het plan dat de Vlaamse welvaart en het welzijn van de Vlamingen moet helpen versterken na corona.

In ons onderwijs wordt steeds meer de nadruk gelegd op STEM-richtingen. We zetten met de Digisprong ook een ambitieuze digitaliseringsoperatie van het hele onderwijs op de rails. Specifiek voor het hoger onderwijs is er in de nasleep van de coronacrisis een Voorsprongfonds van 60 miljoen euro gelanceerd, dat onze hogescholen en universiteiten nog toekomstgerichter en digitaler zal maken.

Het beleidsdomein EWI kan vanuit het Relanceplan Vlaamse Veerkracht 631 miljoen euro investeren. Hiervan wordt 87% uitgetrokken voor onderzoek en innovatie (waterstofonderzoek, bio-economie, digitalisering en duurzaamheid, O&O bedrijven, O&O onderzoeksinfrastructuur, ...) en 13% voor productieve, economische investeringen.

De komende jaren zal innovatie nog belangrijker worden, zeker in het kader van de uitdagingen rond duurzaamheid en zorg. We plannen deze legislatuur 250 miljoen euro voor onderzoek & ontwikkeling en daarbovenop nog eens 195 miljoen euro extra voor onderzoeksinfrastructuur.

Door innovatie als prioriteit van het beleid te blijven zien, willen we ook de komende jaren boven die 3% blijven en de plaats van Vlaanderen in de groep van innovatieleiders verder versterken. Kortom we willen Vlaanderen op het vlak van technologie, wetenschap en innovatie in de Europese cockpit plaatsen.

Het blijft essentieel voor het beleid om alles internationaal nauwgezet op te volgen en hierin speelt het Vlaams Indicatorenboek Wetenschap, Technologie en Innovatie (de tiende editie ondertussen!) een belangrijke rol. Dit geldt zowel op het vlak van de bestedingen voor O&O en innovatie als voor de resultaten van het onderzoek uit het hoger onderwijs, onderzoek, ontwikkeling en innovatie.

Het Vlaams Indicatorenboek is dan ook uitgegroeid tot een belangrijk evaluatie-instrument voor het beleid.

Wij willen in naam van de Vlaamse regering ECOOM en iedereen die eraan meewerkte dan ook uitdrukkelijk bedanken.

Hilde Crevits

Viceminister-president van de Vlaamse Regering en Vlaams minister van Economie, Innovatie, Werk, Sociale economie en

Ben Weyts

Viceminister-president bevoegd voor Onderwijs, Sport, Dierenwelzijn en Vlaamse Rand

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7 Dossiers

In addition to the recurrent chapters, each edition of the Flemish Indicator Book also offers a number of specific dossiers that provide a summary of relevant figures and recent research into relevant themes. In this edition there are six different files that deal with very different topics.

7.2 A qualitative set of indicators for science and innovation

By Kristien Vercoetere, Annelies Wastyn and Danielle Raspoet (Flemish Advisory Council for Innovation & Enterprise, VARIO^[1]).

Being the advisory board for innovation and enterprise, VARIO wants to contribute to the Flemish ambition to become one of the top innovative knowledge regions. In its memorandum 2019-2024 'Flight forward. Destination top 5 knowledge regions' (December 2018), the key message was therefore the importance of an overarching long-term strategy for innovation, with clear objectives and smart KPIs (key performance indicators) as powerful tools.

The Flemish Government Agreement 2019-2024 follows VARIO's recommendation. This ambition will be the central touchstone of our innovation policy. The Flemish Government recognizes the need for a set of strategic policy indicators to monitor the realization of these ambitions and based on which it can steer, shape, and evaluate the policy with respect to science and innovation. This resulted in a coordinated request for advice from Minister-President of the Flemish Government Jan Jambon and the Flemish Minister of Economy, Innovation, Work, Social Economy and Agriculture Hilde Crevits in which they ask for the formulation of 'transparent strategic policy indicators that are periodically available, also at the level of Flanders'.

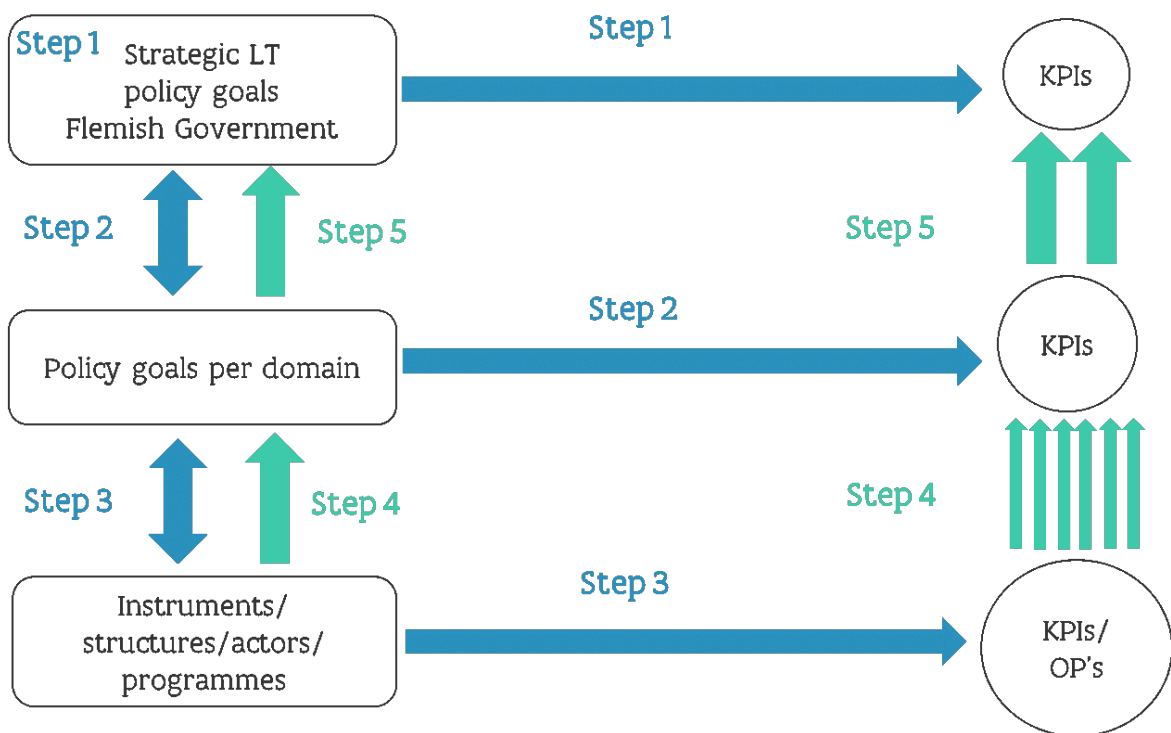
^[1] The Flemish Advisory Council for Innovation and Entrepreneurship (Vlaamse Adviesraad voor Innoveren en Ondernemen, corresponding with VARIO) advises the Flemish Government and the Flemish Parliament on its science, technology, innovation, industry and entrepreneurship policy. VARIO works independently from the Flemish Government and the Flemish stakeholders in the field of science, innovation, industry and enterprise. <https://www.vario.be/en>

7.2.1 VARIO conceptual framework for KPIs in function of policy objectives

According to VARIO, indicators must be set 'smartly', i.e. in function of objectives. In the VARIO advisory report 'Conceptual framework for drawing up KPIs in function of policy objectives' (2019), three levels were included in the model:

1. The 'overarching level' of the Flemish Government,
2. The 'middle level' of policy domains and
3. The 'lowest level' of the individual instruments, structures, actors and programs (see figure).

It is important that the objectives of the different levels are aligned with each other. KPIs must be linked to the objectives at the different 'levels'. They must be complementary and lead to synergy; setting up one KPI must not compromise the achievement of the others.

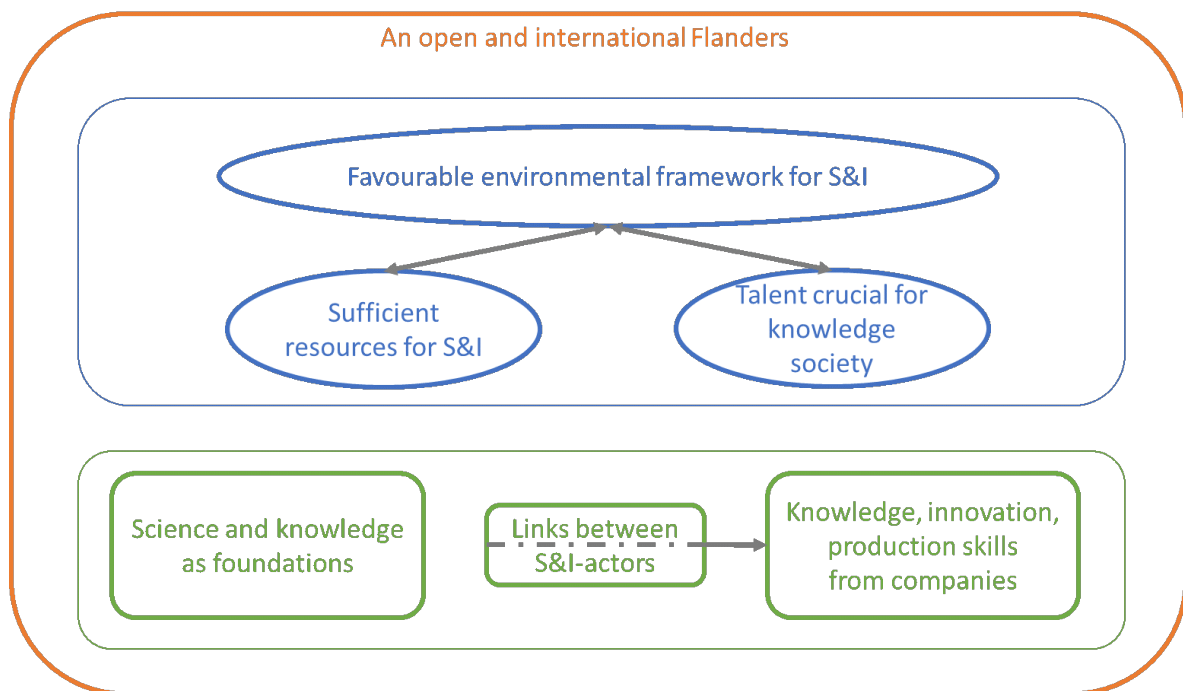


7.2.2 VARIO set of indicators for science and innovation

The objectives and indicators for science and innovation are the starting point for selecting 'smart' indicators.

1) An important step is the identification of critical success factors for science and innovation (identification is based on the VARIO memorandum, VARIO advisory reports and dialogues with the VARIO council members). Based on these critical success factors, objectives have been formulated. The various objectives are bundled into building blocks (see figure).

2) Measurable quantities - indicators - are then linked to the objectives for science and innovation. This makes it possible to monitor whether or not an objective has been achieved and to follow the path towards it. The identification of objectives and the systematic linking of indicators to these objectives is discussed in this dossier. In order to increase transparency, only individual indicators are selected and not composite indices. A robust set KPIs requires good quality control. Several criteria are therefore considered when defining the indicators; availability (at Flemish or Belgian level), international comparability, frequency of indicator availability (annual, biennial...) and reliability (does the method of generating the indicator offer enough guarantees of reliability).



The result of this comprehensive exercise is a set of 20 VARIO-core indicators for science and innovation (see table 1). The set of 20 core indicators is an integral part of a larger grouping of a total of 49 indicators that together cover the broad spectrum of the Science and Innovation system as fully as possible.

Although there is clear overlap with the RIS, EIS, GII... the present tool is not simply the compilation of indicators from those existing indicator sets, but a thoroughly documented exercise. The Regional Innovation Scoreboard and the European Innovation Scoreboard are drawn up from the perspective of innovation/business activities. VARIO prefers to take a broader view and include the entire ecosystem of science and innovation in its monitoring set.

- > Most of the proposed indicators are already existing and well-developed statistics. With regard to some objectives, however, VARIO encountered gaps in the indicator landscape in its exercise and suggestions are made for indicator development. Therefore a distinction has been made between on the one hand those indicators for which the first steps have already been taken and for which the data (sources) are also available (e.g. citations of patents) and which are referred to as 'indicator under development'. On the other hand, for some objectives the data are currently lacking and indicator development should be undertaken (e.g. 'stay rate' of foreign students and share of international R&D personnel in companies). These indicators are referred to as 'to be developed'.
- > In addition, VARIO emphasizes that it is difficult to put indicators on 'impact' because there are many factors that are beyond the control of the policy initiatives set up and because it is not easy to isolate the specific impact of an initiative. In this respect, impact analyses - complementary to indicators - can help to gain more insight in the results of a particular policy initiative.

The 20 core-indicators reflect the critical success factors identified by VARIO and the related objectives. The set of core indicators is also sufficiently easy to manage, allowing the Flemish status regarding Science and Innovation to be closely monitored on a regular basis. The indicators are transparent and generally score very high on the predetermined quality conditions of availability, international comparability, frequency and reliability.

Table 1: Overview of VARIO core indicators for science and innovation for the different building blocks

The 6 Building blocks:

- (1) Sufficient resources for S&I
- (2) Talent is crucial for a knowledge-based society
- (3) Science and knowledge as foundations
- (4) Knowledge, innovation and production skills of companies
- (5) Links between S&I actors
- (6) An open and international Flanders

VARIO-core-indicator		Building block					
		1	2	3	4	5	6
1	GERD (Gross Expenditure on R&D) as % GDP	X					
1a	- Share GERD financed by public sector – 1%	X					
1b	- Share GERD financed by private sector – 2%	X			X		
2	Share of degrees in mathematics, science and technology in higher education in the total number of degrees in higher education		X				
3	Total R&D-personnel per 1000 labour force		X				
3a	- Share per sector of R&D-personnel (higher education, public research institutions and enterprises)		X		X		
4	Average PISA-score on reading, mathematics and science of Flemish 15 year olds		X				
5	Share of population aged 25-64 participating in lifelong learning during the reference period of 12 months prior to the survey		X				
5a	- <i>To be developed:</i> Share of population aged 25-64 participating in lifelong learning during the reference period of 12 months prior to the survey; breakdown to the different forms of learning, the motivation,...		X				
6	Share of Flemish publications in the top 10% highly cited articles			X			
6a	- <i>Under development:</i> Share of Flemish publications in the top 10% highly cited articles, breakdown by domain			X			
7	Number of EPO & PCT patents applied for and USPTO patents granted (Flemish inventor and/or applicant) per million inhabitants			X			
7a	- Number of EPO & PCT patents applied for and USPTO patents granted (Flemish inventor and/or applicant) per million inhabitants; breakdown by sector			X	X		
8	Share of foreigners in the 'ZAP' (academic staff) of Flemish universities			X			X
9	Share of foreigners in the new appointed 'ZAP' (academic staff) of Flemish universities			X			X
10	Share of 'young' companies with high growth ambitions				X		
11	Share of innovating companies				X		
12	Share of in house innovation SMEs				X		
13	Share of HERD privately financed					X	
14	Share of GOVERD privately financed					X	
15	Share of cooperating innovative companies					X	
15a	- Per type of partner					X	
16	Share of innovative companies cooperating internationally					X	X
17a	EU Framework Programme participation grant as a function of GDP						X
17b	EU Framework Programme participation grant as a function of number of inhabitants						X
17c	EU Framework Programme participation grant breakdown by type of actor						X
18	Number of participants to Marie Skłodowska-Curie actions - individual fellowships - at Flemish knowledge institutions						X
19	<i>To be developed:</i> Stay rate – share of international students higher education that stay after graduation						X
19a	- <i>To be developed:</i> Stay rate – share of international students higher education that stay 1 year after graduation						X
19b	- <i>To be developed:</i> Stay rate – share of international students higher education that stay 4 years after graduation						X
20	<i>To be developed:</i> Total R&D-personnel by nationality in enterprises						X

7.2.3 Narrative accompanying the indicator set of science and innovation

In order to draw up a high-quality and meaningful monitoring tool for science and innovation, the starting point must be the policy objectives. Critical success factors lie at the basis of these policy objectives. The various objectives are bundled into the following building blocks:

1. Sufficient resources for science and innovation
2. Talent is crucial for a knowledge-based society
3. Science and knowledge as foundations
4. Knowledge, innovation and production skills of companies
5. Linkages between science and innovation actors
6. An open and international Flanders
7. A favourable environmental framework for science and innovation

The narrative (the motivation) behind the choice of indicators is given below for each building block.

BUILDING BLOCK 1: Sufficient resources for science and innovation

Increasing international challenges and pressure on economic competitiveness in the early 2000s created a growing awareness in Europe about the importance of stimulating R&D. The result was the Lisbon Strategy^[1] with the objective of making Europe “the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion”. One of the sub-objectives formulated to achieve this was to invest sufficiently in research and development (R&D).

Achieve the 3%-target for R&D expenditures as soon as possible, with both the public and private sectors contributing

In the context of the Lisbon Strategy mentioned above, the European summit in Barcelona in 2002 formulated the objective that the European Union should spend 3% of its gross domestic product (GDP) on R&D. Successive Flemish Governments have set the achievement of the 3% target as an objective: *‘As a follow-up to the European Lisbon Strategy, Flanders concluded the Innovation Pact in March 2003, which entails a formal commitment by all the actors involved in the Flemish innovation landscape to spend 3% of GDP on R&D by 2010 through joint and complementary efforts. 1/3 of these R&D expenditures is to be born by the government, the other 2/3 by industry. The subsequent Flemish Governments have renewed this commitment each time.*^[2] In 2009, as part of ‘Flanders in Action’, the ambition to reach the 3% target by 2020 was included in Pact 2020. This objective was in line with the EU 2020-strategy^[3]. In 2019, VIZIER 2030^[4] – a 2030 goal framework for Flanders - was drawn up. One of the 48 objectives concerns the achievement of the 3% target.

› INDICATOR 1: GERD as percentage of GDP

According to a sub-target, the government must account for 1/3 of the R&D expenditure, the companies the other 2/3. Dividing this R&D intensity by financing sector (public or private) yields the so-called 1% norm and 2% target, respectively.

- › INDICATOR 1a: Share of GERD financed by public sector – 1%-target
- › INDICATOR 1b: Share of GERD financed by private sector – 2%-target

^[1] <https://www.europarl.europa.eu/highlights/nl/1001.html>

^[2] For more info we refer to VARIO-advisory report 8: Maintaining Science and Innovation as a priority via an efficient and effective budgetary growth path (June 2019); <https://www.vario.be/nl/publicaties/advies-8-wetenschap-innovatie-als-prioriteit-aanhouden>

^[3] https://ec.europa.eu/eurostat/documents/4411192/4411431/Europe_2020_Targets.pdf

^[4] https://do.vlaanderen.be/sites/default/files/atoms/files/Visienota_Vizier_2030_VR201905_0.pdf

BUILDING BLOCK 2: Talent is crucial for a knowledge society

In today's global knowledge economy, knowledge (development) is central, especially in innovation and economic growth. "A dynamic science and innovation system relies on people. They are the backbone of our knowledge economy. Flanders is already evolving into a bottleneck economy, with an ever-increasing demand for talent, and this in a world where competition for talent is growing. Shortages cause serious damage to the economy" (VARIO Memorandum 2019-2024). Central in a knowledge region is the sufficient quantity and relevant quality of human capital.

1 . Number of STEM degrees must go up

A solid base of S&T (science and technology) graduates is essential for the development of R&D activities and their absorption, and for the establishment of a broader knowledge-based economy. There is also no doubt that, today, STEM (Science, Technology, Engineering and Mathematics) forms the basis for the fastest growing job categories. STEM graduates also appear to have a positive impact on other workers in the same local labour market (Winters, 2020^[14]).

› INDICATOR 2: Share of degrees in mathematics, science and technology in higher education in the total number of degrees in higher education

2 . R&D personnel is important for the absorption capacity of R&D&I investments

Investments in human resources and in knowledge development are important elements in an environment where competition based on knowledge is more important than ever. There is not only a need for researchers, but also for scientifically and technologically trained managers who can introduce innovation into their company, and for a large number of highly educated and technically trained employees who can put this knowledge into practice. Sufficient R&D personnel is important for the absorption capacity of R&D&I investments. R&D personnel are the driving force in knowledge development, dissemination and application. That is why it is also important that the innovation potential is strengthened by investing in human capital.

› INDICATOR 3: Total R&D-personnel per 1000 labour force

› INDICATOR 3a: R&D-personnel per sector (higher education, public research institutions and enterprises)

3 . Attach importance to a solid knowledge base and skills

The democratization of higher education has ensured that Flanders has an increasing number of highly educated people. An increase in the level of education creates employment opportunities, opportunities for higher income, higher economic growth... Secondary education is the start of this; young people must be given a sufficient knowledge base and skills to be able to enter into higher education and to make their contribution to society.

- › INDICATOR 4: Average PISA-score on reading, mathematics and science of Flemish 15-year old

4 . Commit to lifelong learning

"No employee of the future will be able to keep relying on the knowledge gained in school and will have to continue learning throughout life. A culture of lifelong learning will become increasingly important because of the changing job market, because of the ever-increasing degree of digitalization and the fourth industrial revolution" (VARIO memorandum). Cf. the website of the transition area Lifelong Learning^[2], in addition to technology, other trends also have an impact on the career of the future. Increasing individualization, flexibilization, more polygamous labour relations, 'uberization' and active ageing will redesign careers and labour relations, which will require us to think differently about jobs and careers. But, as the concept note 'the Learning Society' states, it is also about ensuring that each person can successfully adapt throughout their life to a world in constant transition. Learning is an integral part of our human development, not just for the economy, jobs and the labour market.

- › Indicator 5: Share of population aged 25-64 participating in lifelong learning during the reference period of 12 months prior to the survey

Training (education) is taken very broadly in this indicator and includes both training in regular education and outside it. The nature of the training is also irrelevant. If we want to gain a clear insight into participation in lifelong learning, it is crucial that the measuring instruments allow for more insight into motivation, formal versus informal learning, and learning intentions.

- › Indicator 5a – To be developed: Share of population aged 25-64 participating in lifelong learning during the reference period of 12 months prior to the survey, breakdown into the different forms of learning, the motivation etc.

^[1] Winters J.V. Do higher levels of education and skills in an area benefit wider society? IZA World of Labor article (2020); <https://wol.iza.org/opinions/is-a-highly-educated-workforce-good-for-less-educated-workers>

^[2] <https://www.vlaanderen.be/vlaamse-regering/transitie-levenslang-leren>

BUILDING BLOCK 3: Science and knowledge as foundation

Crucial in a knowledge society is the creation of knowledge. Only when there is a good breeding ground for knowledge, innovation and entrepreneurship can thrive. If we succeed in further developing, strengthening and growing our already excellent and performing research system, this should/will be visible in an increase in output, in international visibility and in the attractiveness for foreign talent.

1 . Increase the output of our excellent research in terms of quality and high-impact publications

Citation mapping is an excellent bibliometric tool of choice for measuring the impact of publications. Citations are primarily an important form of the extent to which scientific information is used in the context of documented scientific communication. They reflect the acceptance and recognition of published research results by the scientific community. They are also indirectly a measure for the quality/excellence of the research.

It is also interesting to check the citation distribution. The indicator proposed here measures the share of Flemish publications in the top 10% of the most cited publications worldwide, compared to the total number of Flemish publications. This indicator mainly measures the impact of Flemish publications worldwide. High-cited publications are also assumed to be of a higher quality and the result of excellent research. Indirectly, this is therefore a measure for the excellence and efficiency of the research.

- › INDICATOR 6: Share of Flemish publications in the top 10% highly cited articles
 - › INDICATOR 6a – to be developed - : Share of Flemish publications in the top 10% highly cited articles, breakdown by domain

2 . Increase the output and impact of our excellent research in terms of patents

Patents are an established indicator for the inventive, technological output of the research efforts of companies and knowledge institutions. Patent-based indicators provide an insight in the process of technological progress. In addition, they can be used to gain insight in the degree of innovation within an organization, a region, a country... In other words, patents are a unique and very reliable source of data for those who want to measure and monitor technological progress (see also Flemish Indicator book^[1]). When reading and interpreting patent-based statistics, it should be noted that not all inventions are patented, or even more so, that not all innovations rely on patented inventions.

- › INDICATOR 7: Number of EPO and PCT-patents applied for and number of granted USPTO patents with Flemish inventor and/or applicant per million inhabitants

- › INDICATOR 7a: Number of EPO and PCT-patents applied for and number of granted USPTO patents with Flemish inventor and/or applicant per million inhabitants breakdown per sector

3 . Our universities attract high-level international researchers

An excellent and high-performing research system will also contribute to attracting high-level international researchers. In turn, the presence of top international talent at our institutions can further enhance its excellence and attractiveness.

The proportion of international doctoral and postdoc students at Flemish universities has already increased strongly, which mainly reflects the international openness of the Flemish research system. However, this strong internationalization does not seem to extend to the ZAP-staff (academic staff - lecturer, senior lecturer, (full) professor) of the universities, which may mean that Flemish universities/Flanders are (not) yet sufficiently attractive for excellent foreign talent and that there may be bottlenecks that need to be eliminated. After all, attractiveness also has to do with job conditions such as salary, language requirements, quality of life, accessibility, simplicity of administration, open recruitment, ... These bottlenecks and proposals for remediation were already cited in the VARIO-advisory report attracting and retaining top international talent^[2].

- › INDICATOR 8: Share of foreigners in the ZAP-staff (academic staff) of Flemish universities
- › INDICATOR 9: Share of foreigners newly appointed within the ZAP-staff of Flemish universities

^[1] Vlaams Indicatorenboek (2019); <https://www.vlaamsindicatorenboek.be/4.3/de-vlaamse-technologiepositie-analyse-aan-de-hand-van-octrooien>

^[2] VARIO-advisory report 1 'Attracting and Retaining Top International Talent' (2017); <https://www.vario.be/nl/publicaties/advies-1-internationaal-toptalent-aantrekken-verankeren>

BUILDING BLOCK 4: Knowledge, innovation and production capabilities of companies

The Flemish economy has a solid, strongly export-oriented industrial base, with a lot of SMEs situated between one-man businesses and large enterprises, and a very diverse innovation level. It is important that all of these enterprises can survive in a rapidly evolving context. The race to knowledge and innovation economies is being conducted on a global scale (Atkinson and Ezell, 2012)^[1]

1 . Encourage ambitious entrepreneurship and high growth companies

"Entrepreneurship plays an important role in applying this knowledge, and in creating new value in general. To create value, individuals must not only perceive opportunities, but also realize them. This goes beyond individuals merely wanting to be their own boss. To realize opportunities for substantial change in society, ambitious entrepreneurs are needed." (VRWI, 2012)^[2] In the VARIO-Advisory Report "To the Top group of Knowledge- and Innovation-Driven Regions" (March 2020), ambitious entrepreneurship was previously identified as a weakness for Flanders.

High-growth enterprises and ambitious entrepreneurship are an important policy theme (VARIO-Advisory Report 4 Innovative High Growth Enterprises with impact, 2018)^[3] Most jobs are created by a limited number of high-growth enterprises, while employment remains stable at the vast majority of companies. High-growth enterprises are also crucial to a vibrant and dynamic economy; they tend to be young and not necessarily small, are not more common in high-tech sectors.... A publication of JRC^[4] says the following about high-growth enterprises: *"The economic importance of high growth enterprises (HGEs) lies in their impact on job creation, industrial renewal and the leverage effect they can have on sectoral productivity or regional competitiveness."* Research has shown that growth-oriented entrepreneurship has stronger effects on economic growth than other types of entrepreneurship.

> INDICATOR 10: Share of young enterprises with high growth ambitions

2 . Ensure an increase in the number of innovative enterprises

Given the increasing importance of innovation for the competitiveness of Flemish enterprises, stimulating innovation in Flemish companies is a major concern. To make and keep Flanders a dynamic and innovative top region, it is necessary that the conversion of knowledge into products and services runs smoothly and that the innovation power of Flemish enterprises is sufficiently strong. An important objective is therefore to achieve a higher innovative strength of the Flemish economy.

If Flanders were to succeed in this, the total number of innovative enterprises would have to increase. After all, the number of innovative enterprises is a measure for the transfer and application (commercialization) of knowledge in/by companies.

> INDICATOR 11: Share of innovating companies

3 . Involve SMEs into the innovation pool

2. INVOLVE SMEs INTO THE INNOVATION POOL

The Flemish entrepreneurial landscape largely consists of SMEs. A bottleneck in Flanders, cited in the Soete II-report^[5] is the low absorption capacity of Flemish companies, especially SMEs. Absorption capacity is the ability of a company to convert external information that is new to the company into (innovative) products, processes and services. In order to make Flanders a top knowledge and innovation region, it is therefore very important to also involve SMEs in the innovation pool.

> INDICATOR 12: Share of in-house innovative SMEs

^[1] Robert D. Atkinson, Stephen J. Ezell 'Innovation Economics: The Race for Global Advantage' *Yale University Press* (2012)

^[2] VRWI-studiereeks 23 'Ambitious Entrepreneurship: A review of the state of the art' (2012)

^[3] VARIO-advisory report 4 'Innovative High-growth Firms with impact' (2018); <https://www.vario.be/nl/publicaties/advies-4-innovatieve-hoge-groeibedrijven-met-impact>

^[4] High growth enterprises, demographics, finance & policy measures, JRC, (2020)

^[5] 'Soete II'-report: Expert group for the screening of the Flemish innovation instruments (April 2012)

BUILDING BLOCK 5: Linkages between science and innovation actors

The innovation ecosystem is a complex system in which international, collaborative, open innovation models and knowledge markets play an important role (GII, 2012)¹¹. The linear model of knowledge transfer must evolve into a model of continuous interaction and linkages between the actors in order to together create added value.

1 . Knowledge transfer through R&D-collaboration and contract research

Through contract research and scientific services, there is an increasing interaction between knowledge institutions and companies. To map such collaboration, one can look at the share of R&D expenditures performed by institutions of higher education and the share of R&D expenditures by public research centres (imec, VIB, Flanders Make, VITO, ILVO...) financed by private actors. Industry-funded R&D is expected to primarily address the more short-term research needs of industry.

› INDICATOR 13: Share of HERD privately financed

› INDICATOR 14: Share of GOVERD privately financed

2 . Encourage collaboration among different S&I-actors

Increased entrepreneurship and collaboration are the key elements for a better throughput of science into potential commercial or non-for-profit applications. Successful entrepreneurship is increasingly dependent on a company's capacity for external collaboration. Networks should create these conditions to encourage innovation and valorisation. Due to the knowledge explosion and the increasing complexity of innovation processes, individual players do not always have the necessary competencies/knowledge in-house (Soete report III).

› INDICATOR 15: Share of cooperating innovation companies

› INDICATOR 15a: Share of cooperating innovation companies, per type of partner

¹¹ https://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2012.pdf

BUILDING BLOCK 6: An open and international Flanders

"In order to safeguard its position as a knowledge region, Flanders must profile itself internationally. Problems and social challenges, but also solutions, ideas and knowledge, know no boundaries. Especially given the limited scale of Flanders, expertise is often not locally available. In addition, international cooperation and mobility is a lever for excellence. At the same time, economic value chains can no longer be fulfilled at the local or regional level." (VARIO Memorandum 2019-2024).

1 . Encourage international cooperation of companies

Cooperation is one of the most important levers to accelerate the valorisation process and to create (social and economic) value. In addition to cooperation with local partners, cooperation with international partners is also very important. The necessary competences and knowledge are not always available in our own (small) region, so international cooperation is necessary.

- › INDICATOR 16: Share of innovative companies cooperating internationally, per region

2 . Encourage and facilitate participation in European projects

"If Flanders is to be of significance on the international research scene, this implies maximum representation of research groups and companies in international and European research programs" (VRWI-advisory report 197).

Notwithstanding the fact that the 'return' for Flanders from European funding programs (such as Horizon 2020 and its successor Horizon Europe) is currently positive, the threshold to European funding often appears to be too high for knowledge institutions, but especially for companies and certainly SMEs. Flanders can thus set its ambitions high (VARIO-memorandum 2019-2024).

- › INDICATOR 17a: EU Framework Programme participation grant in function of GDP
- › INDICATOR 17b: EU Framework Programme participation grant in function of number of inhabitants
- › INDICATOR 17c: EU Framework Programme participation grant breakdown by type of actor

3 . Encourage international mobility of researchers to leverage excellence and cooperation

If we succeed in further developing, strengthening and growing our - already excellent and performing - research system, this will also become visible in our international presence. The importance of participation to and cooperation in European projects and infrastructure has already been mentioned.

International mobility is also very important. The Marie Skłodowska-Curie Actions provide excellent and innovative research training and attractive career and knowledge exchange opportunities through cross-border and cross-sector mobility of researchers, this to best prepare them for current and future social challenges.

The Marie Skłodowska-Curie programme includes several actions (innovative training networks, individual fellowships, research and innovation staff exchange and COFUND^[1]). We focus on the individual scholarships – individual fellowship (IF) that offer the option to work abroad. The other actions are more focused on building networks.

For mobility, an inward and outward^[2] perspective can be taken. We look at the proportion of participants who choose Flemish institutions as a host institution – the inward mobility. This indicator therefore also provides insight into the international 'attractiveness' of our Flemish knowledge institutions.

› INDICATOR 18: Share of participants to the Marie Skłodowska-Curie actions - individual fellows

4 . Attract international top talent and retain them

In its first VARIO advisory report 'Attracting and retaining top international talent' (2018), VARIO pointed out that investing in talent is crucial for the competitiveness and innovation capacity of countries, especially knowledge regions. In addition to developing our own local talent, attracting and retaining international top talent is also becoming increasingly important, regardless of the status of the labour market. The indicator must therefore be a measure of Flanders' success in attracting and retaining foreign talent.

A first step can already be taken by attracting international students. VARIO indicates that we have no insight in the percentage of international top students (including PhD students and postdocs) that continue to live and work (temporarily) in Flanders after their studies (the so-called stay rate) and points out the need for systematic registration and monitoring. It is crucial to gain a better understanding of this stay rate and to move towards better monitoring.

› To be developed INDICATOR 19 Stay rate – Share of international higher education students that stay after graduation

› To be developed INDICATOR 19a: Stay rate – Share of international higher education students that stay 1 year after graduation

› To be developed INDICATOR 19b: Stay rate – Share of international higher education students that stay 4 years after graduation

No robust information is available about the share of foreigners employed in companies, and certainly not specifically in an R&D function. Many international companies also employ international researchers. However, this is often in a part-time position, whereby they work partly in a Flemish branch and partly in a foreign branch. However, the delineation of functions and activities appears to be much more difficult here than in the academic world.

> To be developed INDICATOR 20: Share of international R&D-personnel in companies

^[1] https://ec.europa.eu/research/mariecurieactions/msca-actions_en

^[2] In addition, it would also be very interesting to gain more insight into the Flemish participants in the individual fellowships who go to work at foreign institutions. However, based on the information available in eCORDA at the EWI department, it is not possible to select the country of origin (and therefore also not the region of Flanders). From the reports of the EC it appears that 'Belgian fellows' can be selected, but there is no clarity on the selection of 'Flemish fellows'

BUILDING BLOCK 7: A favourable environmental framework for science and innovation

In addition to the availability of sufficient resources and talent, a favourable environmental framework is also crucial for supporting R&D&I, both for the foundations of science and knowledge, for the skills of companies and for an open and international Flanders. However, a favourable environmental framework is a very broad concept and cannot always be assigned one-to-one to science and innovation. It mainly includes broader economic, legislative,... elements such as encouraging legislation, administrative simplification, access to infrastructure,... In view of this, in-depth study work remains to be done to identify and develop appropriate and robust indicators for this. Moreover, the environmental factors described here are not exhaustive. Therefore, this building block is kept rather descriptive and no specific indicators are selected.

7.2.4 VARIO recommendations

For the correct use and interpretation of the selected indicators, VARIO also presents the following recommendations:

1. Use this indicator set as a monitoring tool;
2. Take into account limitations of indicators;
3. Put transparency and independence ahead;
4. Supplement this indicator set with impact analyses;
5. Develop monitoring tools further;
6. This indicator set is not absolute;
7. This indicator set should be embedded in a larger system

Between the start of this advisory process (January 2020) and the moment it was completed (July 2020), the world has changed a lot. The Coronavirus has a broad worldwide impact, primarily health-wise, but also economically, culturally and socially. An impact that will be felt for a long time. However, the crisis has no impact on the relevance and validity of the present set of indicators themselves. The indicators are sufficiently robust and are linked to objectives that will continue to be important in the future - post-corona - or could become even more important.