# BUSINESS R&D
## IN WESTERN SWEDEN
2020

**33%**
of Sweden's business R&D expenditure

**SEK 41 BN**
business R&D expenditure

**4.5%**
Business R&D as a share of GRP

Sweden's most concentrated region for innovation with **35 testbeds**

BUSINESS REGION GÖTEBORG

## A region with world-class R&D

Sweden is a country that boasts considerable capacity for conducting research and development (R&D). Year after year, Sweden finishes near the top in surveys looking at how much money countries invest in research and development in relation to their GDP. In 2019, Sweden's total R&D as a share of GDP stood at 3.4 percent, which corresponds to approximately SEK 171 billion. In terms of business R&D expenditure alone, the share of GDP was just over 2.4 percent (approximately SEK 123 billion). In international measurements conducted by the OECD, among others, this means that Sweden has the world's third largest R&D budget in relation to its GDP.[1] This is very impressive for a small, open economy like Sweden. What might Sweden's R&D capacity entail?

The empirical stream of innovation studies often analyses the relationship between R&D and innovation. Broadly speaking, the conclusions show that the more R&D companies conduct, the greater the likelihood of innovations being created and demanded on global markets, and of the companies' productivity increasing. This in turn generates increased value and frees up resources, which can be reallocated to new jobs and technologies. The apple is not falling far from the tree in this respect, as Sweden's innovation potential also appears to be exceptional in several international surveys by bodies such as the European Commission, WIPO and the OECD.[2]

So where is Sweden's R&D conducted in companies and where are the country's innovations and market-leading competitive products, services and processes created?

In 2019, Västra Götaland's share of the country's population and companies stood at approximately 17 percent. When it comes to the county's share of other indicators, such as employment and total salaries, these also stand at around 17 percent. However, some indicators for Västra Götaland show completely different shares of the nation's total. These include the county's share of Sweden's exports and corporate R&D expenditure. In 2019, Västra Götaland accounted for just over a fifth of the country's total export value. When it comes to Sweden's combined R&D expenditure within companies in 2019, Västra Götaland's companies accounted for a massive 33.4 percent.

Business R&D expenditure, as a proportion of the country, is almost twice as large in Västra Götaland compared to the county's other regional macro-indicators, and this confirms the view of the strength of the county's companies in the development of world-leading innovations that are exported on a global market. The companies' innovations in the county are consequently making a major contribution to Sweden's economic growth.

How much do companies in Västra Götaland invest in research and development at their own initiative? In this report we are presenting business R&D expenditure in Västra Götaland during the period 1997-2019. We start with a brief review of the results from empirical studies. Section two illustrates how the region is doing internationally compared to other European regions. The third section analyses corporate R&D expenditure in Sweden and the metropolitan counties, including R&D in relation to GDP/GRP, employees in companies as well as the companies' ownership structure. The fourth section asks what is needed to further increase the R&D expenditure in businesses. Here we present both examples of calculations as well as measures that can be implemented and are already being implemented in the Gothenburg region aimed at further strengthening R&D capacity. Finally, we present our conclusions and recommendations.

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[1] OECD (2020), 'OECD Main Science and Technology Indicators', OECD Directorate for Science, Technology and Innovation, August 2020, Paris, France.
[2] Innovation potential refers to the ability to apply for patents and to create new products, new services and new processes linked to the production of goods and services. In this context, WIPO refers to the World Intellectual Property Organization.

# Sustainable growth

TECHNOLOGICAL ABSORBATION

A mobile labour market, where businesses, seats of learning & the public sector are interacting with each other

Through R&D, a skills platform is giving rise to future ideas, innovations & companies

Skills platform

Ideas, innovations & businesses

Increased employment is resulting in higher GRP per inhabitant, as well as reduced environmental damage

FUNCTIONING INFRASTRUCTURE

- Legal systems
- Water, electricity & ICT
- Accommodation & offices
- Global accessibility
- Meeting places, clusters & test environments
- Efficient transportation (goods & passengers)
- Social functions (health care, school & childcare)

Strength for future innovations regionally, nationally & globally

Increased value for the region's inhabitants

Capital input & investment

Increased productivity

New goods, services & processes

ENVIRONMENTALLY EFFICIENT PROCESSES

PRODUCTION EFFICIENCY

Freeing up financial resources that can be reallocated to new work & technologies, with a focus on environmentally smart processes

Knowledge, development & management of sustainable production are delivering greater production efficiency and

Contents of the report

# 1. Theories on R&D in firms' production

The empirical research provides different ways of analysing the role of knowledge in companies and its impact on regional growth. The starting point for this report is based on the theory of knowledge that is embodied in the companies' production function (drawn from e.g. Schumpeter 1934 and 1942, Arrow 1962, Chambers 1988, Romer 1990, Grossman and Helpman 1991 and Hamermesh 1993). The theory relates to the way increased human capital (known as R&D work) in the production process results in increased productivity among the workforce (Lucas 1988), but also to how an increase in R&D capital (through R&D investments) in production increases the companies' ability to renew themselves (Romer 1990). In this respect, knowledge is embodied in the theory in various forms, such as:

1. in human capital in the form of skills acquired through learning, practice and meetings, by reading and understanding documents and books, through experience or training (Andersson and Beckmann 2009);
2. in goods and R&D capital in the form of technical solutions (e.g. hardware and software) for specific machines or for certain production procedures (Romer 1990, Johansson and Lööf 2014);

or as knowledge that has been outsourced:

3. in licensing agreements where the production of goods, services, initiatives and processes is outsourced to a particular subcontractor possessing the desired knowledge (Cassiman and Veugelers 2000).

The first and second forms of knowledge embodied in the theory can be referred to as distinct channels that disseminate knowledge. Knowledge embodied in people can be transferred through the exchange of ideas when people interact. For example, through meetings with input providers of technical solutions or other knowledge-intensive business services, or through market transactions representing intentional transfer of knowledge (Johansson 2005). The exchange of ideas that takes place when people interact can be related to the theory of human capital (Lucas 1988). In this context, individuals have knowledge traits from which they cannot be separated. Positive externalities arise when the human capital can consequently be disseminated, bearing in mind that individuals are mobile within a location or company, or are mobile between locations or between companies. Other productivity gains from human capital include: improved ability to coordinate activities within the company (Gereffi et al. 2005), increased capacity within management to handle information (Backman 2013), better ability to absorb external knowledge (Cohen and Levinthal 1990).

Knowledge that is embodied in machinery and R&D investments can produce a form of unintentional dissemination of knowledge. This unintentional dissemination of knowledge may occur when equipment and other goods are exchanged through the dissemination of technical know-how (Karlsson and Gråsjö 2014). In endogenous growth models initiated by Romer (1986, 1990, 1993), R&D investments are seen to lead to more new ideas that give rise more new goods, services and processes. The general message from Romer's growth models is that new goods, services and processes are more likely to be developed in companies (or regions) with a greater knowledge of R&D compared to average companies (or regions).

The third form of knowledge usually follows on from a deliberate corporate strategy, for example through outsourcing. There are several underlying reasons for establishing a licensing agreement through outsourcing. One motivation that often constitutes grounds for outsourcing is minimising the cost of certain processes related to production. For example, this might relate to routine assembly, economies of scale reasons or proximity to new markets and customers (van Winden et al. 2011). However, activities related to research, science and innovation could also be strong motivations behind a company's decision to outsource (Veugelers 2010).

Another way of investigating unintentional dissemination of knowledge is through a knowledge production function introduced by Griliches (1979). The starting point within this theory is to analyse how R&D transfers and disseminates knowledge to innovative activities. In this context, knowledge is embodied:

4. within R&D expenditure (e.g. in terms of total effect of R&D), or per inhabitant, or per employee, or as private or public R&D, or as a share of GDP or GRP, in the form of innovative activities related to patents and publication citations or technology licences (Karlsson et al. 2013).

The fourth form of embodied knowledge can be seen as a distinct form of combined knowledge creation and knowledge dissemination.

## 1.1 The impact of R&D in empirical studies

Research and development (R&D) expenditure in the corporate sector, both in terms of R&D work and investments in technology, is seen in many empirical studies as an important driver of increased innovation. Here, the companies' rewards are usually reflected in the form of increased productivity, higher revenues and increased export capacity.

For example, the impact of R&D spending and knowledge spillover on innovations and productivity is being investigated in relation to a selection of more than 9,000 UK companies. The study finds strong evidence that R&D spending is an extremely important element for businesses, both in terms of increased innovation and greater productivity. However, the impact on the companies' productivity from knowledge spillover is greater than the impact on productivity from R&D spending.[3]

Another study looks into the relationship between R&D expenditure (broken down by sector) and innovation in EU countries. The empirical analysis finds clear evidence of a positive relationship between R&D expenditure and innovation, regardless of whether the R&D expenditure originates from companies, the public sector or academia. However, corporate R&D expenditure has the strongest positive impact on innovation capacity in EU countries.[4] Similarly, an empirical time series analysis applied to a large selection of Greek companies finds strong correlations between R&D expenditure and innovative activity in companies, the latter measured in terms of corporate patent applications. The results of the study show clear long-term correlations. For example, the correlation between corporate R&D expenditure and innovative activity in the companies is positive and significant. Total and public R&D expenditure demonstrates a similar correlation in the study.[5]

The relationship between external sources of knowledge (i.e. R&D investments made within the corporate value chain and outside the corporate value chain) and innovation capacity is analysed in a selection of more than 3,200 SMEs in South Korea. There is clear evidence of a positive correlation between R&D investments within and outside the value chain and innovation capacity. For example, the study finds that R&D investments made outside the corporate value chain increase the tendency for the companies to generate a larger number of radical innovations. In terms of R&D investments made within the corporate value chain, this has a positive impact and the companies' capacity to achieve incremental innovations increases.[6]

One study carried out by Medda (2018) analyses R&D intensity and external sources of R&D in relation to innovation, the latter defined according to three categories where manufacturing companies introduce: (i) product innovations, (ii) process innovations and (iii) product and process innovations together. The study focuses on the manufacturing companies' own R&D intensity, but also on R&D expenditure that comes from external sources, where demarcations regarding the external R&D source are made at sector level, such as academia, research institutes and other companies. A large selection of manufacturing companies from five European countries forms the basis for the study, and the results broadly show that the R&D intensity of the manufacturing companies has a positive correlation with innovation capacity, by means of the companies introducing more product innovations, process innovations and both types of innovation together. When the external R&D source is broken down by sector, R&D originating from academia can be seen to have a positive impact on product innovation, although the study finds no significant impact on process innovation. The opposite effect can be seen for external R&D sources coming from other companies, i.e. they have a positive impact on process innovation, but no significant impact on product innovation.[7]

Crowley and McCann (2018) examine the links between innovation and productivity in companies from the majority of European countries. For example, the researchers are investigating whether there are differences between countries that are in a transitional phase, from being efficiency-driven to being more innovation-driven, compared to countries that are already in an innovation-driven stage. The study utilises microdata from innovative companies and non-innovative companies. Some results support the traditional pattern that has been confirmed in previous innovation studies. Namely, that innovation activities and investments in

[3] Audretsch, D. B. and M. Belitski (2020), 'The Role of R&D and Knowledge Spillovers in Innovation and Productivity', *European Economic Review*, vol.123 (April).
[4] Pegkas, P., Staikouras, C. and C. Tsamadias (2019), 'Does Research and Development Expenditure Impact Innovation? Evidence from the European Union Countries', *Journal of Policy Modeling*, vol.41, no. 5, (September-October), pages 1005-1025.
[5] Voutsinas, I., Tsamadias, C., Carayannis, E. and C. Staikouras (2018), 'Does Research and Development Expenditure Impact Innovation? Theory, Policy and Practice Insights from the Greek Experience', *The Journal of Technology Transfer*, vol.43, pages 159–171.
[6] KonShi, K. (2018), 'The Roles of Knowledge Sources in and out of the Value Chain on Radical and Incremental Innovation: Moderating Effects of Knowledge Sources on the R&D Investment-Innovation Relationship', *Journal of Korea Technology Innovation Society*, vol.21, no.1, pages 454-490.
[7] Medda, G. (2018), 'External R&D, 'Product and Process Innovation in European Manufacturing Companies', *The Journal of Technology Transfer*, vol.45, (July), pages 339–369.

physical and human capital are important cornerstones of product and process innovation in companies, regardless of the stage the countries find themselves in, i.e. transitional phase or not.[8]

Strategic partnerships and R&D intensity are analysed in greater detail in an empirical study carried out by Bustinza et al. (2019). Above all, the researchers are examining whether there is a correlation between manufacturing companies in industries that are strong in R&D and their implementation of knowledge-intensive services (KIS) from partnerships, and how this affects their innovation potential. 370 major manufacturers worldwide are included in the selection for this study. The results are clear. Strategic partnerships, between industries that are strong in R&D on the one hand and KIS on the other, lead to more successful product innovation in manufacturing companies, driven by a more service-oriented content.[9]

An additional stream of literature within innovation studies relates to the effects of R&D on the companies' propensity to export and their material investments.[10] For example, Carboni and Medda (2018) analyse the mechanisms behind R&D's impact on companies' propensity to export and their material investments, by using a wide range of manufacturing companies from seven European countries. The results from the study show that the correlation between R&D and the propensity to export is positive and significant. In other words, the greater the R&D investment in manufacturing companies, the higher their propensity to export. Similarly, the study finds a positive and significant correlation between R&D and material investments.[11] Falk and Lemos (2019) also find clear links between R&D, productivity and export behaviour in SMEs in Austria. The empirical results show that both R&D and productivity have a positive and significant correlation with the export behaviour of SMEs. In other words, the higher the levels of R&D and productivity, the more SMEs conduct export activities.[12]

The study 'Västsverige: ekonomisk utveckling och ekonomisk geografi – ny teori och empiri' ('Western Sweden: economic development and economic geography – new theory and empiricism') states that the wage levels in Gothenburg's labour market region for employees with extensive training in STEM sectors[13] are not far behind the corresponding wage levels in Stockholm-Solna. A comparison is also made with Malmö-Lund, whose wage level for STEM appears to be significantly lower than in Stockholm-Solna. The authors interpret this as meaning that the Gothenburg labour market region has productive operations whose high value added requires a workforce with more extensive STEM training. Like the Gothenburg labour market region, Trollhättan-Vänersborg also exhibits higher wage levels within STEM, which is linked to its core of high-tech businesses (including companies such as GKN). The results suggest that Gothenburg's labour market region is an important hub for knowledge-intensive labour and knowledge-intensive operations. This picture is confirmed by data relating to investments in R&D, where Västra Götaland appears to be an important region in Sweden as regards R&D in both companies and academia.[14]

Most innovation studies find a clear, significant correlation between R&D and innovation. In this respect, the innovations take the form of new products and processes, new services or patent applications, etc. This correlation is usually positive and long-term in nature. In other words, if the companies' investments in R&D increase, their long-term reward is greater innovation potential through the introduction of more patent applications or more new products/services/processes on the market. There are also a number of empirical studies demonstrating that R&D has a positive impact on companies' propensity to export, their productivity and their material investments. An R&D-intensive business sector can thereby pave the way for the innovative and sustainable solutions of the future on the global market. These sustainable innovations from companies are more important now than ever when it comes to reducing our environmental footprint.

[8] Crowley, F. and P. McCann (2018), 'Firm Innovation and Productivity in Europe: Evidence from Innovation-Driven and Transition-Driven Economies', Applied Economics, vol.50, no.11.
[9] Bustinza, O. F., Gomes, E., Vendrell-Herrero, F. and T. Baines (2019), 'Product–Service Innovation and Performance: The Role of Collaborative Partnerships and R&D Intensity', vol.49, no.1 (Special Issue), *Industry and International Aspects on R&D Management*, (January), pages 33-45.
[10] In this regard, material investments refer to investments in: real estate, other companies, asset infrastructure, goods linked to technology.
[11] Carboni, O. A. and G. Medda (2018), 'R&D, Export and Investment Decision: Evidence from European Firms', *Applied Economics*, vol.50, no.2, pages 187-201.
[12] Falk, M. and F. F. Lemos (2019), 'Complementarity of R&D and Productivity in SME Export Behavior', Journal of Business Research, vol.96, (March), pages 157-168.
[13] Science, technology, engineering, medicine (STEM).
[14] Andersson, M. and Johan P. Larsson (2019), 'Västsverige: ekonomisk utveckling och ekonomisk geografi – ny teori och empiri', *VGR Analys 2019:14*, Region Västra Götaland and the Swedish Agency for Economic and Regional Growth, Gothenburg, Sweden.

# 2. R&D in an international comparison

Every two years (and sometimes annually), the European Commission conducts a focused survey of regional innovation potential within the EU. The Regional Innovation Scoreboard produces comparisons and assessments of the performance of regional innovation systems in the EU. The innovation potential is measured on the basis of 27 indicators, which can generally be grouped into four major foundations: basic regional conditions, investments, innovation activities as well as external and internal impact on companies (i.e. on their sales and employment). The regions' innovation potential is assessed according to performance groups ranging from 'modest' to 'leader', where each performance group has three status levels. For example, the 'modest' performance group may deteriorate to 'modest -' or improve to 'modest +'.

The 'innovation leader' performance group includes a total of 38 regions with innovation potential that is more than 20 percent above the EU average (see Table 1). Regions with a 'strong' innovation potential lie at between 90% and 120% of the EU average and include 73 regions in the EU. The 'moderate' innovation potential performance group includes the largest number of regions, and here the capacity lies at between 50% and 90% of the EU average. Regions with 'modest' innovation potential are the fewest in number. In the Regional Innovation Scoreboard 2019, a total of 29 regions within the EU found themselves in this innovation potential performance group, which means that their results are below 50% of the EU average.

**TABLE 1** INNOVATION POTENTIAL PERFORMANCE GROUP IN REGIONAL INNOVATION SCOREBOARD 2019

| Modest +<br>Modest<br>Modest - | Moderate +<br>Moderate<br>Moderate - | Strong +<br>Strong<br>Strong - | Leader +<br>Leader<br>Leader - |
|---|---|---|---|
| EU-regions: 29 | EU-regions: 98 | EU-regions: 73 | EU-regions: 38 |
| Top 5 | Top 5 | Top 5 | Top 5 |
| 1. Észak-Alföld (Hungary) | 1. Central Norrland (Sweden) | 1. West Austria (Austria) | 1. Zürich (Switzerland) |
| 2. Sumadija (Serbia) | 2. Emilia-Romagnia (Italy) | 2. Vlaams Gevest (Belgium) | 2. Ticino (Switzerland) |
| 3. Mazowiecki (Poland) | 3. Bratislava (Slovakia) | 3. South West (United Kingdom) | 3. Helsinki (Finland) |
| 4. Lubelskie (Poland) | 4. Koblenz (Germany) | 4. Gelderland (Netherlands) | 4. Stockholm (Sweden) |
| 5. Swietokrzyskie (Poland) | 5. Niederbayern (Germany) | 5. Limburg (Netherlands) | 5. Copenhagen (Denmark) |
| | | | 12. West Sweden (Sweden) |

Source: Regional Innovation Scoreboard 2019, European Commission

## 2.1 West Sweden – an innovation leader +

It is then reasonable to ask how the region's innovation potential compares to other regions in the EU. In the Regional Innovation Scoreboard 2019, the geographic regions appear to be slightly larger than we are used to in our comparisons at county, labour market region or metropolitan region level. Here, the European Commission uses NUTS 2 units, which for the Gothenburg region means that the geographic region refers to all 55 municipalities that make up Västra Götaland and Halland counties. In Stockholm's case, it refers to the 26 municipalities that make up Stockholm County, which also defines the unit for the Stockholm metropolitan region. This means that Stockholm enjoys better accuracy, which corresponds to developments in the metropolitan region. The situation is reversed in the Gothenburg region, as West Sweden's results are less accurate when it comes to depicting actual developments in the Gothenburg region.

Table 2 shows West Sweden's results from the Regional International Scoreboard between 2007 and 2019. The rankings started with the 2011 annual report, at which time West Sweden was ranked 16th, and since then the region has been at a slightly higher level, but not lower. In the latest survey, from 2019, West Sweden was in 12th position in the EU. Over time, West Sweden's innovation potential has been classed as 'Leader', although in 2019 the region is moving up to the 'Leader +' level. In view of the latest study, the potential exists to further strengthen the position of West Sweden. For example, the region is only authorised in indicators such as 'non-R&D innovation expenditures', 'SMEs innovating in-house', 'innovative SMEs collaborating with others', 'product and/or process innovations', 'market and/or organisational innovations' and 'design applications'. What is remarkable, despite the improvement compared to 2017, is the result for 'innovative SMEs collaborating with others', which is awarded a fail in this measurement. If we look at long-term changes

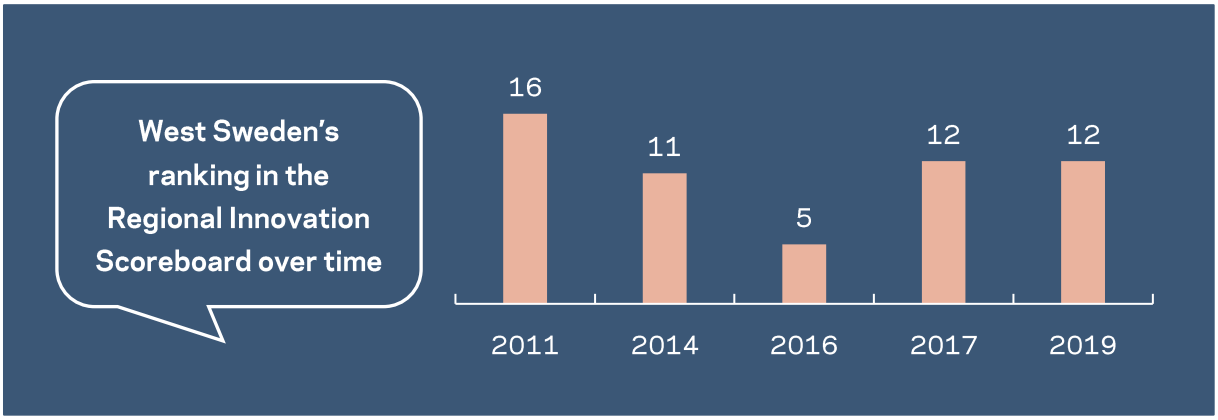
(going back six years), West Sweden's innovation potential has been strongest within the indicator 'sales of new-to-market and new-to-firm innovations' and weakest in respect of the both the indicators measuring the innovation potential among SMEs. In the overall ranking, West Sweden drops 1 position, from 11th to 12th. In the slightly shorter term (going back three years), West Sweden's innovation potential has proven strongest within the indicator 'private and public co-publications', while 'design applications' is weakening most between the surveys in 2017 and 2019. In the overall ranking, West Sweden's position remains unchanged at number 12 in the EU.

**TABLE 2** WEST SWEDEN'S POSITION IN REGIONAL INNOVATION SCOREBOARD 2007-2019

| Indicator | 2007 | 2009 | 2011 | 2014 | 2016 | 2017 | 2019 | Change 3 years (cf. 2017) | Change 6 years (cf. 2014) |
|---|---|---|---|---|---|---|---|---|---|
| Post-secondary education | 0.61 | 0.64 | 0.68 | 0.72 | 0.78 | 0.75 | 0.64 | -0.11 | -0.08 |
| Lifelong learning | .. | .. | .. | .. | .. | 0.90 | 0.93 | 0.03 | .. |
| R&D expenditure – public sector | 0.87 | 0.53 | 0.53 | 0.50 | 0.31 | 0.61 | 0.65 | 0.04 | 0.15 |
| R&D expenditure – private sector | 0.91 | 0.83 | 0.83 | 0.78 | 0.68 | 0.68 | 0.90 | 0.22 | 0.12 |
| Non-R&D innovation expenditure | 0.66 | 0.59 | 0.33 | 0.38 | 0.40 | 0.35 | 0.55 | 0.20 | 0.17 |
| SMEs' 'in-house' innovation | 0.50 | 0.57 | 0.62 | 0.75 | 0.61 | 0.62 | 0.53 | -0.09 | -0.22 |
| Innovative SMEs' cooperation with others | 0.48 | 0.58 | 0.61 | 0.52 | 0.45 | 0.31 | 0.35 | 0.04 | -0.17 |
| Scientific co-written publications | .. | .. | .. | .. | .. | 0.55 | 0.74 | 0.19 | .. |
| Private and public co-written publications | 0.79 | 0.79 | 0.79 | .. | .. | 0.52 | 1.00 | 0.48 | .. |
| Most cited publications | .. | .. | .. | .. | .. | 0,73 | 0,63 | -0,10 | .. |
| EPO patents | 0.73 | 0.72 | 0.70 | 0.50 | 0.60 | 0.52 | 0.67 | 0.15 | 0.17 |
| Product and/or process innovators | 0.51 | 0.58 | 0.57 | 0.57 | 0.63 | 0.39 | 0.52 | 0.13 | -0.05 |
| Market and/or organisational innovators | 0.56 | 0.49 | 0.43 | 0.46 | 0.47 | 0.47 | 0.51 | 0.04 | 0.05 |
| Employment in knowledge-based | 0.75 | 0.71 | 0.70 | 0.75 | 0.65 | 0.70 | 0.70 | 0.00 | -0.05 |
| Exports of high-tech manufacturing goods | NA | NA | NA | .. | 0.67 | 0.65 | .. | .. | .. |
| Sales of innovations, new for the market and new for companies | 0.31 | 0.32 | 0.19 | 0.25 | 0.19 | 0.36 | 0.58 | 0.22 | 0.33 |
| Brand applications | NA | NA | NA | .. | .. | 0.44 | 0.69 | 0.25 | .. |
| Design applications | NA | NA | NA | .. | .. | 0.68 | 0.53 | -0.15 | .. |
| Ranking | NA | NA | 16 | 11 | 5 | 12 | 12 | 0 | -1 |
| Innovation potential | Leader | Leader | Leader | Leader | Leader | Leader | Leader+ | | |

Source: Regional Innovation Scoreboard 2007-2019, European Commission

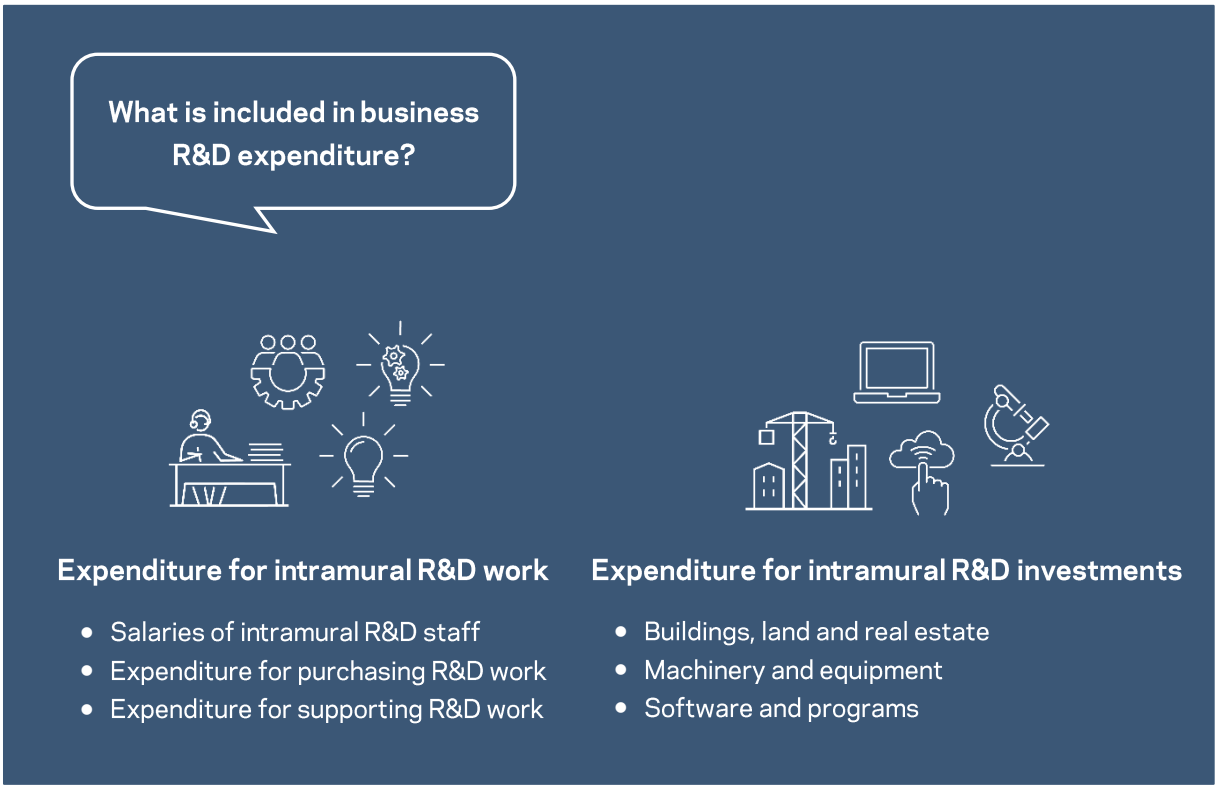
**Notes:** (..) means that the indicator is not reported in the survey for the specific year. SME refers to small and medium-sized enterprises. EPO patents refer to patent registrations with the European Patent Office.



## 3. Businesses R&D expenditure

The question might then be asked as to what is included in the statistics regarding businesses funds that have been earmarked for R&D. The statistics are based on a selection that is adjusted to achieve approximate values per county, and in this case are based on a survey. As a result, the statistics regarding intramural business R&D expenditure do not refer to an entire population. The development of the companies is monitored over time, where new R&D actors are added and old actors that have ceased conducting R&D are removed over the years. The survey is carried out by Statistics Sweden and is published every two years. According to Statistics Sweden, the statistics only include R&D expenditure for R&D activities in Sweden. R&D that is carried out by Swedish and foreign-owned companies abroad is not included in the statistics. The survey selection covers companies with at least 10 employees and relates to the companies' expenditure for R&D that they themselves perform and support. The R&D expenditure consists of two components: expenditure for R&D work and expenditure for R&D investments.

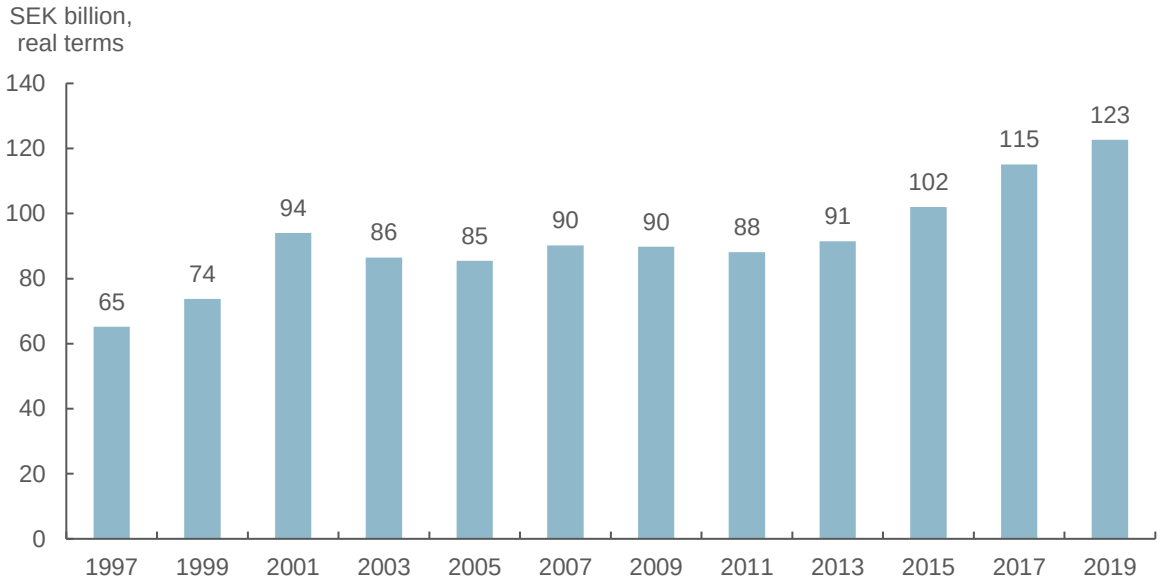
Expenditure for R&D work relates, for example, to 'wages for intramural R&D staff'. R&D work also includes the company's expenditure for purchasing R&D work from other companies, as well as expenditure the company has for supporting R&D work in other organisations. On the other hand, R&D investments consist of expenditure on physical and technological necessities that are required to carry out the R&D work at the company. This includes entries such as 'buildings, land and real estate', 'machinery and equipment', 'software and programs', etc. For example, Geely's establishment of an innovation centre in Gothenburg is included in the statistics under the entry 'buildings, land and equipment' and its employees under the entry 'salary to own R&D staff'.




### 3.1 Business R&D expenditure in Sweden

Sweden's companies invest enormous resources in conducting intramural research and development. In real terms, R&D expenditure has almost doubled since 1997. Figure 1 shows how business R&D expenditure has developed over time in Sweden. In 1997, the companies invested just over SEK 65 billion (calculated at 2019 prices). In 2019, business R&D expenditure stood at approximately SEK 123 billion, which corresponds to an increase in real terms of 88 percent or SEK 57 billion compared to 1997. In particular, it is the period 2015-2019 that reports large R&D investments among the companies in Sweden, although business R&D expenditure was also slightly higher in 2001 than the average for the whole period.

**FIGURE 1** INTRAMURAL BUSINESS R&D EXPENDITURE (SEK BILLION, REAL TERMS) IN SWEDEN, EVERY TWO YEARS FROM 1997




Source: Statistics Sweden

What proportion of intramural business R&D expenditure can be attributed to a specific industry? Is there any sector that stands out in terms of business R&D? Table 3 presents business R&D expenditure for 2019 by breaking down the total of approximately SEK 123 billion by industry.[15]

The largest share of business R&D expenditure relates to the 'automotive industry'. In 2019, the 'automotive industry' accounted for just over a quarter of business R&D expenditure in Sweden, corresponding to approximately SEK 32 billion.

The 'information and communication' sector also represents a significant portion of intramural business R&D expenditure in Sweden, accounting for just under a quarter of the country's total R&D expenditure in companies (equivalent to approximately SEK 30.5 billion). Within 'information and communication', the SNI segments 61-63 in particular account for the majority of business R&D expenditure (approximately 92 percent of total R&D expenditure in 'information and communication'). This segment includes companies in telecommunications, computer programming and computer consultancy, IT and data services, as well as other information services.

In 2019, companies in 'research and development institutions' reported the third-largest expenditure for conducting intramural R&D in Sweden. [16] In total, the industry invested approximately SEK 11.4 billion, which means that the sector accounts for around a tenth of business R&D expenditure in Sweden.

If we look instead at more broadly defined sectors in which companies are included, such as goods manufacturers and service providers, we see that a majority of business R&D expenditure in Sweden is earmarked within goods-producing companies.[17] In 2019, the goods-producing part of the economy accounted for 53 percent (corresponding to just over SEK 64 billion) of business R&D expenditure. The remaining 47 percent, which is invested in the service-providing part of the economy, thereby accounts for just over SEK 58 billion of business R&D expenditure in Sweden.

[15] The term 'industry' refers to the Swedish Standard Industrial Classification (SNI) 2007 at two-digit level.
[16] This includes companies that are active in the following industries: 'biotechnological research and development', 'other scientific and technological research and development' and 'social sciences and humanities research and development'.
[17] Statistics Sweden defines goods-producing companies as companies in SNI segments 01-43, i.e. agriculture, forestry and fisheries, all of manufacturing, the mining industry and construction. Service-providing companies fall under SNI segments 45-99, which include all retail trade along with the transportation sector, business services, public sector companies as well as personal and cultural services.

**TABLE 3** INTRAMURAL BUSINESS R&D EXPENDITURE (SEK BILLION) IN SWEDEN, BY INDUSTRY 2019

| Industry | SNI code | R&D, SEK billion | Share |
|---|---|---|---|
| Agriculture, forestry, fishing and mining and mineral extraction | 01-09 | 0.40 | 0.3% |
| Food, beverages and tobacco | 10-12 | 0.36 | 0.3% |
| Textiles, leather, wood and products made of wood, cork and rattan (excluding furniture), as well as graphic reproduction | 13-16, 18 | 0.25 | 0.2% |
| Pulp, paper and stationery | 17 | 1.51 | 1.2% |
| Coal products, petroleum products and the chemical industry | 19-20 | 2.06 | 1.7% |
| Basic pharmaceutical products and pharmaceutical preparations | 21 | .. | .. |
| Rubber and plastic | 22 | 0.27 | 0.2% |
| Other non-metallic mineral products | 23 | 0.14 | 0.1% |
| Steel and metalworks | 24 | 2.25 | 1.8% |
| Metal products except machinery and equipment | 25 | 1.87 | 1.5% |
| Computers, electronics and optical products | 26 | 2.48 | 2.0% |
| Electrical equipment | 27 | 3.07 | 2.5% |
| Other engineering industry | 28 | 8.99 | 7.3% |
| Automotive industry | 29-30 | 31.88 | 26.0% |
| Furniture industry and other manufacturing | 31-32 | 0.90 | 0.7% |
| Repair and installation of machinery and equipment | 33 | .. | .. |
| Energy, water and waste | 35-39 | 0.74 | 0.6% |
| Construction industry | 41-43 | 0.24 | 0.2% |
| Retail trade as well as hotels and restaurants | 45-47, 55-56 | 7.58 | 6.2% |
| Transportation and storage | 49-53 | 0.06 | 0.0% |
| Information and communication | 58-63 | 30.46 | 24.8% |
| Finance and insurance | 64-66 | 1.94 | 1.6% |
| Real estate, travel services and other support services | 68, 77-81 | 0.58 | 0.5% |
| Legal and financial consultancy firms | 69-70 | 0.43 | 0.3% |
| Architectural offices, technical consultancies, technical testing and analysis | 71 | 4.66 | 3.8% |
| Research and development institutions | 72 | 11.39 | 9.3% |
| Advertising and market research, other business services as well as civil authorities and defence | 73-75, 82, 84-99 | 1.08 | 0.9% |
| Classified due to few observations | 21, 33 | 7.07 | 5.8% |
| Total business R&D expenditure in Sweden | 01-99 | 122.65 | 100% |
| of which goods-producing companies | 01-43 | 64.48 | 53% |
| of which service-providing companies | 45-99 | 58.17 | 47% |

Source: Statistics Sweden

**Note:** (...) denotes that there are insufficient observations in the industry to present a result.

## 3.2 The regional spread of business R&D expenditure in Sweden

When it comes to the distribution of business R&D expenditure per county in Sweden, a clear concentration can be seen around the country's three metropolitan areas. Just over 75 percent of business R&D expenditure in Sweden in 2019 can be attributed to Västra Götaland, Stockholm and Skåne. In 2019, companies' earmarked budgets for conducting intramural R&D in Sweden totalled approximately SEK 123 billion. Of this amount, Västra Götaland accounted for the largest share of the country's total business R&D expenditure, with 33.4 percent. The corresponding share for Stockholm County was approximately 32 percent, while Skåne accounted for around 10 percent. A significant proportion of business R&D expenditure is also located in Östergötland County, whose share of the Sweden's R&D expenditure in companies stands at just over 9 percent (see Figure 2).

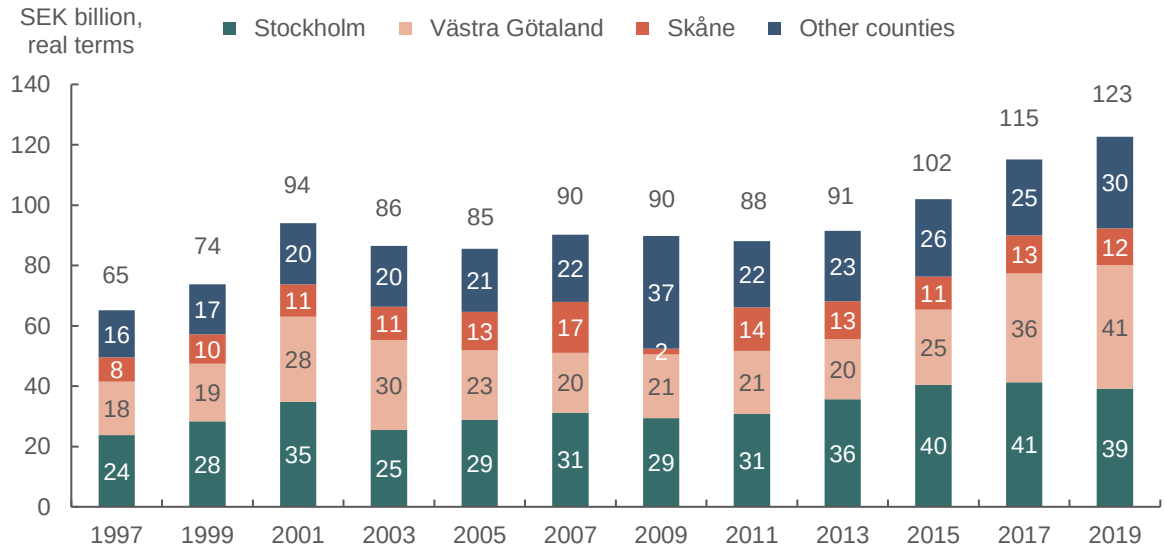
**FIGURE 2** THE COUNTY'S PROPORTION OF SWEDEN, INTRAMURAL BUSINESS R&D EXPENDITURE, 2019


Source: Statistics Sweden

Figure 3 shows how the business R&D expenditure has developed over time in the metropolitan counties as well as in other counties from 1997. Over the entire period, Stockholm County has accounted for the largest share of business R&D expenditure, except in 2003 and 2019, when Västra Götaland reported the largest R&D expenditure. Between 1997 and 2019, real-terms business R&D expenditure in Stockholm has fluctuated between SEK 24-41 billion. Over the entire period, Stockholm's companies invest an average of around SEK 32 billion in R&D. Västra Götaland's companies also account for a large proportion of business R&D in Sweden, with varying R&D investments over the period ranging from SEK 18-41 billion in real terms. On average, over the entire period, the companies in Västra Götaland invest around SEK 25 billion in R&D. The corresponding figure for Skåne and Other counties shows averages of SEK 11 billion and SEK 23 billion respectively, while Sweden as a whole invests an average of SEK 92 billion, over the entire time period.

In 2019, business R&D expenditure stood at SEK 41 billion in Västra Götaland and SEK 39 billion in Stockholm. The two counties' companies thereby accounted for approximately two-thirds of Sweden's total business R&D expenditure in 2019. In Skåne, total business R&D expenditure amounted to approximately SEK 12 billion. When it comes to real-terms changes between 2017 and 2019, Västra Götaland's companies accounted for the largest share of the growth in business R&D expenditure. With an increase in real terms of approximately SEK 5 billion in business R&D expenditure in Västra Götaland between 2017 and 2019, the county accounted for nearly two-thirds of Sweden's increase of approximately SEK 8 billion.

**FIGURE 3** BUSINESS R&D EXPENDITURE (SEK BILLION, REAL TERMS) IN METROPOLITAN COUNTIES, EVERY TWO YEARS FROM 1997




Source: Statistics Sweden

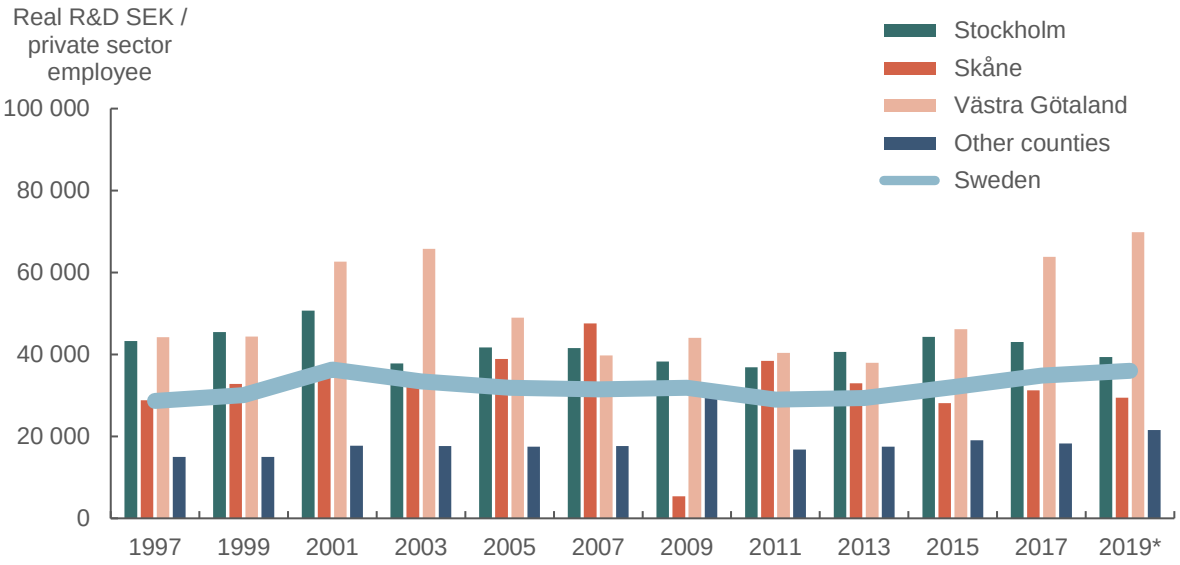
**Note:** The figures above the bars show Sweden's total intramural business R&D expenditure for each reference year.

Stockholm is Sweden's most populous county and the county with the highest density of companies. In theory, its absolute figures and nationwide shares ought to be the highest, as can also be seen from Figure 3 for most of the period 1997-2019 in terms of business R&D expenditure. However, if we instead normalise the comparison between the counties by taking the size of their geographic area into account in the analysis, we can obtain more information about how intensive and productive the companies are in terms of their R&D expenditure.

In Figure 4, the R&D expenditure is normalised by measuring the development per person employed in the private sector. In other words, people employed in operations that are owned by municipalities, regions and the state have been excluded from the denominator, and only those employed in the private sector are included. Västra Götaland and Stockholm both have the highest amounts spent on R&D in real terms per person employed in companies, viewed over the entire period. Over time, however, Västra Götaland's companies are investing slightly more in R&D per employed in the private sector than in Stockholm. The exception to this is 2007, when companies in both Stockholm and Västra Götaland invested less in R&D per person employed compared to companies in Skåne. In 2019, Västra Götaland's companies invested

approximately SEK 70,000 per person employed in the private sector, compared with just over SEK 39,000 in Stockholm. In Skåne and Sweden as a whole, the corresponding figures were just over SEK 29,000 and SEK 36,000 respectively per person employed in the private sector. Västra Götaland's companies report the largest R&D expenditure per person employed in the private sector in an impressive nine out of the 12 two-year periods. This intensity shows that the companies in Västra Götaland have a great ability to conduct research and development at their own initiative.

**FIGURE 4** INTRAMURAL BUSINESS R&D EXPENDITURE PER PRIVATE SECTOR EMPLOYEE (IN SEK, REAL TERMS), EVERY TWO YEARS FROM 1997




Source: Statistics Sweden

* Private sector employment is estimated on the basis of the long-term trend (1993-2018) for metropolitan counties and Sweden.

Västra Götaland's business R&D expenditure represents a significantly larger proportion of Sweden's total compared to the county's other macro-indicators, such as population, employment, total salaries, etc. As regards Sweden, the country appears high up in international surveys of how much money is allocated to R&D as a share of GDP. In 2019, Sweden had the world's third largest R&D budget in relation to GDP, with total R&D accounting for as much as 3.4 percent of Sweden's GDP. Business R&D expenditure accounted for just over 2.4 percent of Sweden's GDP in the same year, which is also considered to be very high in an international perspective.

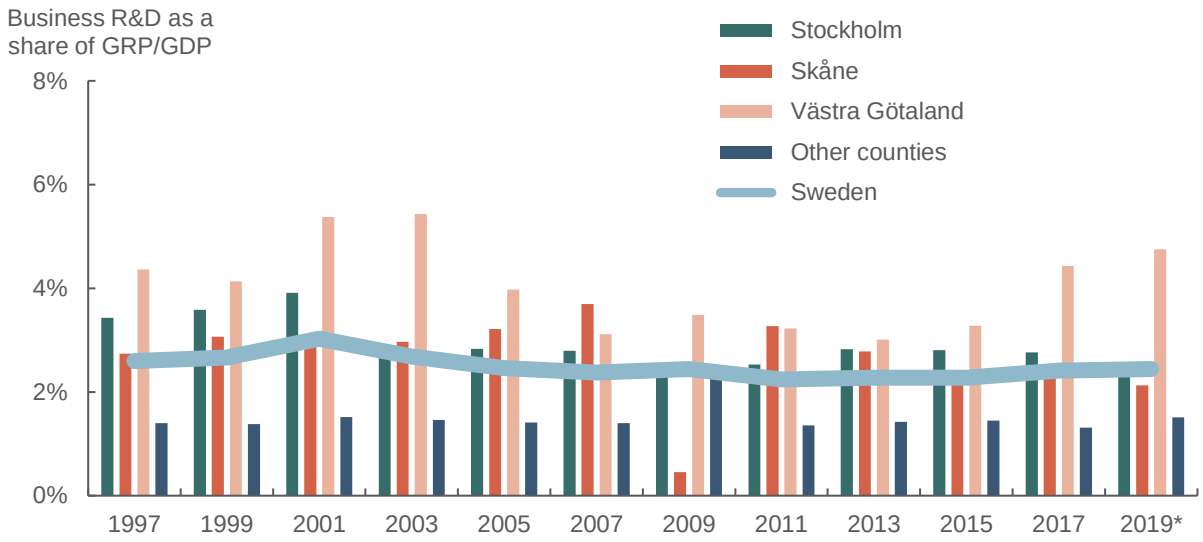
What is the situation at the regional level? Is there a similar earmarking of business R&D expenditure as a proportion of the metropolitan counties' total GRP?

According to Figure 5, the metropolitan counties generally have a higher proportion of business R&D expenditure in relation to GRP than Sweden as a whole. This relates in particular to Västra Götaland and Stockholm. Out of twelve periods over time (every two years between 1997-2019), Västra Götaland's business R&D expenditure as a share of GRP is highest in every year except for 2007 and 2011, when Skåne achieved the highest share.

2017 is one year in which companies have reported exceptionally high R&D expenditure in Västra Götaland. Companies spent approximately SEK 36 billion on R&D in that year, which represents as much as 4.4 percent of the county's total GRP for the same year. Despite this strong performance in 2017, the companies in Västra Götaland are exceeding these R&D investments yet again in 2019. In 2019, Västra Götaland's companies invested approximately SEK 41 billion in R&D, which means that business R&D expenditure as a share of GRP for the latest period stands at 4.8 percent.

An interesting observation is that business R&D as a share of GRP in Västra Götaland is, on average, 1.5 percentage points higher compared to Sweden as a whole over the entire time period. Here, we can see clear evidence of the companies' considerable R&D capacity in Västra Götaland. A significantly higher proportion of the gross regional product is earmarked by companies for conducting R&D at their own initiative.

**FIGURE 5** INTRAMURAL BUSINESS R&D EXPENDITURE AS A SHARE OF GRP IN METROPOLITAN COUNTIES, AND INTRAMURAL BUSINESS R&D EXPENDITURE AS A SHARE OF GDP FOR SWEDEN, EVERY TWO YEARS FROM 1997




Source: Statistics Sweden

* GRP estimated based on long-term trend (1993-2018) for metropolitan counties. The GDP for Sweden is preliminary.

| Total R&D Västra Götaland | R&D private sector | R&D public sector | R&D academia |
|---|---|---|---|
| 48.8 BSEK | 40.9 BSEK | 1.4 BSEK | 6.5 BSEK |
| 100 % of R&D in county | 83.8 % of R&D in county | 2.9 % of R&D in county | 13.3 % of R&D in county |
| 28.5 % of R&D in Sweden | 33.4 % of R&D in Sweden | 18.3 % of R&D in Sweden | 15.5 % of R&D in Sweden |

**The county's total R&D expenditure, by sector 2019**

Source: Statistics Sweden

**How is the ownership form of the companies defined?**

**Foreign-owned**

Companies in which more than half of the shares are held by one or more owners abroad. If the company is part of a group in Sweden, it is counted as foreign if the parent company in Sweden is foreign. If the company is owned in several segments, it is the group parent company that determines the nationality of the company.

**Swedish international**

Refers to companies in Sweden belonging to a Swedish international group.

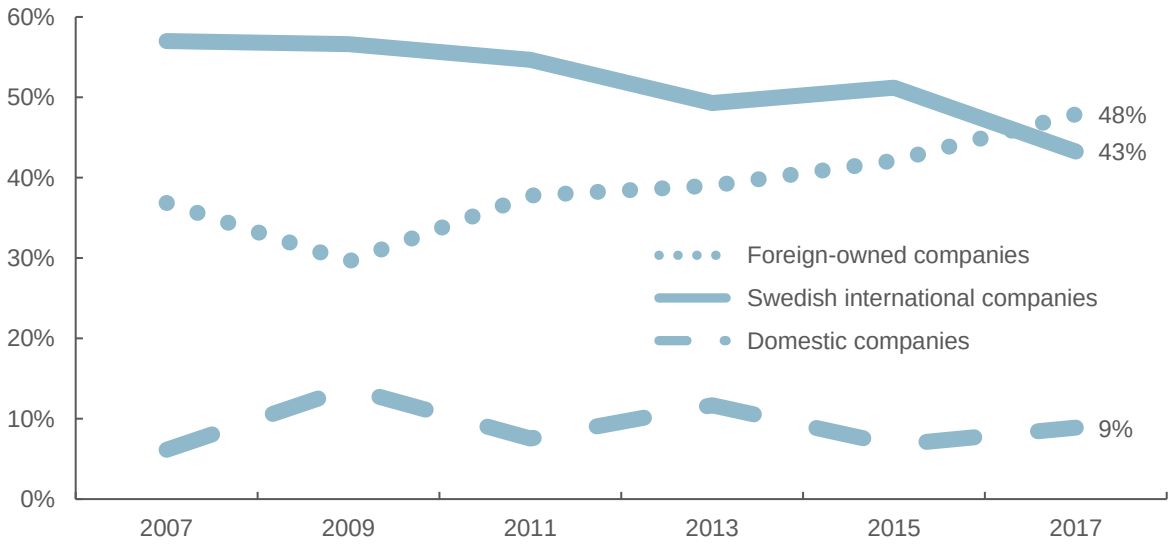
**Domestic**

Swedish-owned companies without subsidiaries abroad.

## 3.3 Business R&D expenditure by ownership form in the metropolitan counties

It is possible to see a clear characteristic among companies that conduct intramural R&D in Sweden. A clear majority of them are either foreign-owned or globally accessible. *Unfortunately, we can only see developments by form of ownership up until 2017, as the 2019 statistics regarding ownership form will not be published until May 2021.* Out of approximately SEK 111 billion in R&D expenditure in Swedish companies in 2017 (refers to 2017 prices), foreign-owned companies accounted for almost half. More than two-fifths of Sweden's R&D expenditure in the private sector is in Swedish international companies. Domestic companies accounted for just under a tenth of the business R&D expenditure (see Figure 6). Developments over time show that foreign-owned companies are investing more and more money in conducting intramural R&D. In recent years, it also appears that foreign-owned companies account for the largest share of business R&D expenditure in Sweden. As a result, we can conclude that the country's foreign-owned companies play a very important role in Sweden's innovative capacity, both now and in the future.

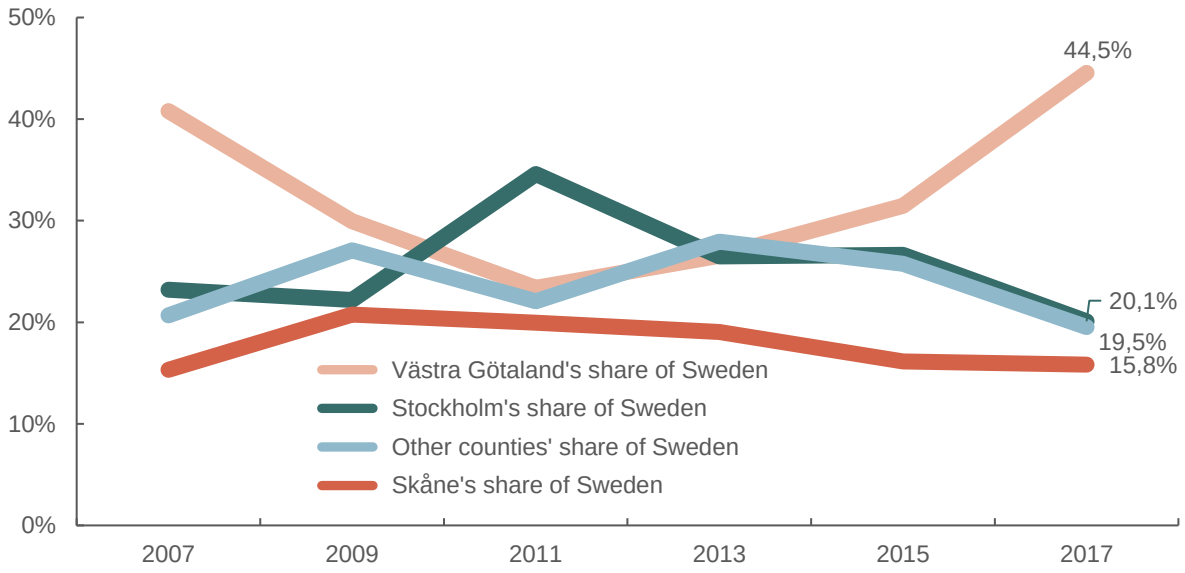
**FIGURE 6** INTRAMURAL R&D EXPENDITURE IN VARIOUS TYPES OF BUSINESS FORM, SHARE OF SWEDEN'S TOTAL EVERY TWO YEARS FROM 2007




Source: Statistics Sweden and Growth Analysis

If we instead break down business R&D data by metropolitan counties and as a share of Sweden's total for the companies' various forms of ownership, we get a regional overview of the extent of the concentration around the country. Figure 7 shows that almost half of Sweden's R&D expenditure in foreign-owned companies in 2017 (equivalent to SEK 53 billion at 2017 prices) is in Västra Götaland. Just over a fifth is in Stockholm County, while around a sixth of R&D expenditure in foreign-owned companies is in Skåne.

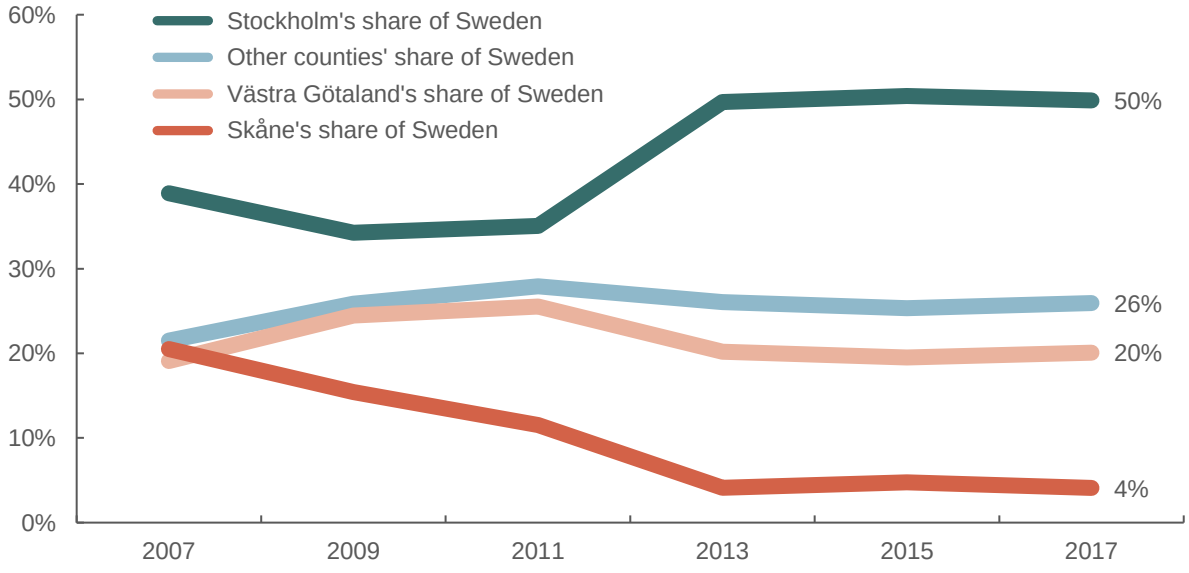
**FIGURE 7** INTRAMURAL R&D EXPENDITURE IN FOREIGN-OWNED COMPANIES, SHARE OF SWEDEN'S TOTAL EVERY TWO YEARS FROM 2007




Source: Statistics Sweden and Growth Analysis

When it comes to R&D expenditure in Swedish international companies (approximately SEK 48 billion at 2017 prices), the country's largest concentration, almost half, is seen in the capital city region. A fifth of the country's business R&D expenditure is in Swedish international companies located in Västra Götaland, while Skåne's share is approximately 4 percent (see Figure 8).

**FIGURE 8** INTRAMURAL R&D EXPENDITURE IN SWEDISH INTERNATIONAL COMPANIES, SHARE OF SWEDEN'S TOTAL EVERY TWO YEARS FROM 2007




Source: Statistics Sweden and Growth Analysis

**What is meant by 'intramural R&D'?**

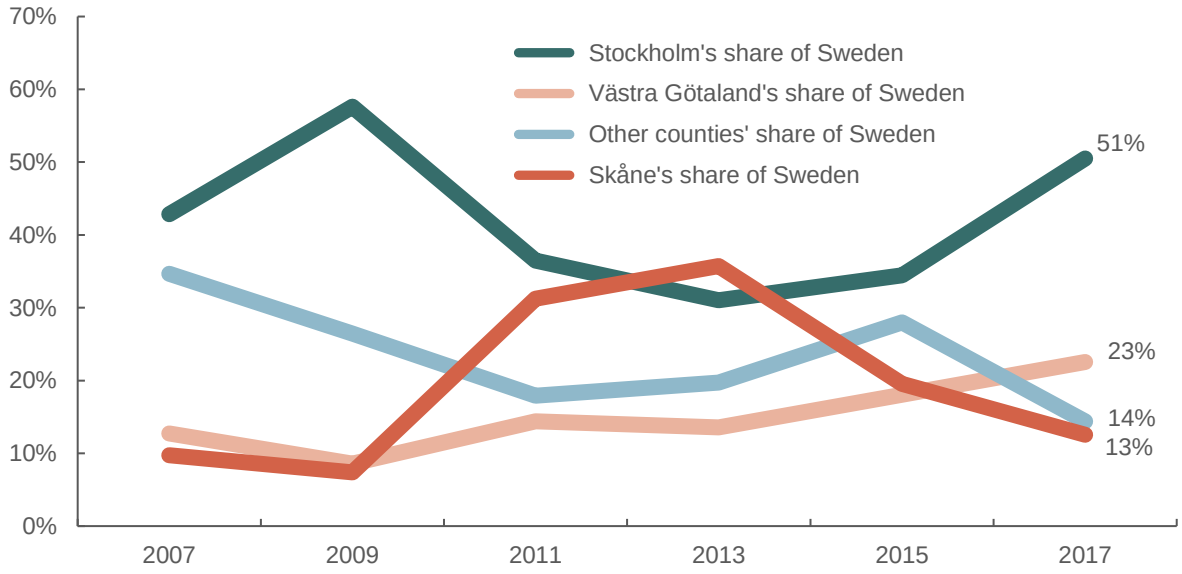
**Intramural R&D**

R&D activities that have been carried out by an organisation with its own staff, or been carried out by consultants in R&D projects that have been led by the organisation and in which the company's staff has worked alongside the consultants.

Intramural R&D also includes R&D carried out at the request of others. Expenditure for intramural R&D consists of both operating costs and investment expenditure.

When we look at domestic Swedish companies Stockholm County accounts for just over half of the country's R&D expenditure for this particular form of company (see Figure 9). Overall, however, R&D expenditure in domestic companies is significantly lower than the two previous company forms. In 2017, domestic companies conducted intramural R&D to the value of just under SEK 10 billion (calculated at 2017 prices). Around a quarter of this amount can be attributed to domestic companies in Västra Götaland, while Skåne's share is 13 percent.

**FIGURE 9** INTRAMURAL R&D EXPENDITURE IN DOMESTIC COMPANIES, SHARE OF SWEDEN'S TOTAL EVERY TWO YEARS FROM 2007



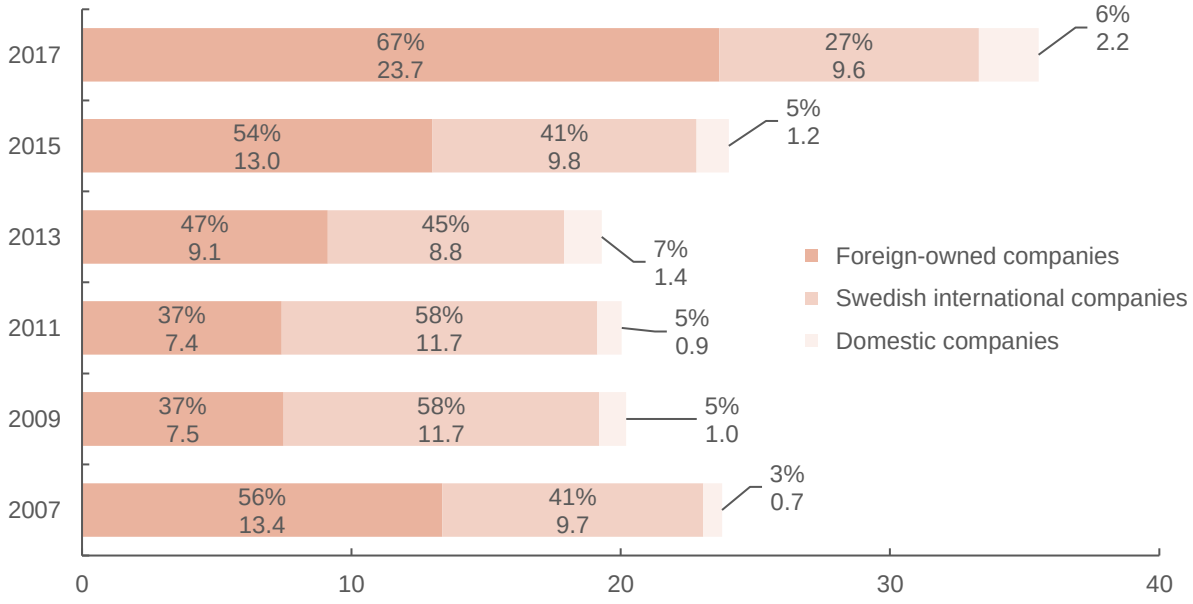

Source: Statistics Sweden and Growth Analysis

## 3.4 Business R&D expenditure in Västra Götaland – form of ownership, SEK and share

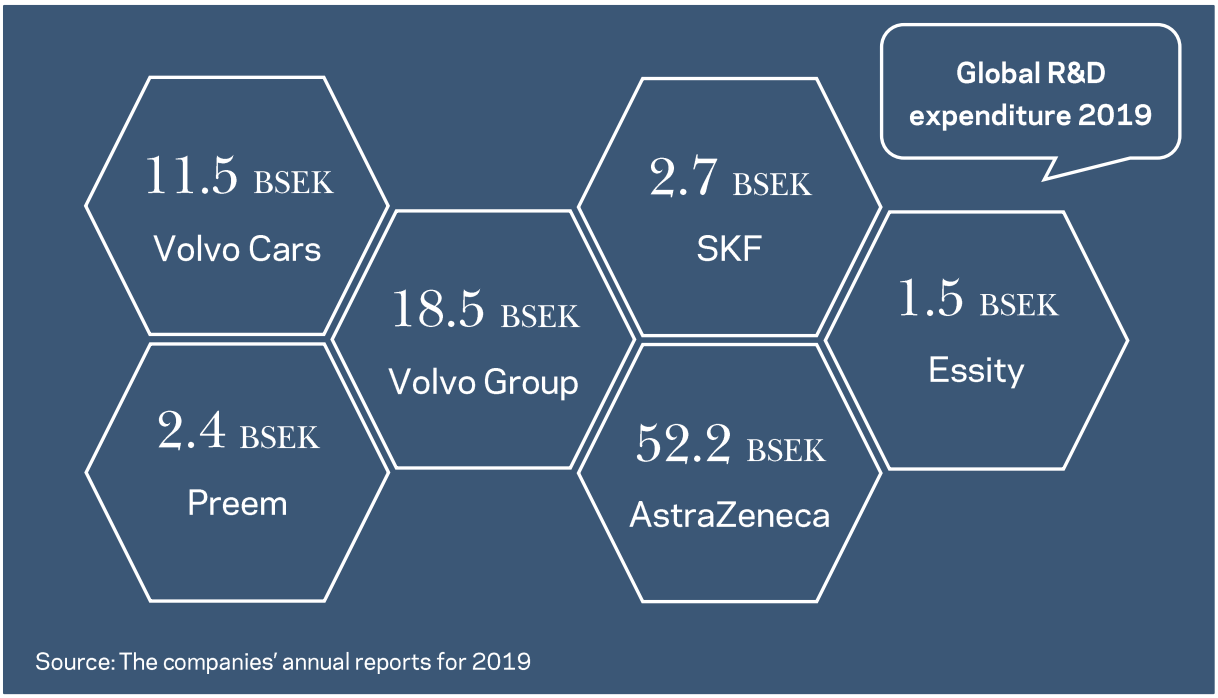
The statistics for Västra Götaland are clear. Just over two-thirds of the intramural business R&D expenditure carried out takes place in foreign-owned companies. In 2017, approximately SEK 24 billion, out of the total for the county of SEK 35.5 billion, was invested in R&D in foreign-owned companies. In this respect, foreign-

owned companies in the region, such as Volvo Cars, AstraZeneca, CEVT, Preem, Cochlear and many others, appear as major drivers of the county's overall business R&D expenditure (see Figure 10). For Swedish international companies, R&D expenditure in 2017 amounted to approximately SEK 10 billion (just over a quarter of Västra Götaland's total business R&D expenditure). This group of companies includes a large number of successful businesses, such as Volvo Group, SKF, Ericsson, Stena, etc. Most of these companies conduct intramural R&D on a global stage, which means that not all of the R&D budget invested by the companies ends up in Västra Götaland. For example, Volvo Group and Ericsson invest significantly more than SEK 10 billion in R&D, but parts of the R&D expenditure end up in research centres around the world where the companies conduct R&D. Domestic companies, i.e. Swedish companies without subsidiaries abroad, reported just over SEK 2 billion in R&D expenditure in 2017 (corresponding to approximately 6 percent of intramural business R&D in Västra Götaland).

**FIGURE 10** INTRAMURAL BUSINESS R&D EXPENDITURE (SEK BILLION, REAL TERMS) IN VÄSTRA GÖTALAND AND SHARE OF THE COUNTY'S TOTAL (IN %), EVERY TWO YEARS FROM 2007




Source: Statistics Sweden and Growth Analysis



# 4. What is required to increase the level of business R&D expenditure?

The fact that the Gothenburg region's business sector is investing a lot of money in R&D is nothing new. In previous sections, we have seen that Västra Götaland's share of intramural business R&D expenditure amounts to just over a third of the total business R&D expenditure in Sweden. A large amount of the businesses R&D in Västra Götaland is invested by companies with operations located in the Gothenburg region. As a result, it is important to create the conditions for further strengthening the region's already R&D-intensive business sector. From the majority of empirical studies, there is strong evidence that R&D-intensive activities within companies generate future increased value for the companies through improved products, services and processes, as well as new markets opening up. The increased value can be invested into further improving the company's productivity through investments in new technology and/or increased resources for recruiting new skilled labour, which means that more people can be employed. In this way, the companies' productivity and competitiveness are both strengthened.

## 4.1 A calculation example – business R&D expenditure as a share of GRP increases by one percentage point

In order to estimate how much the Gothenburg region's companies invest in intramural R&D, we use a number of indicators with data at a more detailed level, in order to weight the Gothenburg region's share of the county's total. For example, we look at: (i) number of establishments, (ii) number of establishments with more than 50 employees, (iii) population, (iv) number of jobs (gainfully employed), (v) total wage sum and (vi) export value during the period 2009-2019. The arguments for using these particular indicators for weighting are drawn from empirical literature where, for example, R&D-intensive companies tend to be close to regions with dense populations, and where access to skilled labour and wage premiums for workers are highest. In this respect, control variables also include accumulated export value for the region, as we have previously seen that many companies that conduct R&D have operations on international markets. An additional control variable that we include refers to the proportion of establishments in the region, as well as the proportion of establishments with 50 or more employees, since R&D expenditure among corporate groups (foreign-owned and Swedish) accounts for a significant share of total business R&D expenditure.

Median shares over time show that the Gothenburg region's share of the county's total stands at between 57-78 percent, depending on which indicator i) – vi) we are looking at (see Table 4). By obtaining an average of the medians, we can determine a reasonable share for the Gothenburg region, which is estimated to be 64 percent during the period 2009-2019. A certain amount of the Gothenburg region's business R&D expenditure ends up in Halland County, as Kungsbacka is located in Halland. However, this is deemed to have only a minimal impact on the overall picture in the Gothenburg region.

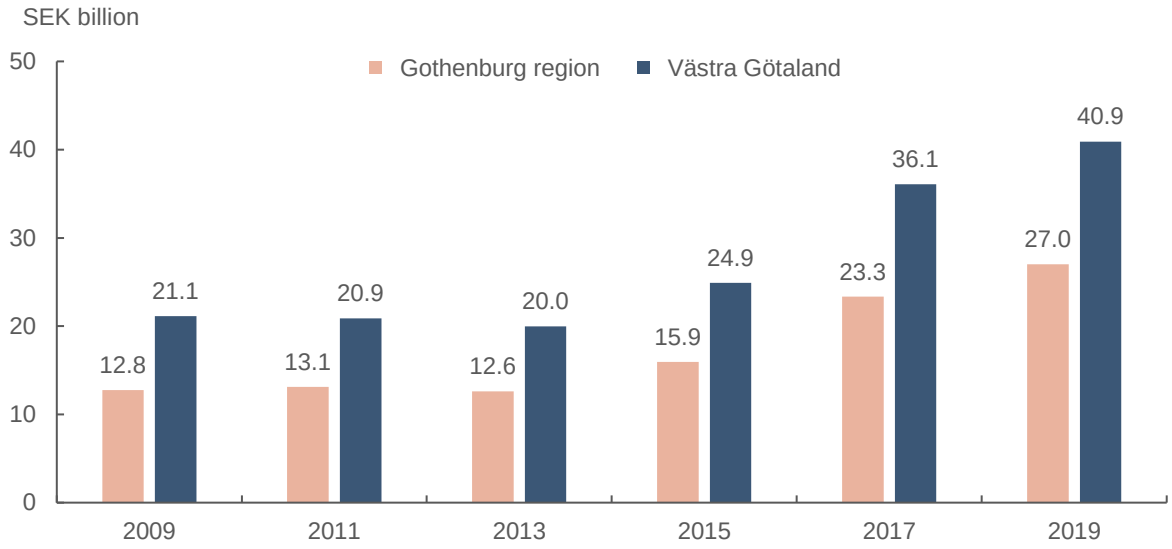
**TABELE 4** GOTHENBURG REGION'S SHARE OF VÄSTRA GÖTALAND FOR VARIOUS MACRO INDICATORS, FROM 2009

| Year | Establishments (total) | Establishments (50+ employees) | Population | Employed | Wage sum | Export value | Average across indicators |
|---|---|---|---|---|---|---|---|
| 2009 | 56% | 60% | 58% | 60% | 63% | 65% | 60% |
| 2011 | 56% | 60% | 59% | 60% | 64% | 77% | 63% |
| 2013 | 56% | 61% | 59% | 61% | 65% | 76% | 63% |
| 2015 | 57% | 62% | 60% | 62% | 65% | 79% | 64% |
| 2017 | 57% | 62% | 60% | 62% | 66% | 81% | 65% |
| 2019 | 58% | 62% | 60% | .. | 68% | 82% | 66% |
| Mean | 57% | 61% | 59% | 61% | 65% | 77% | 63% |
| Median | 57% | 62% | 60% | 61% | 65% | 78% | 64% |

Source: Adapted based on data from Statistics Sweden

Figure 11 shows estimated business R&D expenditure (in SEK billion) in the Gothenburg region. Here, we have used the Gothenburg region's annual averages from Table 4 and estimated what the Gothenburg region's share is expected to be, based on business R&D expenditure in Västra Götaland. For 2019, around two-thirds of the business R&D expenditure in Västra Götaland has been allocated to the Gothenburg region. This corresponds to SEK 27 billion of the county's business R&D expenditure totalling SEK 40.9 billion.

**FIGURE 11** ESTIMATED BUSINESS R&D EXPENDITURE IN THE GOTHENBURG REGION AND BUSINESS R&D EXPENDITURE IN VÄSTRA GÖTALAND (IN SEK BILLION, REAL TERMS), EVERY TWO YEARS FROM 2009

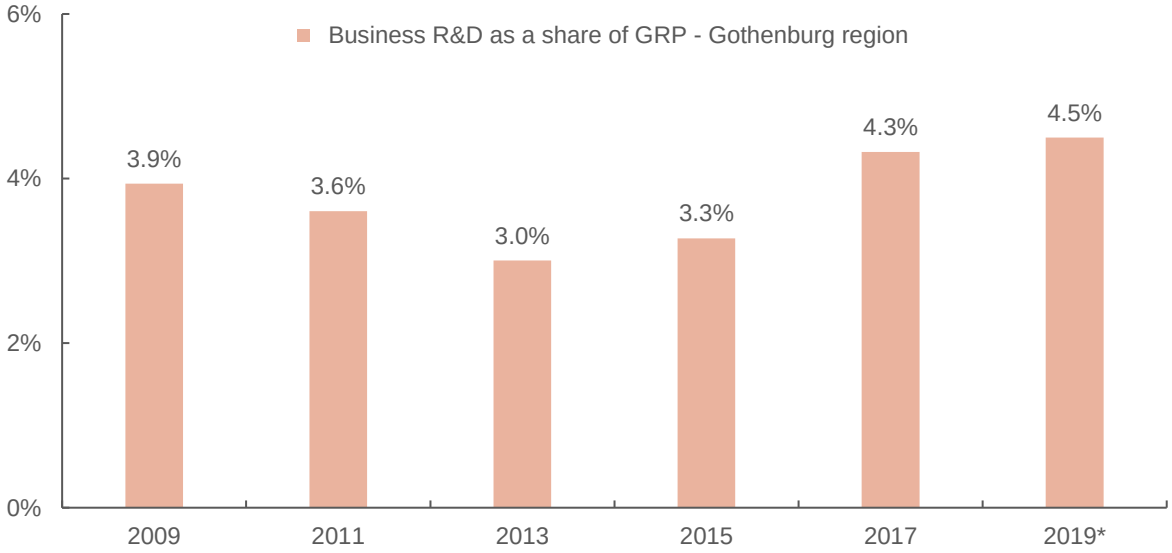



Source: Adapted based on data from Statistics Sweden

For normalisation purposes, international comparisons between countries and between regions are usually calculated on the basis of shares of e.g. gross domestic product (GDP) or gross regional product (GRP), number of people employed in the business sector, number of inhabitants, etc. Here, we are choosing to analyse business R&D expenditure as a share of the Gothenburg region's GRP. The Gothenburg region's private and public sectors generate considerable value added, which goes to the region's overall GRP. In 2019, the Gothenburg region's total GRP for goods and services is estimated at just over SEK 600 billion. If we view the estimated business R&D expenditure in relation to GRP in the Gothenburg region, this will be equivalent to 4.5 percent in 2019. Figure 12 shows business R&D expenditure (estimated) as a share of GRP in the Gothenburg region every two years from 2009.

The main question for this section remains: What does it take to increase business R&D expenditure as a share of GRP, for example by one percentage point?

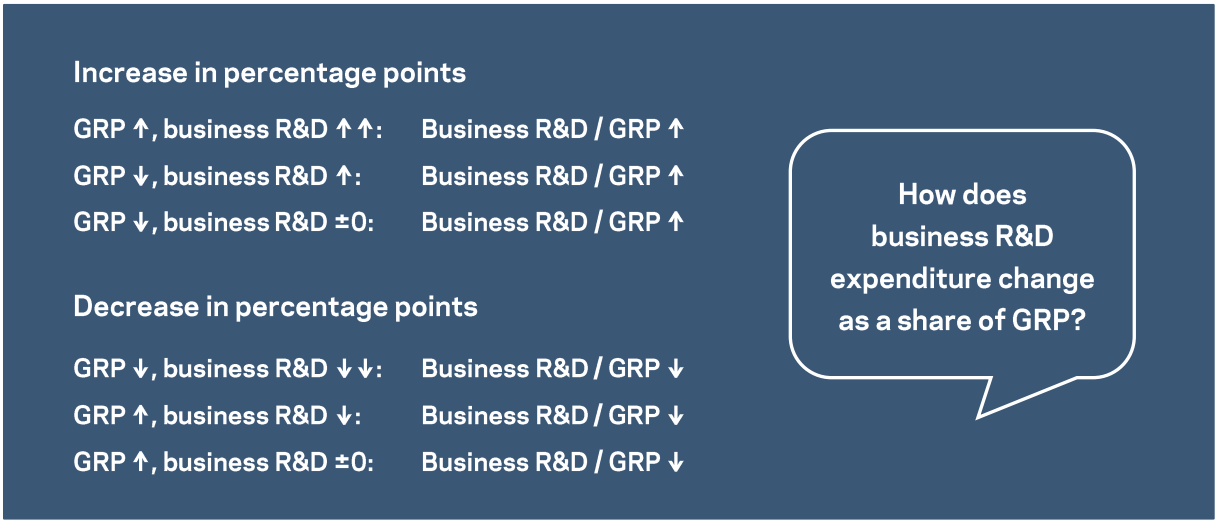
**FIGURE 12** BUSINESS R&D EXPENDITURE (ESTIMATED) AS A SHARE OF GRP IN THE GOTHENBURG REGION, EVERY TWO YEARS FROM 2009




Source: Adapted based on data from Statistics Sweden

* GRP is estimated on the basis of the long-term trend for Västra Götaland (1993-2018) and for the Gothenburg region (1993-2017) on the basis of the region's share of Västra Götaland County.

For 2019, the Gothenburg region's intramural business R&D expenditure is estimated at SEK 27 billion, or 4.5 percent of GRP. If this share is to increase by one percentage point, business R&D expenditure as a share of GRP must increase from 4.5 percent to 5.5 percent. In order to achieve this share increase, the R&D expenditure must increase by more than the GRP increases. Business R&D expenditure as a share of GRP could also increase in the event of a recession: for example, by companies keeping earmarked resources for R&D unchanged, or by business R&D expenditure being reduced by less than the decrease in GRP, or by companies instead opting to increase their R&D expenditure while GRP decreases.




Between 2009 and 2019, the Gothenburg region has reported an average annual real-terms GRP growth of 4.5 percent, which is considered to be significantly above the long-term trend in the 21st century of 3.8 percent.[18] If we take the Covid-19 pandemic in 2020 into account and go back to the calculation example, we can assume that GRP will continue to increase. However, it is more likely that GRP growth will be clearly below the long-term trend. With a development that is below the long-term trend, the Gothenburg region is expected to report GRP equivalent to SEK 631 billion in 2021. An increase in R&D expenditure's share of GRP by one percentage point from 2019 means that the share will be 5.5 percent in 2021. 5.5 percent of SEK 631 billion means that total business R&D expenditure must be SEK 34.7 billion in order to satisfy the share increase of one percentage point in 2021. In real terms, this development requires an increase of SEK 7.7 billion in business R&D expenditure in the Gothenburg region in 2021 compared to 2019 (see Table 5).

**TABLE 5** CALCULATION EXAMPLE – BY WHAT AMOUNT DOES BUSINESS R&D EXPENDITURE HAVE TO INCREASE IN ORDER TO RAISE ITS SHARE OF GRP BY 1 PERCENTAGE POINT BETWEEN 2019 AND 2021, GOTHENBURG REGION

| GRP development | Annual real-terms GRP growth (in %) up to 2021 | GRP (in SEK billion), 2021 | Business R&D as a share of GRP (in %), 2021 | Business R&D (in SEK billion), 2021 | Required real terms increase in business R&D (in SEK billion) |
|---|---|---|---|---|---|
| Above trend | 4.5% | 656 | 5.5% | 36.1 | 9.1 |
| Follows trend | 3.8% | 647 | 5.5% | 35.6 | 8.6 |
| Below trend | 2.5% | 631 | 5.5% | 34.7 | 7.7 |

Source: Adapted based on data from Statistics Sweden

So how can we get more companies to earmark more resources for R&D and thereby strengthen the Gothenburg region's R&D expenditure by an additional SEK 8 billion by 2021?

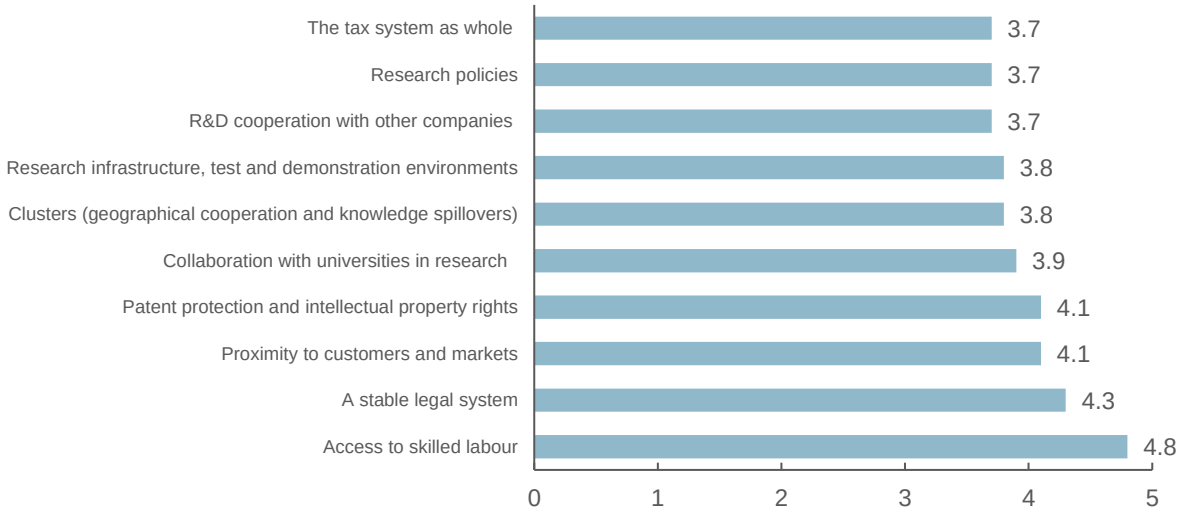
[18] The Gothenburg region's gross regional product for 2018 and 2019 has been estimated according to the same method described in line with Figure 12.

## 4.2 Measures to increase the R&D capacity in companies

What measures can be put in place to increase businesses R&D capacity and what do these efforts result in? This question relates to companies of all sizes. Additional characteristics of these companies are that they have high levels of skilled labour and possess a considerable willingness to cooperate. Empirical studies show that greater investment in R&D in companies tends to increase the likelihood of impeding disruptions, by means of the companies succeeding in marketing more innovative goods, services and processes.

Being innovative as a company requires a great many different tools. These tools, large and small alike, can affect the companies' ability to seize the moment for the disruptive wave that exists in time and space. Some factors play a particularly large role, and a great deal of empirical evidence is available to support these. In particular, this includes (i) access to skilled labour and meeting places, (ii) individuals' mobility on the labour market, (iii) proximity to customers and cluster initiatives, (iv) stability in legal systems, patent protection and intellectual property rights, (v) access to collaborative platforms (where companies, public actors and academia/institutes are represented), testing and demonstration environments and research infrastructure, and (vi) access to financially strong investors, which can be crucial for getting a bearing on an idea that has the potential to do well on the market. It is important to point out that there are a number of other underlying factors that strengthen the companies' innovative capacity, but which we are not covering here. In IVA's R&D Barometer for 2020, companies in Sweden list the most important factors for the localisation of R&D (see Figure 13).[19] In the survey, access above all to skills is viewed as the single most important factor when localising R&D for companies in Sweden. Legal systems and proximity to customers and markets also play an important role.

**FIGURE 13** HOW IMPORTANT ARE THE FACTORS FOR LOCATING R&D ON A FIVE-POINT SCALE? – TOP 10

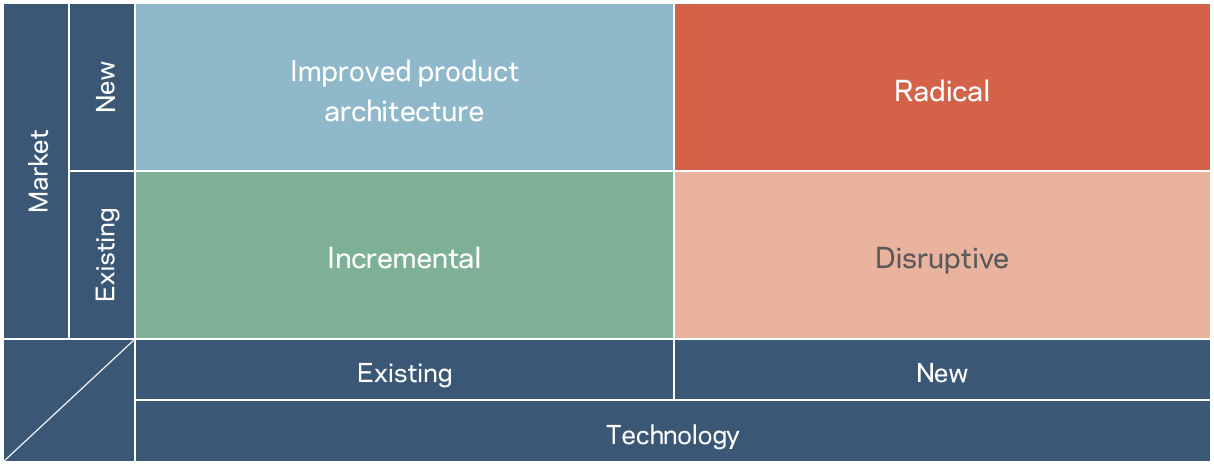



Source: IVA (2020)

A review of various types of innovations shows that there are different stages for innovations that take the form of goods or services or processes (linked to the production of goods and services). The innovations can either be new to both market and technology, or existing for market and technology. Figure 14 sets out the four types of innovation. When the innovation already exists, both for technology and the market, the innovation is considered to be incremental.[20] If the innovation is deemed to be new to the market, although the innovation already exists technologically, this relates to an innovation with improved product architecture. When the innovation uses a new technology at the same time as the market already exists, it is considered to be disruptive. If the technology behind innovation is new and new markets are being opened up for the innovation, it is considered radical. It is in the latter two segments that the greatest successes are achieved by the companies.

[19] IVA (2020), 'R&D Barometer 2020', R&D investment in the business community, Royal Swedish Academy of Engineering Sciences (IVA), October, Stockholm, Sweden.
[20] Incremental innovations with existing market and technology refer to incremental improvements to an existing product, service or process.

**FIGURE 14** VARIOUS TYPES OF INNOVATION FOR THE MARKET AND TECHNOLOGY




Source: Slater et al. (2013) [21]

Creating the conditions for the region's companies to strengthen their R&D capacity can be achieved in several different ways. One approach is through collaborative projects. A number of major collaborative projects are already taking place in the Gothenburg region, where the focus is on developing and testing goods, services and processes in actual testing and demonstration environments (we will take a closer look at these initiatives later in this section).

Another way of strengthening the R&D capacity in the region is to work more strategically with new establishments, above all by attracting more R&D-intensive companies to establish operations in the region. Companies that have a clear focus on work and investments linked to R&D can help to further strengthen the region's future innovative capacity and competitiveness.

Allocation-oriented initiatives can also help strengthen businesses R&D capacity through transition and innovation on how to enhance the future production of businesses in the region. Here, for example, resources can be allocated (or earmarked) to a particular type of innovation linked to construction, infrastructure, production, etc., making it possible for companies to strengthen their capital flow in order to build more sustainably or use less energy for industrial production, or to develop more sustainable solutions for transportation etc. An example of this in the City of Gothenburg is the 'Green Bonds' allocation system.

Large companies account for a significant portion of R&D expenditure in the region. However, SMEs are equally important for the region's overall R&D capacity. We have seen in previous sections that the Gothenburg region is at the lower end in international comparisons (for instance, in the Regional Innovation Scoreboard) when it comes to innovation potential among SMEs. For example, this group of companies receives poor ratings in relation to 'in-house innovation'.[22] In addition, the region's SMEs receive poor marks as regards interaction with others when it comes to developing innovative solutions for goods, services and/or processes.[23] Strengthening SMEs' capacity to conduct R&D does not only enhance their own innovation potential, but also raises the R&D capacity among companies for the entire region.

As mentioned previously, a number of initiatives are already being conducted in various collaborative projects in the Gothenburg region. Triple helix collaborations, where companies cooperate with public bodies and academia/institutes, are nothing new in the Gothenburg region. In the Gothenburg region, 35 test beds (some 60 across the whole of Västra Götaland) are currently in operation in R&D-intensive environments, all of which are helping to increase the likelihood of developing the disruptive and radical innovations of the future within sustainable consumption, production, transportation, construction and housing. The next section takes a closer look at test beds in the Gothenburg region.

[21] Slater, F. S., Mohr, J. J. and S. Sengupta (2013), 'Radical Product Innovation Capability: Literature Review, Synthesis, and Illustrative Research Propositions', *Journal of Product Innovation Management*, vol.31, no.3, pages 552-566.
[22] Defined here as the number of SMEs that have introduced a new product/service/process within the company (i.e. in-house). Companies that sell new products/services/processes developed by other companies are not included.
[23] Defined here as the number of SMEs that have introduced a new product/service/process in collaboration with other companies. Companies that sell new products/services/processes developed by other companies are not included.

## ABIGO – a success story from Gothenburg with considerable R&D capacity

ABIGO was founded in 1989 by the brothers Jan and Leif Smith. The company covers the entire chain of pharmaceuticals and medical technology products, for example developing the technology behind Sorbact®, a clinically established innovation for advanced wound care.

ABIGO has a microbiological lab in Askim where the company conducts R&D. The company also has its own 10,000 $m^2$ production facility in Askersund.

In February 2020, Essity acquired 75 percent of ABIGO. The remaining 25 percent of the company is retained by Jan Smith, who also remains the Chairman of the company's Board of Directors.

- Headquarters
  Gothenburg
- Operations
  Research and development, Gothenburg
  Production, Askersund
  Sales in 70 countries
- Sector
  Pharmaceuticals and medical technology products
- Areas
  Research and development, manufacturing, distribution, marketing and sales.
- Key figures
  Turnover (2019): SEK 403 million
  Employees (2019): 170

## 4.3 An innovative business environment paves the way for more testing

There are a number of different initiatives taking place within R&D-related projects in the Gothenburg region, as can be seen from statistics produced regarding testbeds in the region. In this context, testbeds refer to physical or virtual environments where companies, academia/institutes, public bodies and other organisations can collaborate in the development, testing and introduction of new products, services, processes or organisational solutions within selected areas. They provide equipment, systems and skills to develop products, services and business models in a way that makes it easier for new technologies to reach the market, and to resolve societal challenges more rapidly with sustainable solutions and business models.

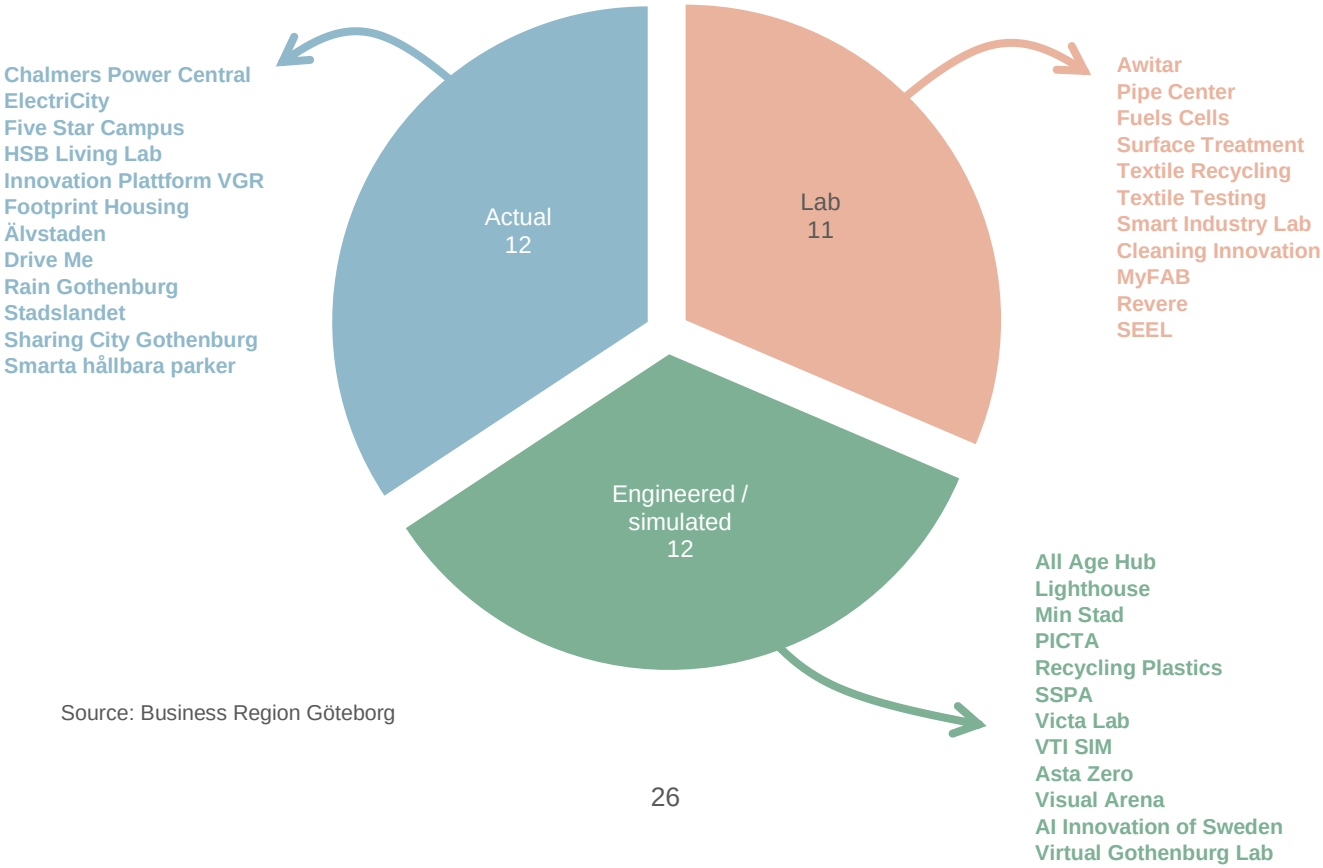
Testbeds can be operated in various forms, including in a:

- **Lab environment:** the focus is on individual properties and functions that are tested in a controlled environment.
- **Engineered / simulated environment:** testing complete products, services or processes in a simulated environment.
- **Actual environment:** testing technologies/processes in and by the operations in which they are intended to be used.

The central criteria for the testbeds in Gothenburg and the surrounding area are that they are, or are made, available and open to users outside the testbed's own operating organisation. At the same time, they must have a duration that extends beyond a single test project. There are also criteria regarding the testbed's area of application. For example, the area of application cannot be limited to a single specific product, service, process or user. The testbeds should be intended for the testing and development of new products, services and processes, i.e. they should not function as locked demonstration objects. The actual content of the testbeds includes both hardware in the form of physical infrastructure (e.g. equipment, installations, measurement methods, localisation, etc.) and software in the form of expertise, organisation, service offering, business concept, policy development, etc.

According to Figure 15, a total of 35 testbeds were in progress in the Gothenburg region in 2019. As regards the testbed environment of the ongoing testbeds in the region, these are evenly distributed. 12 of the region's testbeds are conducted in a constructed/simulated environment (such as AI Innovation of Sweden and Virtual Gothenburg Lab), while the same number of testbeds are conducted in an actual environment. 11 testbeds are conducted in the form of a lab environment.

**FIGURE 15** TESTBED ENVIRONMENTS FOR ALL TESTBEDS IN PROGRESS IN THE GOTHENBURG REGION 2019




Source: Business Region Göteborg

## HSB Living Lab – a test bed in an actual environment

HSB Living Lab is a reality-based environment for research and increased understanding of a sustainable living environment. The project currently functions as a research and demonstration arena, which includes housing in the form of accommodation for students and visiting researchers. The aim is to generate knowledge about a more sustainable lifestyle in the home. Innovations are created on site, which will help to improve the quality of current and future housing as well as the energy efficiency of buildings.

HSB Living Lab is a collaboration between industry, the city and academia, and was originally initiated by Chalmers University, HSB and Johanneberg Science Park.

- Location
  - Chalmers campus, Gothenburg
- Partners
  - Chalmers University
  - HSB
  - Johanneberg Science Park
- Collaborative partners
  - Tengbom, Peab, Akademiska Hus, Tieto, Electrolux, Bengt Dahlgren, Göteborg Energi, Elfa and Vedum.
- Financing
  - Participating partners


Photography: Felix Gerlach / HSB Living Lab

There are 35 testbeds in progress in the Gothenburg region in 2019, but there have been more over time. Figure 16 shows the timeline of all the testbeds that are currently in progress, as well as those that have been completed.

Some of the testbeds have been running for quite a while, having been in progress since 2009 or earlier. The testbeds that have been running for a long time include Chalmers Power Central, Lighthouse, Pipe Center, SSPA, Textile Testing and MyFAB.[24]

Some of the testbeds that have been launched over this timeline have been completed. The completed testbeds include Sensors and Recycling, which concluded in 2017, as well as TUCAP, Famna, FED and Agrifood & Bioscience, all of which concluded in 2018.

During 2019, however, a considerable number of testbeds have been launched in the Gothenburg region. These include AI Innovation of Sweden, which is a national centre for applied research and innovation about and within artificial intelligence. The test bed is located in Lindholmen in Gothenburg.

Another testbed that has been launched in 2019 is Sharing City Gothenburg. The focus of this testbed is to encourage Gothenburg and other Swedish cities to work actively and critically to increase the opportunities for residents to participate in sharing economies. Other cities included in the testbed are Stockholm, Malmö and Umeå. The aim is to develop world-leading testbeds for sharing economies.

Smarta Hållbara Parker (Smart Sustainable Parks) is an open and innovative arena for developing the smart green areas of the future. Green areas in cities are becoming increasingly important, and new technology is playing a crucial role in the way future parks and green areas can be managed. The purpose of the testbed, which is situated in Gothenburg, is to create an open and innovative demonstration arena. Through digitalisation and automation, the focus will be on increasing the productivity of the day-to-day activities that take place in parks and green areas, at the same time as strengthening the recreational value and reducing the environmental impact.

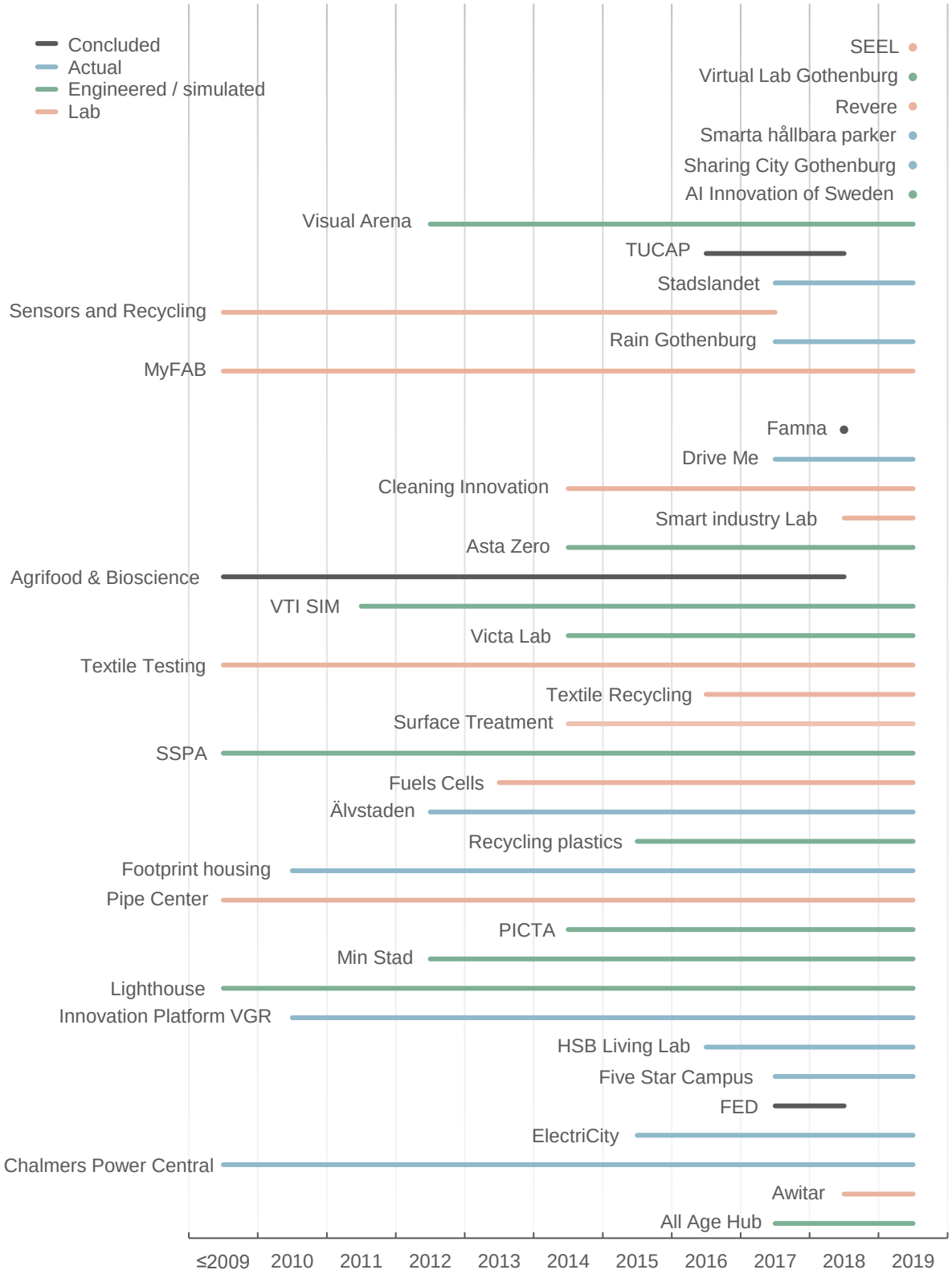
The Revere testbed is a research facility where the focus is on vehicle-related research. The most important research areas relate to autonomous vehicles, active safety and vehicle dynamics. Revere's test lab is home to test vehicles (both light and heavy vehicles), environmental sensors and simulators. The research facility, situated in Lindholmen in Gothenburg, measures approximately 400 $m^2$.

Virtual Gothenburg Lab was launched in 2019. This testbed creates unique opportunities to test and develop working methods, tools and methods for visual, digital and virtual activities. Virtual Gothenburg Lab is linked to Virtuella Göteborg, the City of Gothenburg's digital twin, and in this way the testbed will support and strengthen the City of Gothenburg's urban development going forward. The testbed is a collaboration between a large number of partners from the public sector, academia and the business sector.

In 2017, RISE and Chalmers were commissioned by the Government to create a testbed for electromobility. This was realised in 2019 through the launch of the Swedish Electric Transport Laboratory (SEEL) testbed in Lindholmen in Gothenburg. CEVT, Scania, Volvo Cars and Volvo Group are also included as partners in SEEL, in addition to RISE and Chalmers. The purpose of the testbed is to strengthen the competitiveness of the Swedish automotive industry, as well as to contribute to Sweden remaining at the forefront when it comes to innovations in the transport sector. The investment in SEEL will also accelerate Sweden's transition to a fossil-free society.

[24] Read more about the region's test beds here: http://www.investingothenburg.com/doing-business/find-testbeds

**FIGURE 16** NUMBER OF TESTBEDS IN THE GOTHENBURG REGION AND THE SURROUNDING AREA – UP TO 2019




| Start year / duration | ≤2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total in progress | 8 | 10 | 11 | 14 | 15 | 20 | 22 | 25 | 31 | 33 | 35 |

Source: Business Region Göteborg

# 5. Conclusions and recommendations

Following the above review, we can state that Västra Götaland's companies have considerable capacity to conduct research and development (R&D) at their own initiative. Previous empirical studies present strong evidence of a positive link between R&D and innovation in the business sector. An increase in business R&D is also reflected in the significant strengthening of the companies' export capacity, productivity and investments. As a result, R&D activities in companies can be viewed as strategically important for a region, as they have a major spin-off effects for the rest of the economy in the form of more jobs, increased productivity and a larger international market.

*However, we would like to draw attention to a number of challenges that could hamper the region's R&D capacity in the longer term:*

- This relates in particular to R&D activities conducted by SMEs. From an international perspective, the region's SMEs are lagging behind somewhat when it comes to introducing innovations in the form of new products, services or processes. The interaction between SMEs and others is also at a modest level compared to other European regions. In this respect, we need to work more effectively to invite these companies to participate in further collaborative projects, where their innovations can be tested and demonstrated in order subsequently to be marketed even better. In the long term, such collaborations might increase the likelihood of SMEs' innovations reaching out to a broader domestic market, as well as opening up channels to international markets.

- Foreign-owned and Swedish international companies account for a significant portion of business R&D expenditure in Västra Götaland. This means that an overwhelming share of the region's active companies (which are made up of domestic companies without subsidiaries abroad) only account for a small portion of the county's total R&D expenditure in businesses. This composition of business R&D expenditure could increase the vulnerability of the overall R&D capacity, as large global companies can quickly make decisions regarding the restructuring of research activities.

Strong collaboration in terms of the innovation work (between companies, the public sector and academia) through R&D is important for achieving sustainable development. Why? Because R&D lays the foundations for the new ways of consuming and producing more smartly, more environmentally efficiently and more sustainably in future.

*The region's R&D activities need to be safeguarded, nurtured and grown:*

- The companies in Västra Götaland are at the forefront when it comes to work and investments in R&D. It is important to safeguard this position and view it as an important strength in Sweden's future development towards more sustainable growth.

- At the same time, the region is extremely strong as regards running collaborative projects. One of Sweden's most concentrated locations for testing and demonstration environments is situated in Västra Götaland, including in the Gothenburg region. Testbeds are considered to be incredibly important when it comes to the new ways of consuming and producing in future. We must protect, develop and grow these, in order to continue to be a leader both in Sweden and globally.

The public sector can achieve a great deal, including by supporting and collaborating with companies and academia. Further permissive environments can be created, where goods, services and production processes can be demonstrated and/or tested in real-world environments. In this respect, meeting places are important for gathering R&D capacity and working together. The aim is jointly to strengthen Västra Götaland's position as a world-leading region, whose innovations are driving the sustainable growth of the future. The companies' competitive goods, services and processes should have the whole world as their market – with the primary precondition being that these goods, services and processes are environmentally smart and, above all, environmentally efficient.

Through our knowledge, we in Västra Götaland are able to contribute to more sustainable consumption and production worldwide. In this way, we can strengthen global health by exporting the region's innovations, in order that more people can benefit from the results of our knowledge and technologies.

However, a constant challenge for our business sector relates to the question: If the companies in Västra Götaland are already at the forefront in terms of R&D, how can their competitiveness and R&D be strengthened another notch? We will leave this question as the starting point for further studies regarding R&D in the region's companies.

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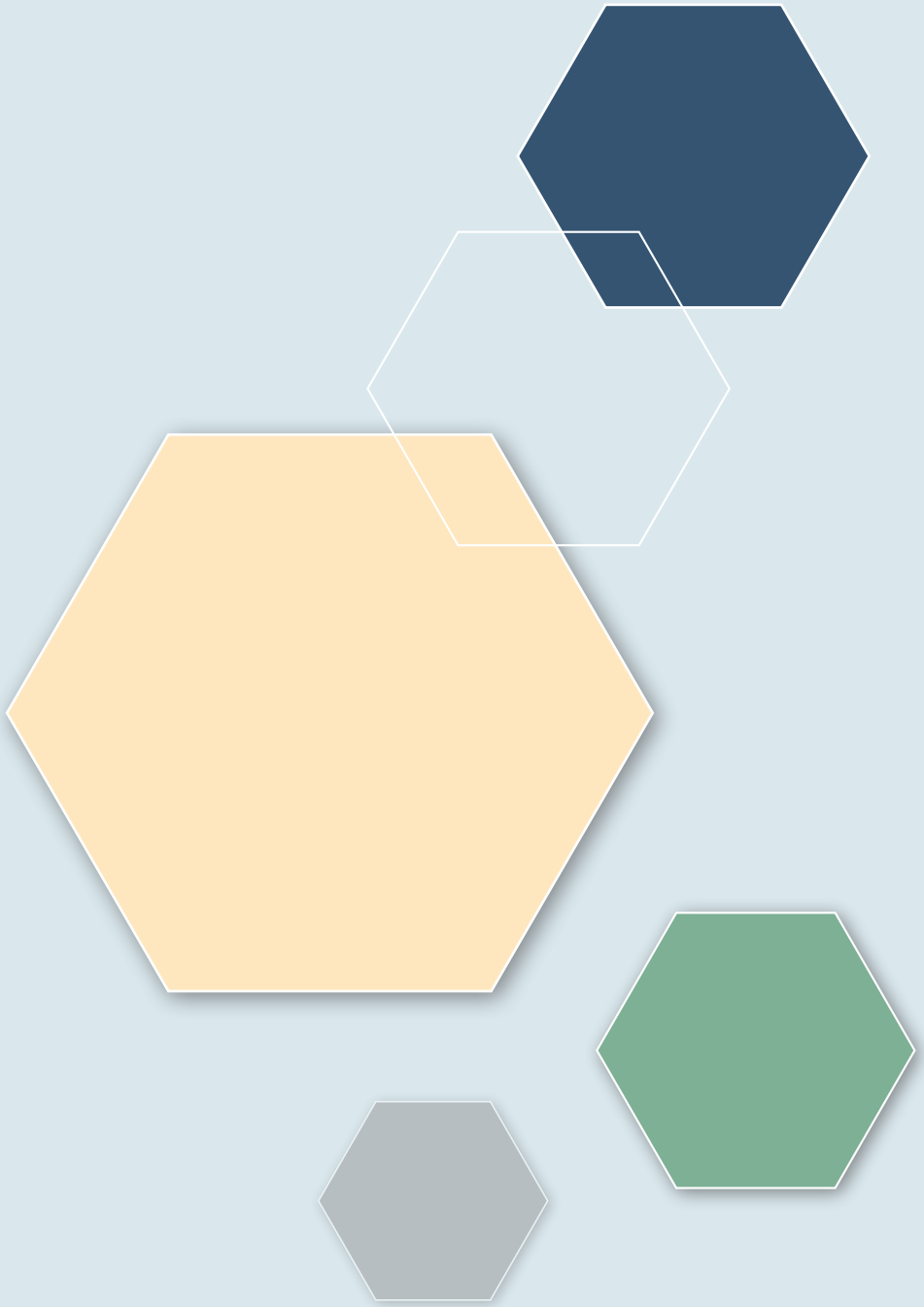

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