Institut für
Wirtschafts- und Innovationsforschung

Final Report

The Leverage Potential of the European Research Area for Austria's Ambition to become one of the Innovation Leaders in Europe

– A comparative study of Austria, Sweden and Denmark

Study on behalf of the ERA Council Forum Austria

Vienna, October 2015

JOANNEUM RESEARCH Forschungsgesellschaft mbH
POLICIES – Institut für Wirtschafts- und Innovationsforschung
Büro Wien
Haus der Forschung, Sensengasse 1
A-1090 Wien, Austria
Tel.: +43-1-581 7520
Fax: +43-1-581 7520-2820
E-Mail: policies-tip@joanneum.at

DAMVAD ANALYTICS A/S

Havnegade 39
DK-1058 København, Denmark
Artillerigatan 6
SE-114 51 Stockholm, Sweden

Team of authors:

JOANNEUM RESEARCH:

Wolfgang Polt, Maximilian Unger, Michael Ploder, Daniel Wagner-Schuster

DAMVAD ANALYTICS:

Torben Bundgaard Vad, Samuel Palmquist, Henrik Barslund Fosse

Content

Figures

Tables

1 Executive Summary

Background of the study

Against the background of an apparent loss of dynamics of the Austrian Research and Innovation system, and the danger of missing the target of the Austrian STI strategy from 2011 to advance among the ranks of the innovation leaders, the ERA Council Forum Austria commissioned a study in the beginning of 2015 which should identify the main gaps and barriers for Austria to become an innovation leader, the role of Austrian universities and their potential contribution to this goal and to compare Austria to 'Innovation Leaders', especially Denmark and Sweden with a view to learn from their performance and practices.

The study was carried out by JOANNEUM RESEARCH (AT) in cooperation with DAMVAD Analytics (DK/SE). It employed a mix of quantitative and qualitative approaches including Interviews, Webinars, policy roundtables and workshops covering a broad range of actors in both comparator countries. It gradually advanced from the aggregate quantitative level of comparison of indicators to the micro-level of individual policy initiatives and programmes, at each stage refining and reformulating the hypothesis. In this process, we benefitted from the feedback of both the ERA council forum, the members of our scientific advisory board as well as from colleagues in Denmark and Sweden. In addition, an OECD Review of Swedish innovation policy which ran in parallel to this study provided chances for exchange and joint discussions.

International comparative policy learning is not possible in a simplistic way, in which one tries to identify 'best practice examples' from leading countries and attempts to transfer these. Rather, contexts would have to be taken into account and weighed in. In this study, we tried to learn also from the challenges and problems we encountered in the comparator countries and tried to capitalise on the (self)critical discussions in both countries.

A starting point was the identification and qualification of the mayor gaps between Austria and Denmark and Sweden in the IUS, but – given the well-founded methodological critique towards the IUS - a number of other sources of comparison were also taken into account to get a more nuanced picture. In particular, apart from a comparison on the system we looked more closely into

- the structure and governance of R&D funding,
- the structure and performance of higher education institutions,
- the industrial structure and the role of VC funding for industry,
- Science-Industry- Relations, and
- the role of ERA for STI policies as well as at the trend towards mission-oriented policies.

Assessment on the System Level

- Denmark and Sweden are undoubtedly innovation leaders by more than one measure. Both score high with respect to the level of development of their research and innovation system, Denmark (and to a lesser degree also Sweden) also with respect to the dynamics of some important dimensions of the research and innovation system (e.g. scientific output, venture capital). As comparability also with a number of other dimensions is high, both countries lend themselves well to comparison and offer fertile ground for potential policy learning.
- International comparative policy learning though is not possible in a simplistic way, in which one tries to identify 'best practice examples' and attempts to transfer these to Austria. Rather, it would have to (i) identify which characteristics can and should be emulated, (ii) those which are potential role-models but would be difficult to transfer and (iii) take also into account the challenges and inherent tensions within the systems of the comparator countries, from which also a lot of lessons can be drawn. In this vein, we also noticed quite some debate in Denmark and Sweden alike about the appropriateness of some measures - notably a perceived imbalance of the input and output side with a cautionary note on potential overinvestment.
- A starting point was the identification and qualification of the mayor gaps between Austria and Denmark and Sweden in the IUS, but – given the well-founded methodological critique towards the IUS - a number of other sources of comparison were also taken into account to get a more nuanced picture. In particular, we looked more closely into the structure and governance of R&D funding, the structure and performance of higher education institutions, the industrial structure and the role of VC funding for industry, Industry-Science Relations, the role of ERA for the research and innovation system and STI policies as well as at the trend towards the implementation of large scale mission-oriented funding programs in Denmark and Sweden.
- As a general observation on the aggregate level, it has to be maintained that Austria continues to have lower inputs than the innovation leaders. While R&D intensity has been rising in Austria in the past decades, Denmark and Sweden have invested more (in some areas like HEI substantially more) in this period. This holds true by and large for public as well as private investments, for the HEIs as well as for the business sector. The differences in past performance that make up for the different positions in the rankings thus can be attributed to a good deal also to this difference in inputs.
- While this is not depicted in the IUS, we were often hinted towards marked differences in societal attitudes between Austria, Denmark and Sweden. There are signs of marked differences in attitudes e.g. towards entrepreneurship and female participation in research. In both respects Denmark and Sweden outperform Austria (in some measures by far), which hints to the need for changes in general societal attitudes and approaches like fostering the ease of doing business or sharing of family duties.

Governance and Funding Structure

- In terms of quality of the policy processes, some lessons could be drawn e.g. from the rich evidence-based policy process on which the Swedish Government Bills for research to the parliament are formulated and the emphasis on impact assessment in the case of Danish assessments of individual measures as well as from the streamlined policy and funding structures in Denmark: the majority of all innovation and research policy support measures is concentrated in one Danish ministry and delivered through two main councils. Furthermore, a streamlining and clear division of labour between public funding schemes for both innovation and research was established in recent years. Austria might learn from these policy processes, e.g. by taking it as a starting point for a discussion about a more optimal division of labour between ministries and an adjustment of its funding portfolios.
- In terms of funding structure, with a view on broadening the financial base in Austria, public competitive funding should be increased significantly following the examples of Denmark and Sweden. Likewise, Denmark and Sweden also compare favorably with respect to the diversified landscape of private funding, mostly through foundations. Steps in these directions have recently been made in Austria, the effects of which should be revisited and assessed in some years. Some caveats do apply here as well in terms of portability of approaches: Given the amount of the gap between Austria and Denmark and Sweden, and the time it took to develop the landscape of private foundations in these countries, a quick closing of this gap seems unrealistic. In the meantime, other sources for private funding and an increase in public funding are needed to narrow the gap. But as both Denmark and Sweden provide generous tax exemptions (up to a rate of 125% of research expenditures on capital income of private foundations), a further raise of tax exemptions on private philanthropic foundations also could be an option for Austria.
- On the other hand, there are also some less warranted side-effects of the multiplicity of different funding sources: in Denmark and Sweden the increase in mostly competitively awarded funding has raised questions about the necessity of co-funding which reduces degrees of freedom in the research institutions (e.g. with respect to the scientific specialization through the impact of large thematically dedicated foundations). Emphasis has to be put on developing monitoring mechanisms and alignment strategies of private funding with public interest, as these often introduce different incentives, different formal requirements and can add to the complexity of handling third party funding.

Tertiary Education System

- Both Sweden and Denmark have tried to substantially improve their HEI systems, both through marked increases of funding and institutional reforms, which were very substantial in the Danish case, involving concentration of research in a comparatively smaller number of organizations. Both have succeeded in producing high numbers of students, graduates and scientific output (especially in the case of Denmark), though the developments and dynamics differ somewhat between Sweden and Denmark. Despite the high level, there are concerns in Sweden about the impact and quality of research and concerns about the quality of teaching and graduates in both countries. We believe that the main thrust of these reforms and improvements of the HEI sector can be a good orientation for Austrian reforms as well. In order to emulate the positive development of the HEI sector, Austria would have to increase its spending for HEI considerably to reach the level of Denmark and Sweden. While such an increase in public funding is necessary, it is not a sufficient condition for improvement. As we have seen from the examples of Denmark and Sweden, institutional changes have to accompany increased funding.

- Both Denmark and Sweden are characterized by a pronounced concentration of research in a smaller number of institutions. This concentration has grown ‘organically’ in Sweden, with a small number of ‘old’ universities accounting for the bulk of R&D among HEI, while it was recently established through mayor institutional reforms in Denmark. These reforms – significantly reducing the number and increasing the size of research institutions and establishing a quite clear division of roles between research institutions with the aim of pooling resources and gaining international visibility – ought to be guidance for Austrian STI policy as well.
- Austria should follow the example of the innovation leaders and should aim for a continuous and substantial increase in the number of tertiary graduates. In Austria by far the highest share of tertiary education is performed at universities which might be a less efficient and more costly way to raise the number of graduates when employability is in focus. This balance in the distribution of students among several types of higher education institutions is different in Denmark and Sweden with university colleges playing a more prominent role, especial in professional tertiary education. If Austria were to follow the expansionary course of Sweden in its HEI-system, more emphasis needs to be put on the role of universities of applied sciences and other type of post-secondary education. Solely focusing on increasing the number of tertiary graduates might lead to an “inflation of graduations”, that might not necessarily lead to an increased employability or provision of required skills in the business sector.
- At the same time, Austria shows a lower share of doctoral graduates, which are an important input for R&D activities. Following the Danish and Swedish examples, to increase the quality and structure of doctoral education should be a cornerstone of a HEI reform in Austria. Means to do so would include increasing regular employment of doctoral students as well as the connectivity with industry/private sector (e.g. the Industrial PhD program). A standardization of PhD-courses between universities also concerning the permeability between universities and universities of applied science are a key pr-erequisite. Collaborative graduate and PhD/ doctoral schools/colleges directly linked to high level research (cross-institutional) infrastructure (at least two HEIs, if possible cross border) are recommended, both to improve the interfaces between institutions as well as between sectors.
- In terms of increasing the international attractiveness for talents and skills – an important issue in all countries in comparison -, Austria should put emphasis on retaining skilled and trained people from abroad after finishing their degrees in Austria. In this vein, Austria needs to reduce entrance barriers to the labour market for graduates at Austrian HEIs

from abroad. This requires an overhaul of the red-white-red card especially regarding minimum wage requirements and the limited time-frame allowed for becoming employed.

- Both Denmark and Sweden do not apply tuition fees or structurally different entry barriers to universities (like numerus clausus), but student intake is directly linked to financing for HEIs, i.e. allowing therefore to directly compensate increased student numbers by an increase financing. Austria should follow this example and to this end speed up its efforts to implement a student-place-based finance mechanism ("Studienplatzfinanzierung").

Higher Education Funding

- Austria provides a nearly equal amount of funding for R&D, compared to Denmark, to 22 universities, whereas Denmark does for eight. Furthermore, competition between institutions, both about public basic funding as well as about a variety of public and private sources from agencies and foundations is higher developed both in Denmark and Sweden. The establishment of international competitive and visible research requires an overhaul of the Austrian university landscape, including strategic alliances or merger of universities, faculties or departments. A required increase of the share of competitive funding needs further to be complemented by measures implementing full cost calculation in public areas.
- Both Denmark and Sweden have a tradition of providing funds separately for research and teaching, with the latter being dedicated on the basis of student-place and student-success financing mechanisms. Furthermore, as emphasized both by the empirical findings in Denmark and Sweden as well by the assessment of stakeholders, strategic concentration and the establishment of a critical mass are key for the performance of international competitive research. In Denmark universities were financially incentivised to merge, in Sweden research funding and performance is traditionally concentrated at a few, 'old' institutions. New universities in Sweden are mainly incentivised to finance their research from competitive sources and in collaboration with the industry.
- The level of autonomy of institutions is high in both countries, but also governance mechanisms within universities are relatively weak. However, both HEI systems in Sweden and Denmark are characterized by a much greater steering capacity of public funding through the application of key performance indicators attached to public funding. Performance-based funding has a much greater weight in the Danish and Swedish system than in Austria. The assessments on the newly established funding modes for research at higher education institutions in both countries are both ambiguous and limited due to the inherent time lags in the impact of such measures on the performance and outcome of research. Furthermore, since they have been implemented quite recently, they have no explanatory power for the performance of the Danish and Swedish universities in the past two decades. This performance may be better explained by the sustained long-term funding and the institutional setting favouring concentration. Nevertheless, these practices offer substantial scope for policy learning and should be applied to greater extent also in Austria.

- The Austrian system of performance contracts as administrative justification of block grants has no feature of actual performance-based budgeting as long as milestones in the performance contracts are not directly contingent to public funding. A solution might be a more pronounced increase of the “Hochschulraumstrukturmittel” to become the major pillar of financing. Separate accounting for teaching and research is required. The establishment of a performance-based measure for the financing of student places (“Studienplatzfinanzierung”) according to the Austrian “Hochschulplan” of 2011 has to be speeded up.

Business R&D and Innovation

- The structure of funding of business R&D expenditures in Austria is quite different from the structure in Denmark and Sweden. While in Sweden and Denmark a large part of BERD is funded by the national business sector itself, only a bit less than two third of the Austrian BERD is funded by intramural enterprises. This is explained by a comparatively high share being funded of enterprises from abroad was well as by the government sector.
- Funding systems differ quite a lot between the countries in comparison: in Sweden, the share of public funded R&D in the business sector is much lower (also due to large R&D-intensive companies). Sweden also applies no tax incentives for corporate R&D compared to Austria or Denmark. R&D funding for companies in Sweden is mainly for collaborative R&D and R&D in large companies is not funded on a large scale. In Denmark, funding is provided mainly to SMEs in the form of start-up and market development support. The framework concerning public funding of business R&D is quite favourable in Austria for several reasons: Continuing policy to focus on public funding towards R&D and innovation instead of investment. Public RDI funding is also used as a ‘locational argument’ corresponding to a high significance of foreign affiliates.

  While individual measures of business R&D support have been assessed, impact assessments of the public support to business R&D remain scarce. All countries lack a ‘portfolio evaluation’ of their instruments. Austria has yet to evaluate its direct and indirect support measures for Business R&D and Innovation.
- The industrial sectoral structure of Austria shows significant differences compared to Sweden and Denmark. While Sweden and Denmark have a comparatively high share of value added in high-tech sectors, Austria has a relatively high share in medium and low technology sectors (and vice versa). Austria has competitive advantages in these areas considering the strong supply linkages to European (especially the German) industry. However, the gap between Austria and the Nordic countries with respect to the share of value added in high-technology sectors increased since 2002. Since the IUS puts emphasis on industry structure rather than on sectorial performance, this leads to an underrating of Austria in the ranking. But a recalculation of R&D intensities shows that the structural differences only explain about one third of the difference in the overall research intensities. Thus, Austrian companies are also outperformed by their Swedish and Danish counterparts with respect to their research efforts when structural disadvantages are

taken into account. Hence innovation and R&D intensity and diffusion of Key Enabling Technologies in these areas can be improved significantly.

- Austria shows relatively low dynamics in business start-ups compared to Denmark and Sweden, and also the total number of companies stagnated from 2009 to 2012. This is at least partially due to different regulatory frames and corresponds with comparatively high survival rates of Austrian firms. However, highly innovative business start-ups are a main driver of structural change and need to be fostered continuously.
- The differences in firm demography between Austria, Denmark and Sweden, (e.g. the large increase of one-person companies in Denmark), raise questions about the framework conditions and the ease of doing business in Austria. While recently some initiatives have been launched in Austria with the ambition to position the country among the European countries with the highest enterprise birth rates, this remains to be an area which should receive high policy attention and should be addressed from various angles (regulation, provision of VC, awareness and education, IPRs, encouragement of academic spin-offs etc.). Austria shows a broad spectrum of policy measures supporting highly innovative business start-ups in early phases (including awareness building, incubation and funding) but a strong business 'eco-system' is still lacking. Denmark and Sweden could be role-models in this vein, especially in some hot-spot areas (like the capital regions of both countries). Supporting schemes for later phases of business (e.g. accelerators in Denmark) exist but ought to be strengthened in Austria.
- Austria performs at about the same level as companies in Sweden and Denmark when it comes to innovation activities in general. Especially Austrian large and medium sized companies show higher levels of innovation activities than enterprises in Sweden and Denmark. Also, Austrian firms perform very well in non-technological innovation and have larger shares of innovative firms compared to Sweden and Denmark. While Austria performs well regarding patent activities in Europe, there is a relatively large gap concerning the number of EPO patent applications per million inhabitants to the benchmark countries Sweden and Denmark. Even though Sweden seems to be out of reach in high-tech EPO patent applications and Denmark had a slightly higher number of EPO patent applications per million inhabitants in the high-tech sector, Austria performed better than Denmark in ICT patent applications per million inhabitants. Also, Austria shows a strong performance in the field of biotechnology, where it surpasses the benchmark countries.
- Even if the propensity to innovate and patent is relatively high in Austria, not least due to a favourable framework concerning public funding of business R&D, there is room for improvement concerning the input-output relation and for commercialisation of these inventions (e.g. following the example of recently launched measures (like 'Marktstart') to support market development for SMEs. Overall though, scope for 'quick-fixes' are limited as changes in industrial structure and innovation behaviour of firms can only be changed in the mid- to long term. To do so, Austria is certainly not at a disadvantage concerning the (public) funding instruments as compared to its peers in Denmark and Sweden given the size and scope of its innovation funding for the business sector.

- A comparison of Austria, Denmark and Sweden regarding venture capital investments shows that the total volume of VC in Austria is significantly lower than in Sweden and Denmark, although this is not the case for the number of companies funded. Total VC for Austria in 2014 (seed, start-up and later stage venture) was 1/8 of Denmark and 1/9 of Sweden. This gap already existed before the financial crisis in 2007 and thus was no consequence of it. The number of VC firms and their VC volume increased significantly for digital start-ups over the last few years, where internet and technology firms were the most popular ones for investors. Since the ICT landscape is on the one hand smaller and on the other hand even decreasing in Austria compared to Germany, Sweden and Denmark, this might be an additional reason for the weak performance of Austria with respect to venture capital. Furthermore, the Austrian VC system shows marked differences with respect to the stage of investment, with emphasis of public VC funding being put on the early-stage other than in Denmark and Sweden. This is very much due to thedependence of Austrian companies on the banking sector that is especially problematic in the early stage of young firms..
- Denmark is especially remarkable, as it experienced a very different development, seeing its VC markets increase even in the years of the financial crisis. Notably the Danish Growth Fund (DGF) was able to attract private VC investors using a fund-of-funds model, and highly successful in leveraging private investments into the risk capital market thereby demonstrating the benefits of well-designed and well-managed initiatives to help grow a sustainable risk capital market. The chances to emulate this development in Austria might not be too high, as the DGF relied on the (pre)existence of other funds which are available to a much lesser extent in Austria, but deserves further examination.
- Overall, especially risk capital from the private sector has to be increased significantly in Austria. Innovation in high-tech branches involves high risks and large financial resources, which cannot be carried by the public sector alone. The main target of the public sector should be to provide a well-designed framework and a well-managed platform in order to attract venture capital investors.
- Another marked difference between Denmark and Sweden and Austria is the role of ICT in the development of the respective research and innovation system. The role and weight of this sector is not only more pronounced in industrial structure, but also in the general 'ICT readiness' of the countries. ICT readiness is weak especially in Austrian peripheral regions and the coordination between federal levels could be improved. Denmark and Sweden societies are more IT oriented, better equipped with infrastructure and more prone to use IT both in households as well as in enterprises. While industrial structures cannot be changed easily, the uptake and diffusion of IT can. Measures in this vein include further advances in eGovernment initiatives, Smart Cities initiatives and the provision of sufficient broadband infrastructure. Like in Denmark and Sweden, Austria would benefit from a coordinated federal digitalization agenda.

Industry-Science Relations

- With respect to the different channels of industry-science relations, it is hard to assess whether Sweden or Denmark could serve as role models: Austria seems to be on a comparatively good level, with (negative) differences mainly due to structural characteristics of industry and the greater propensity to collaborate of larger enterprises and in ICT and life sciences, where both Denmark and Sweden have a more pronounced specialization.
- One might argue that both countries have been early birds in certain specific areas, Denmark in terms of encouraging university patenting, Sweden with its implementation of the Competence Center Program, that became role models for other countries like Austria. Other specific features like the existence of large and research intensive companies in Denmark and Sweden cannot be emulated. Whereas Sweden is focusing on funding mechanism concerning industry-science relations for all HEIs, in Denmark it is more of a competitive effort by the leading universities to show that that they areconnected with the business sector and have a positive impact on research, innovation and businesses productivity. It is important that universities are developing more research and innovation cooperation linkages especially with small innovative and foreign companies in HT/Knowledge-intensive /fast growing sectors.
- With respect to policies supporting industry-science relations, Austria faced a remarkable catch-up in terms of implementing programs and measures to encourage industry-science relation since the beginning of the 2000s, at this stage already learning from other countries' experiences and approaches At the current stage of development of science-industry relations in Austria, emphasis has to be put on evaluating the success of existing measures and adopting the recommendations that has already been provided on programs like COMET or other recent evaluations. A focus should be on the optimization of the programmes with respect to their output (including 'behavioural additionality') and impact. Besides funding for establishing industry-science relations, Austrian universities should be incentivized to measure their industry cooperation and set up ambitious targets (reflected also in the performance contracts). In this respect, Austria should look towards Denmark and focus on implementation of reforms and to make quantitative impact assessments of industry-science relations. An approach worth being considered is the promotion of the inter-sectoral exchange of individuals with specific programs. Austria could think about the implementation of programs similar to e.g. the Danish Industrial PhD.

The Role of ERA policies for national STI policy

- Both the Danish and the Swedish research and innovation systems are well anchored internationally, though there are some debates about the attractiveness for students and researchers from abroad. Discussions about necessary steps to foster internationalization are going beyond Europe though, and address questions of positioning the HEI and the enterprises in global competition and value chains. Policy debates are characterized by predominantly national concerns and do not give European STI policy a large weight. This might be a reflection of well-endowed national research systems. Nevertheless, ERA priorities seem to have had at least some influence on priority setting, especially in the up-take of 'grand societal challenge' topics (following the Lund declaration). When it comes to support infrastructures, again there might not much to learn from the Danish and Swedish examples (scope for policy learning is quite often seen the other way round!). ERA initiatives, targets and instruments seem to play a greater role in Austria's strategic R&D-policy setting than in Denmark or Sweden. In the adoption of ERA-policy instruments in Austria (e.g. ERA-Observatory, FFG-EIP, ERA-Roadmap), Austria serves as a role model for Denmark and Sweden rather than the other way round.

- Even though, Austria performs significantly behind Sweden in terms of FP and H2020 indicators, regarding the share of retrieved funds to total funding as well as participation numbers and the share of project coordinators in FP6 and 7 and up till now in H2020. Regarding ERC grants (up till now 16 approved in H2020) Austria is in absolute terms behind Denmark (19) and Sweden (18) but compares well, if the respective sizes of the research base are taken into account. The expansion of these might also be the best way to approach the self-set Austrian target with respect to participation and coverage rate in H2020.
- ERA-related funding, policies and initiatives (FPs, ERA-Nets, JPIs etc.) are seen as an important supplement to existing strongholds rather than for the creation of new fields of excellence. Working on the efficient streamlining of public funds and positioning Austria according to the European requirements for tackling societal challenges and European priorities efficiently and at the same time exploit national strengths for future competitiveness have to be continuous challenges for national R&D and innovation policy.
- Mission-oriented funding seems to be gaining importance in a number of countries, among them the countries in comparison. This is triggered both by national debates on societal challenges as well as by the respective priorities set on the European level. The exact weight of this strand of policies is hard to assess, though. Overall, the role of thematic funding on national level compared to generic and structural funding is comparatively small in Austria. The most important source for thematic funding in Austria are the so-called topical programmes, mostly administered by the Austrian Research Promotion Agency FFG, accounting for around ¼ of total agency's funding. These programmes aim to support national and international priority areas, including energy, ICT, production, and security research, representing the most successful topics of Austrian participation in the Framework Programmes.
- The international trends show mission-oriented funding to shift from a technologically driven approach towards a user- and demand-driven orientation. Taking into account the learnings from the examples of other countries, Austria needs to start process towards aligning and disentangling of its structures for R&D-policy making and funding on several levels of policy making (national and regional governments and municipalities). A national effort towards mission- and challenge-oriented prioritization process, aligned with respective policies at the European level, might be a useful anchor for such a project.

- Experiences show that especially small countries might benefit from such a challenge-driven approach in mission-oriented funding based on bottom up-principles. Compared to the priorization of certain technology fields, this allows for a greater flexibility, since the government might not be right one to “pick winners”.
- Mission-oriented approaches require both, a strategic agenda, based on broad inclusion of stakeholders, as well as a dedicated amount of funding at least by ear-marking existing funds. Strategic and competitive funding programmes might be an incentive for universities to encourage specializations in certain areas. The formulation of measurable targets, both qualitative and quantitative, as well as monitoring and evaluation process is key to increase the accountability of any strategic program.

2 Technical Report

2.1 Background and target of the analysis

In the past two decades Austria experienced a remarkable catching-up process regarding key elements of its research and innovation system: research intensity increased from 1.93% of GDP in 2000 to estimated 3.01% percent in 2015, positioning Austria well ahead of the EU28 and OECD averages. Furthermore, the number of R&D performing firms rose substantially, especially comprising specialized SMEs and niche-players, industry-science relations improved considerably and research output from the Austrian science system showed positive developments both in terms of volume and quality (as measured e.g. in impact and international co-publications). For quite a while, Austria did not only see the indicators of its overall innovation performance (as depicted in the IUS) improve, but also saw an improvement in its position in rankings.

Against this background, in 2011 the Austrian government launched an RTI-Strategy[1] with the ultimate goal for Austria to become an innovation leader until 2020, according to its position in the European Commission's Innovation Union Scoreboard (IUS). Beside the target to broaden the financial base by increasing research intensity to 3.76% of GDP until 2020, and a substantial increase of the funding also for the tertiary sector (up to 2% of GDP), the strategy relies on a broad pillar of objectives in a comprehensive set of priority fields that needs to be addressed to meet the goal of catching-up to the group of innovation leader countries. These priority fields comprise human capital and the education system, universities and basic research, research infrastructure, the support for innovation and cooperative research, the cooperation between science and business, venture capital and start-up-support for research and innovation activities, efficient political government mechanisms including priority setting and funding mechanisms and internationalization of research.

Since the adoption of the RTI strategy, though, circumstances have changed and the Austrian research and innovation system seems to have lost its dynamism. Even during the catching-up phase, Austria's position in the Innovation Union Scoreboard remained in the so-called group of innovation follower countries. Whereas Austria's position in absolute values of the index slightly improved since 2006, they do so less than in other countries and hence the target of advancing to the ranks of the innovation leaders (as defined by the IUS) becomes less and less realistic, with Austria seeing its position recede in the past years and again falling by one position in the IUS 2015. Denmark and Sweden on the other hand persistently lead the group of innovation leader EU countries, just behind Switzerland, since the implementation of the IUS, putting strong emphasis on research and innovation policies and funding. This picture is reflected also by other research and innovation related rankings like the 'Innovationsindikator' of the Deutsche Telekomstiftung or the Global-Innovation-Index, especially pointing out the strong science base in Demark and Sweden. Like Austria, both have been facing serious reforms in past decades, e.g. regarding structure and financing of the tertiary sector.

[1] Austrian Federal Government (2011): Becoming an Innovation Leader - Strategy for Research, Technology andInnovation of the Austrian Federal Government, Vienna

The purpose of this study therefore is to draw lessons from successful policies and measures as well as to gather insights on the interaction of several aspects of the research and innovation systems in Denmark and Sweden, like the quality of tertiary education with the performance in research and innovation or the environment for business start-ups, that might be explanatory for the performance of those countries. Another important focus is the potential of ERA engagement to become an innovation leader. Potential success factors for the Danish and Swedish performance and national debates on the appropriateness and success of research and innovation policy measures are therefore assessed against the Austrian structure of the research and innovation system regarding the potential to draw learnings from Danish and Swedish research and innovation policies in the national context.

The project's Terms of Reference (ToR) addressed the following main research issues under which the Austrian research and innovation system should be analysed in the study:

Table 1: Key research questions

Becoming an innovation leader	Which mechanisms/policy measures/incentives would be the most appropriate to support the political objective for Austria to move from being an innovation follower to becoming an innovation leader? Which key stakeholders should be involved and how? What role is played by research-oriented enterprises, including spin-offs?
The role of Austrian universities	As the major part of research is carried out in Austrian universities, how can their profiles in the European context be raised further and more clearly defined? How can competition between and within universities be enhanced in order to optimise available resources and to incentivise performance? To the extent that universities in Sweden and Denmark function as backbones of their country's overall excellent performance in RDI: what are the main drivers behind their success?
Performance barriers in Austria	Which are the most serious/specific obstacles that restrain the innovation potential of Austria? What is the Potential of the European Research Area to overcome existing barriers in Austria? What could be mechanisms of consensus building be, in order to tackle the most serious obstacles in in Austria? What could be feasible options in an Austrian context and What existing good practice and/or failures, in Sweden, Denmark, or other countries do exist?
Specific lessons from Sweden and Denmark	To the extent that universities in Sweden and Denmark function as backbones of their country's overall excellent performance in RDI: what are the main drivers behind their success? Given the differences of each system, what are the components in Sweden and in Denmark that successfully combine scientific strengths and research capacity with industrial attractiveness and innovation What lessons can be learned from the strategic approaches of Sweden and Denmark in enhancing the research capacity and performance of universities and non-university research organisations, to increase the industrial attractiveness and innovation performance? How do these strategies and results compare to Austria?

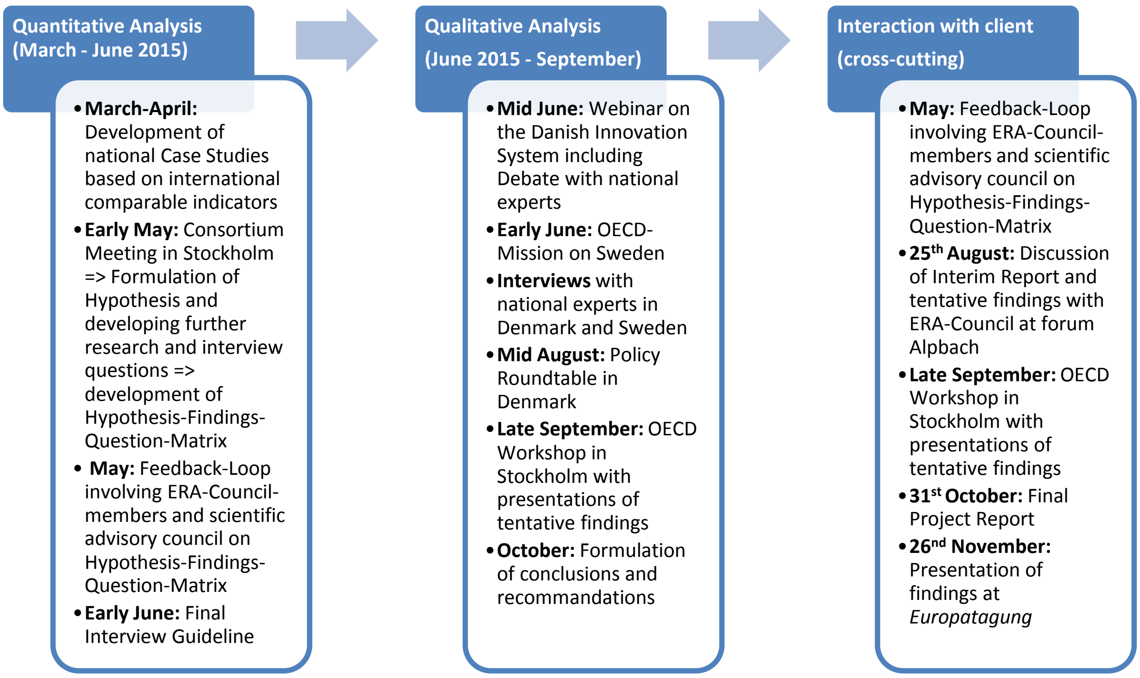
The aim of the study is to identify promising areas in terms of potential lessons for Austria, rather than performing a systemic analysis of strengths and weaknesses of the respective research and innovation systems in Denmark and Sweden as such. In terms of potential areas of improvement from an Austrian perspective, the IUS served as a starting point, but the aim was to look beyond the indicators that form the basis of the IUS, both by broadening the quantitative picture behind respective indicators as well as by adding a qualitative understanding of what constitutes an 'innovation leader' country more broadly.

Thus, conclusions and recommendations developed in this study are mainly based on assessments of national experts, also reflecting opinions on their explanatory power for the performance of Denmark and Sweden. The analysis of certain instruments, policy areas and strategies also took into account structural characteristics of the research and innovation systems in both countries and were reflected against the background of the Austrian framework conditions for RTI policy making, on wheter they actual have the potential to be emulated.

2.2 Structure of work

The operationalization of the research questions formulated in the ToR as well as the derivation of potential fields of improvement and recommendations for Austria's research and innovation policy was based on a two step-approach in terms of methodologies applied. The first part of the project in March and April 2015 aimed at i) taking stock of existing knowledge and current debates about the state of the innovations systems in Austria, Denmark and Sweden, ii) deepening our understanding of differences between the countries as depicted in the IUS by adding additional quantitative information along several dimensions. This comparison of specific features of the Austrian, Danish and Swedish research and innovation system was the basis for the identification of structural differences and the formulation of hypothesis of where Austria might have to improve its performance to become an innovation leader. This quantitative analysis provided the basis for starting of the qualitative testing of hypothesis, as well as for diving deeper into main areas of interest. Figure 1 gives an overview about major steps of the project.

Figure 1: Major steps in the project



2.2.1 Quantitative data collection and analysis

In a first step, the performance of Austria, Denmark and Sweden was analysed along the dimensions targeted by the IUS. The objective was to compare and extend the picture provided by the IUS with key findings from other analysis of the respective national innovation systems, comprising the OECD STI Outlook, the OECD STI Scoreboard and other OECD as well as national reports, evaluations and statistics on the innovation system. Furthermore, according to the issues emphasized in the ToR, IUS dimensions were extended by issues concerning the ERA, as well as the governance structure for RTI-policies and funding-schemes. Based on the quantitative identification of fields of performance differences main focal areas of further comparison and in-depth analysis were elaborated together with the project's scientific advisory board and the ERA Council Forum Austria:

- The funding structure for R&D,
- The role ERA instruments and policies for national R&D-system,
- Business R&D and Innovation Performance,
- The contribution of HEIs to national innovation performance in terms of i) the provision of skills, ii) scientific research, iii) policies and instruments to enforce knowledge transfer and commercialization activities.

On the basis of the findings from quantitative stock-taking, seven core hypotheses of where Austria might have to improve to catch up to the performances of the innovation leaders were developed. These hypotheses do not have the character of final conclusion but where mend to serve as motivation and input for the interviews with Danish and Swedish experts to directly contextualize their assessments with an Austrian perspective. The seven hypotheses are:

1. H1: Austria has to increase the number and improve the quality of graduates from HEI considerably to become an innovation leader,
2. H2: Austria has to increase the quality and international recognition of its research to the levels of Sweden and Denmark to become an innovation leader. In order to do so, it must raise at the same time the amount of spending on HEI and implement institutional reforms in its HEI institutions,
3. H4: Austria would have to substantially increase funding, especially competitive funding, funding for HEI, basic research and more risky research to become an innovation leader,
4. H4: Austria would have to foster structural change towards High-Tech/Knowledge-intensive /fast growing sectors to become an innovation leader:
    a. especially towards ICT (i.a. in the context of I4.0?),
    b. by fostering start-ups (i.a. through VC, change in legal framework),
5. H5: ERA can be a major leverage for the Austrian innovation system (both in terms of thematic orientation as well as financing) and is instrumental to become an innovation leader,
6. H6: Austria would have to review, assess and speed up implementation of its RTI Strategy to approach the self-set targets (which in turn will help in becoming an innovation leader),

7. H7: To become an innovation leader, Austria has to significantly improve Industry-Science Relations.

For each of these hypotheses, related research and interview questions were formulated to dig deeper into the respective areas, both by enriching the empirical base as well as by testing the perceptions with stakeholders' expertise. The resulting matrix of findings, hypotheses and questions was circulated and discussed with the members of the ERA-Council and the project's scientific advisory council. This framework of hypothesis and related questions forms the framework for the qualitative stage of the study towards the development of conclusions and recommendations from an Austrian perspective. Qualitative analysis was undertaken between June and September 2015.

2.2.2 Qualitative analysis

Based on the framework, elaborated from the quantitative comparisons, qualitative field work has been carried out. This includes several different approaches:

a. Webinars
b. Interviews
c. Focus Groups/policy roundtable

A Webinar was held on the Danish research an innovation system. Webinars are seminars carried out on a web platform (e.g. webex, http://www.webex.com). Webinars allow for presentations and structured debate across distance allowing for knowledge transfer, expert debates and learnings. The scope of the webinar was to gather a first insight on strategies and targets of Danish R&D and innovation policies, as well on of success factors and explanatory drivers for the overall performance of the Danish innovation system, based on the assessment of national experts. The webinar was structured along Danish expert-presentations and discussion with an Austrian debate panel among the following topics:

- The Danish innovation system and the significance of research quality
- Higher education structure and reforms influencing the innovation system
- Research, collaboration and entrepreneurship

The Outcome of the Webinar fed into the further development of research questions interview guideline. The derivation of research questions as well as interviews with Danish and Swedish experts from policy analysis, higher education institutions, funding institutions, public research institutions, policy advisory and performer councils as well as representative organisations from the business sector were performed by Austrian research team as well as by the partners from DAMVAD Analytics, being located both in Denmark and Sweden, incorporating their experience and knowledge from past work and their participation in national debates. A detailed list of interviewees could be found in the Annex. To discuss findings and conclusions on Denmark in broader context, a policy roundtable, including representatives from the Confederation of the Danish Industry, the national think tank DEA and the Danish Agency for Science, Technology and Innovation, was held with the members of the research team.

2.2.3 The OECD mission on Sweden and relation to this project

Independently, the Swedish authorities have requested the OECD to carry out a new Review of Sweden's Innovation Policy. This Review was carried out in parallel to our study. Building on the first OECD Review, published in 2012, the OECD will examine six major policy initiatives contained in the previous (2008) and current (2012) Research and Innovation Bill. One of our research team, Wolfgang Polt, has been invited to participate in and contribute to the OECD study. While the purpose and focus of the OECD study was different, there were thematic overlaps, as the OECD study was looking in-depth into issues relevant to the main building blocks that have also been identified as being in the core of this study. Arrangements have been made to allow for a mutually beneficial exchange of information while ensuring confidentiality and a clear distinction of the two studies.

Accordingly, the interview schedule of this project was adjusted in order to avoid collision with the fact-finding mission of the OECD review team. Interviews with Swedish national experts were mainly held in September. On the other hand, a major workshop of the OECD project, scheduled for September 30^{th} 2015 was used as an opportunity to discuss preliminary conclusions of our project with a high-level Swedish and international audience.

2.2.4 The scientific advisory council

This study was accompanied by a scientific advisory council, consisting of national experts of partnering countries in several fields of RTI-policy making. The scientific advisory council was engaged at several stages of the project, including the formulation of hypothesis and the development of an interview guideline as well is in development of final conclusion and recommendations. The scientific advisory council consisted of:

Mag. Gernot Hutschenreiter: Senior Economist, Country Studies and Outlook Division, Directorate for Science, Technology and Industry, OECD - Organisation for Economic Co-operation and Development, Paris

Dr. Michael Stampfer: Managing Director of the Vienna Science and Technology Fund WWTF

Charles Edquist: Holder of the Ruben Rausing Chair in Innovation Research at CIRCLE, Lund University, Sweden

Peter OLESEN: Chairman of the Danish Council for Strategic Research

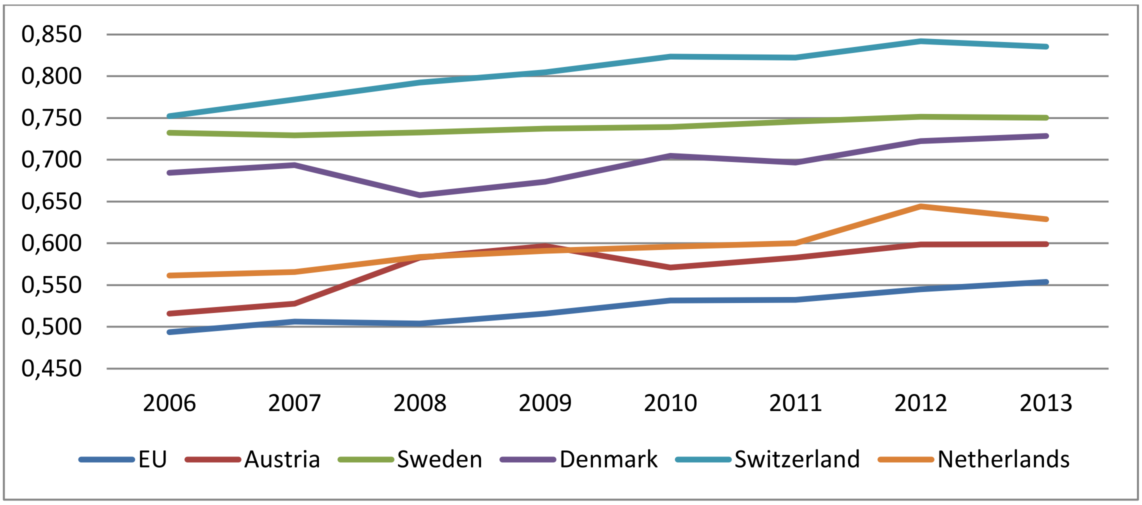
3 The overall picture: the gaps to become an innovation leader

3.1 Differences in IUS as benchmark: where are the gaps?

Since 2006 Austria's performance in the IUS-composite index increased in absolute terms. Nevertheless, due to a loss in dynamism in 2009, it is persistently ranked among the group of so-called *innovation follower* countries, even falling behind again by one position in the IUS 2015, now ranging on the 11th position of all EU-countries. Due to methodological changes (definitions and data sources of four indicators[2]) in the IUS 2015 compared to 2014, the methodological framework of the IUS 2014 was used for the identification of structural differences between Austria, Denmark and Sweden, since on this basis a consistent time series is availably between 2006 and 2013[3]. Though these methodological changes led to a slight improvement in the index' absolute value, they did not change the overall picture of some structural weaknesses of Austria according to the IUS dimensions, and therefore, since the IUS is a relational index, could not prevent Austria from again losing a position.[4]

Whereas Austria steadily improved regarding the level of the composite index it stagnates in its dynamic of catching up to innovation leader since 2009 with a performance above the EU average ranging between 108% and 110% since 2010. Sweden and Denmark, ranging in the group of innovation leaders on position 1 and 2 in the EU perform 135%, respectively 132% above the EU average.

Figure 2: Performance in IUS Composite Index



Source: IUS 2014

[2] Changes covered re-defintions of the following indicators: 1) Non-R&D innovation expenditure; 2) Community designs; 3) Contribution of MHT product exports to trade balance; 4) Employment fast-growing firms of innovative sectors.

[3] IUS 2014 data is based on up-till 2013 data sources.

[4] See BMWFW, BMVIT (2015): Austrian Research and Technology Report 2015. Report of the Federal Government to the Parliament (National Council): under Section 8(2): of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria, chapter 1.2

Though overall performance improved since 2006 in absolute terms, Austria suffers from structural characteristics and weaknesses that account for the overall stagnation of the Austrian position regarding the goal of becoming an "Innovation Leader". Whereas in some of the indicators improvements could be achieved, the overall picture remains rather stable since the implementation of the IUS. In eight out of 25 indicators of the IUS Austria even persistently performs below the EU-average (see Table 2Figure 2 for 2014). These trends do not indicate a possibility to catch-up to the high performance of Innovation Leaders in the near future. Especially, structural weaknesses comprise[5]:

- Non-R&D innovation expenditures
- Venture capital
- Non-EU doctorate students
- Knowledge-intensive services exports
- Sales of new to market and new to firm innovations
- Employment fast-growing firms of innovative sectors
- Population completed tertiary education
- Licence and patent revenues from abroad

Since Austria's position according to the IUS composite indicator is very much determined by the performance and developments of other countries, due the calculation method applied[6], the overall strides in improving its capacity for innovation (e.g. the increase in R&D-intensity, higher medium- and high-tech exports, increase in the share of workforce with university degree, as well as the increased publication actions of universities) are just poorly reflected in its ranking performance. Additionally some of the indicators negatively affect Austria's position due to their structural composition. This especially holds true for those indicators that rely on the structural composition of economic sectors, i.e. the indicators: *Employment fast-growing firms of innovative sectors*, *Employment in knowledge-intensive activities* and *Knowledge-intensive service exports*. These indicators reflect Austria being specialized in Medium- Low-tech sectors, according to the share of value added. Since the definition of knowledge intensity refers to the statistical classification of sectors with an international average share of university graduates of at least 33%, these indicators actually reflect the structural distribution instead the actual innovation performance of sectors. The same holds true for the indicators on *Employment fast-growing firms of innovative sectors* and *Contribution of MHT product exports to trade balance*, though in the latter Austria has a comparative advantage. Austria's relatively low score in the contribution of medium- and high-technology exports to the trade balance is partly due to its export surplus in low-technology goods. The indicator does not measure the trade balance in medium- and high-technology exports on their own, but whether this balance is more favourable than the overall trade balance. This means that countries with a trade deficit in medium- and high-technology goods can still achieve a positive score on this indicator, while highly competitive trade surpluses can produce a negative score if the surpluses in low-technology trade are higher still. The low score on the percentage of knowledge-intensive services exports among all services exports is mainly due to Austria's high

[5] BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014. Status report in accordance with Section 8(1): of the Research Organisation Act on federally subsidised research, technology and innovation in Austria, chapter 1.3

[6] „Minimum-Maximum"-method

services exports in the area of tourism, which are not regarded as knowledge-intensive, while logistics services (shipping, aviation, forwarding) are regarded as knowledge-intensive. Austria's below-average patent intensity among PCT applications primarily reflects the lack of large domestic corporations in the high-tech industries, since it is such corporations that dominate the patent activity in PCT applications.[7] This might also be the reason for its low performance in *Licence and patent revenues from abroad*.

The low share of tertiary graduates in the age cohort covered by the IUS (30-34 year old) points to a structural characteristic in Austria's education system, that is the high importance of colleges for higher vocational education (ISCED 3) for the Austrian labour market.[8] The weak performance in the indicator on Non-EU doctorate students might be also misleading regarding Austria's openness for foreign students, since the highest share of students from abroad comes from EU countries (43% from Germany)[9]. Furthermore, it is questionable, why the share of especially Non-EU-graduates might be explanatory for the innovation performance of countries, since it does not even reveal if they will stay in the respective country. Less explanatory power is also stated for the indicators on Venture Capital, without being accomplished by further analysis of typical entrepreneurial finance structures of a country, which are e.g. in Austria very much based on banking credits, especially for SMEs[10].

Table 2: Performance of Austria in IUS 2014 compared to DK and SE

	EU	DK	SE	AT
ENABLERS				
Human resources				
1.1.1 New doctorate graduates	1,7	2,3	2,9	2,2
1.1.2 Population completed tertiary education	35,8	43,0	47,9	26,3
1.1.3 Youth with upper secondary level education	80,2	72,0	86,4	86,6
Open, excellent and attractive research systems				
1.2.1 International scientific co-publications	343,2	1839,6	1711,9	1247,8
1.2.2 Scientific publications among top 10% most cited	11,0	14,5	12,7	11,1
1.2.3 Non-EU doctorate students	24,2	17,7	21,9	8,6
Finance and support				
1.3.1 Public R&D expenditure	0,75	1,02	1,08	0,88
1.3.2 Venture capital	0,277	0,296	0,289	0,134
FIRM ACTIVITIES				
Firm investments				
2.1.1 Business R&D expenditure	1,31	1,96	2,31	1,95
2.1.2 Non-R&D innovation expenditure	0,56	0,51	0,64	0,35
Linkages & entrepreneurship				
2.2.1 SMEs innovating in-house	31,8	40,8	37,7	36,3
2.2.2 Innovative SMEs collaborating with others	11,7	15,5	17,5	20,5
2.2.3 Public-private co-publications	7,3	13,1	12,1	9,3
Intellectual Assets				
2.3.1 PCT patent applications	1,98	2,55	2,97	2,30
2.3.2 PCT patent applications in societal challenges	0,92	1,45	1,47	1,09
2.3.3 Community trademarks	5,91	7,45	7,61	10,01
2.3.4 Community designs	4,75	8,14	4,82	8,39
OUTPUTS				

[7] BMWFW, BMVIT (2014)
[8] Bildung in Zahlen 2012/13 – Statistik Austria
[9] BMWFW (2014): Universitätsbericht 2014
[10] E.g. Hölzl, W. (2010): Austria's Small and Medium-sized Enterprises in the Financial Market Crisis, AUSTRIAN Economic Quarterly 1/2010

Innovators				
3.1.1 SMEs introducing product or process innovations	38,4	41,6	47,4	42,2
3.1.2 SMEs introducing marketing/organisational innovations	40,3	42,6	42,1	42,3
3.1.3 Employment fast-growing firms of innovative sectors	16,2	19,2	20,4	15,3
Economic effects				
3.2.1 Employment in knowledge-intensive activities	13,9	15,5	17,6	14,2
3.2.2 Contribution of MHT product exports to trade balance	1,27	-3,34	1,80	3,55
3.2.3 Knowledge-intensive services exports	45,3	65,1	39,8	23,8
3.2.4 Sales of new to market and new to firm innovations	14,4	15,0	8,4	11,9
3.2.5 Licence and patent revenues from abroad	0,77	0,89	1,13	0,45

Source: IUS 2014

To sum up: the IUS provides us with a good entry point into the debate of what Austria can learn from the two Innovation leaders. At the same time, critical reviews of the IUS have hinted to the fact that some of the IUS indicators might be a misleading guide for policy and even where appropriate and meaningful indicators were used, these cannot give a qualitatively rich picture on the underlying causes of the respective development. Hence, in the course of this study we aim to extend the picture of indicators by complementary figures, with a first attempt to reveal the underlying dynamics, as well as to discuss whether they are really decisive for Austria's innovation capacity. The following chapters will give a first overview of our attempts, but to arrive at a complete and in-depth picture will be the task of the second phase of the study.

3.2 Are Denmark and Sweden (really) innovation leaders? Some observations on the respective national debates

On the face of it, both comparator countries unquestionably deserve the label 'Innovation Leader'. Both countries consistently rank among the group of innovation leaders depicted not only in the IUS, but also in a number of other international RTI rankings (see e.g. the respective chapter 1.2 in the Austrian Research and Technology Report 2015).

But underneath the superficical views provided by these rankings, a more nuanced picture can be found: one of tensions, imbalances and challenges even these advanced innovation systems face. In the following, we will highlight a few of them. And policy learning for Austria will be most fruitful if not only focussing on the aspects where these two countries are ahead, but also on those where they face difficulties and the debate on how to meet them.

In the following, brief accounts on basic general characteristics of the respective innovation systems are provided. A more detailed discussion of its main sectors is given in subsequent chapters.

3.2.1 The Case of Sweden[11]

Sweden is among the highest ranked countries in the world in R&D investments as percentage of GDP and is consequently well above EU average in this measure. Despite having managed the effects of the 2008-2012 economic crises better than most EU countries and despite thorough efforts in the past few years to counter these negative trends, Swedish annual

[11] See for the following: Swedish Agency for Growth Policy Analysis (2011): The Performance and Challenges of the Swedish Nation Innovation System, Östersund; OECD (2013b): OECD Reviews of Innovation Policy: Sweden 2012; OECD Publishing and DAMVAD (2015): Case Study Sweden. Copenhagen/Stockholm

investment in R&D has been in steady (relative) decline. The main reason for this is dropping private sector R&D expenditure. On the performer side, the private sector dominates, with around 60% of the total R&D investments, of which a small number of very large companies account for the largest part of the private sector R&D activities. A strong academic sector consumes over 90% of the governmental appropriations for R&D and is thus responsible for most of the public R&D including not only basic research but also applied and strategic research programs for Swedish long-term competitiveness.

Sweden’s industrial structure is characterized by a comparatively large knowledge-intensive and export-oriented manufacturing sector, a relatively small private service sector but a large public service sector. Both the public and the private sector are dominated by large organizations. A large share of small- and medium-sized businesses and a few giant companies characterizes the industry. There are a little bit more than 1 million companies distributed among sole proprietorship (74 percent), businesses with 1-9 employees (22,4 percent), businesses with 10-49 employees (3 percent) and companies with more than 50 employees (0,56 percent).

The Swedish National Innovation System is quite polarized into two main groups of actors: on the one hand a small number of large multinational groups – about 10 - and a similar number of dominating universities. These two groups are responsible for the larger part of the R&D performed in Sweden. The universities that dominate the university sector and produce almost all R&D performance in the country are: The Karolinska Institute, Chalmers University of Technology, Uppsala University, Lund University, Gothenborg University, the Royal Institute of Technology (KTH), Stockholm University, Linköping University and Luleå University.

STI policy in Sweden is summarized in one national innovation strategy. The main thrust of the current Swedish national innovation strategy and vision for 2020 is to provide the best environment in six prioritized areas:

- Innovative people: The educational system is perceived to play a major role in contributing to the development of creativity and entrepreneurship. The Government's education policy aims to increase knowledge and competence in this vein.
- High quality research and higher education towards innovation: The Government points out research expertise in key enabling technologies as an important precondition for addressing challenges facing society. Infrastructure for innovation in research and higher education is seen as essential for a favourable innovation climate. The Innovation Strategy highlights excellence in research at universities and the development of leading research environments at the universities as an important measure also to foster innovation.
- Frameworks and infrastructure that create innovation: The Government emphasises the importance of developing framework conditions that enables incentives for individuals, businesses and other organisations to invest in innovation and risk taking in order to develop new solutions and grow. In this respect, there is also the ambition is further to strengthen the collaborations within EU, but even more so in global markets.
- Innovative businesses and organisations: The Government perceives that businesses in Sweden will grow by offering innovative solutions to the global market. In order to

facilitate SMEs to grow through innovation the government intends to focus on developing incentives to attract foreign entrepreneurs, and providing capital funding resources and more equal tax conditions. Further, ambitions are to increase the awareness of how social innovation can contribute to meet social challenges in all levels of society.

- Innovative public sector: One of the main objectives highlighted in the Strategy is to achieve effective public innovation support activities with customer value in mind. The National Council for Innovation and Quality in the Public Sector monitors this work.
- Innovative regions and environments: The strategy puts strong emphasis on the need for strategic efforts at the regional level. Therefore, the Government will provide measures that support long-term regional strategies, particularly focusing on strong innovation environments and clusters.

The Swedish Agency for Growth Policy outlined 29 indicators (see ANNEX) that are of particular importance to quantitatively measure how well Sweden is performing with respect to these priorities. These indicators will also be used in our study for comparison and for a widening of the perspective as compared to IUS.

<u>Main perceived strengths and challenges confronting the Swedish innovation system:</u>

From what we gathered from experts' opinions and interviews so far, there is a considerable debate about the sustainability of the Swedish Innovation system and its main pillars. These debates evolve around on the following topics:

- With respect to the quality of research (which is still highly ranked in international comparison using standard bibliometric indicators) there are concerns voiced about a gradual decline of the Swedish standing[12]. Significant improvements are said to be needed to counter this tendency, e.g. with respect to the internationalisation of staff at Swedish HEI or with respect to necessary concentration and specialisation of Swedish research on specific research areas (counterarguments point to the already high concentration institution wise). Several schemes have been put in place to increase Sweden's attractiveness for international researches.
- In higher education, following the strong increase in the numbers of students and graduates in the past decade, there is a perception of declining quality of graduates and their employability. Teaching (and its quality) is seen by some as a mayor construction site in Swedish HE system. In this vein, there is also a debate about the respective roles of HEIs (especially with respect to the 'younger' universities and the university colleges) in research and/or teaching.
- Financing streams for R&D are also subject of some controversy: many in the HEI sector argue for a further increase in block funding (which has increased in the past and ranks high in international comparison) as compared to streams of competitive funding. These are said to limit the degree of freedom for universities too much (because of their co-funding requirements) and hence should be reduced in weight. Likewise, the increased thematic orientation of the streams of competitive funding (e.g. the increased orientation

[12] Öquist, G., Benner, M. (2012): Fostering breakthrough research: a comparative study, AKADEMIRAPPORT, Stockholm

towards societal goals alongside the thematic priorities set at the European level or the tying of these streams to science-industry cooperation) are questioned and named as obstacles to research excellence.

- While the industrial base in Sweden is still strong, recent years have seen problems in long-established industries and firms, in some instances accompanied by a loss of strategic ownership. While this is sometimes seen as a necessary development in increasingly global value chains, it is also associated with fears about a re-location of strategic functions of the companies, among which R&D.
- Shifts in industrial structure, entry into new growth areas and the renewal of industrial base through start-ups – though more rapid than in Austria, especially in the ICT sector – are sometimes perceived to be too slow to cope with international competition[13].
- While Sweden performs considerably better than Austria regarding business R&D, venture capital and science-industry linkages, these are quite often not perceived as strengths, but as challenges of the Swedish Innovation System. E.g. interaction between the academic sector (basic research) and industry (applied research and development) is sometimes characterized as resulting among others in a suboptimal performance in commercialization of research results from academia. A recent report points to a relative lack of venture capital and other critical resources for innovation especially in SMEs, and an entrepreneurial climate hampered by unfavorable incentive structures for starting firms compared to regular employment.[14][15] Here, we will have a closer look at the relative importance of the differences between Austria and Sweden in VC funding and start-up incentives.
- Also, the research and innovation policy system does not receive unequivocal acclaim, as it is quite often characterized as being lop-sided towards science and higher education policy with (relatively little weight on innovation policy). Also, the system seems to pay relatively little attention to European RTI policy (despite the topical reference to the Lund conference) and seems to be mainly concerned with either national or global contexts.

  On the overall level, it is recently debated whether Sweden is really an Innovation leader in terms of outputs, e.g. by members of the newly formed Innovation Council hinting at an unfavourable rate of inputs (which are said to be high) and outputs (which are said to be mediocre)[16].

[13] See e.g. Färnstrand D. E., Thursby, M. (2015):, University entrepreneurship and professor Privilege, in: Industrial and Corporate Change, Volume 22, Number 1, pp. 183–218

[14] largely stemming from the structure of the welfare system which favors wage earners

[15] See Norden Nordic Innovation (2012): The Nordic Growth-Entrepreneurship Review 2012, Nordic Innovation Publication 2012:25, Oslo

[16] Edquist, C., Zabala-Iturriagagoitia, J.M (2015): The Innovation Union Scoreboard is Flawed: The case of Sweden – not being the innovation leader of the EU. Lund Papers in Innovation StudiesPaper no. 2015/16

3.2.2 The Case of Denmark

In the last decade, funding for R&D and innovation activities especially from the public sector increased substantially. This was accompanied also by a number of structural reforms in the system based on the assumption, that an increase in inputs has to be aligned with more efficient institutional structures. A major reform comprised the restructuring of the higher education sector and public research performing institutions in 2007, reducing their number from almost 30 to eight public universities and three public research institutions.[17] Furthermore, there are nine so-called GTS-Institutes (Godkendt Teknologisk Service) in place which are comparable in their mission and structure to Fraunhofer Association as independent not- profit organisations whose purpose is to spread technical know-how, new methods and knowledge to industry and society in order to create and increase development.

The major target of public policies is to increase the impact of research on productivity and innovativeness, i.e. the better utilisation of the already excellent science base. The Globalisation Strategy of 2006 set the target to increase R&D-expenditures to 3% of GDP, which is already achieved with total R&D-expenditures of € 8 billion in 2014 (3.1% of GDP)[18]. Regarding the structure of R&D-expenditures, Denmark also meets the Barcelona-targets with public expenditures accounting 1.1% of GDP and private sector expenditures for 2% of GDP in 2012. Funding for R&D (€ 2.8 billion in 2013) in the public sector mainly comes from public sources. € 2.1 billion comprise public expenditures, € 0.4 billion come from private foundations, € 0.2 billion from abroad (incl. EU-Funding, Nordic Council of Ministries, UK and US) and € 0.1 billion from private companies.

Against this background, in the Innovation Strategy of 2012 a new funding target of 3.5% of GDP was set. While the Globalisation Strategy 2006 was mainly focusing on improving the efficiency in public spending on research and education, the target of increasing the impact of research on productivity and innovation performance has not been achieved so far, as several evaluations pointed out.[19] The Danish Innovation Strategy of 2012 widened the emphasis on research and innovation to contribute to solutions to grand societal challenges as well as further increasing competitiveness of the business sector. Targets are stated that Denmark should catch up to Top-5 OECD-countries, regarding the share of innovative enterprises, the amount of private R&D-expenditures as well as the amount of people with higher education the private sector. Public R&D-expenditures in % of GDP are already the top 5 among OECD-countries.

Based on experts' assessment gathered so far, factors explaining success and strengths of the Danish STI-system are described in the following.

<u>Main perceived strengths and challenges confronting the Danish innovation system:</u>

- Strong human resources for R&D with scientific personnel and researchers in the public as well as the private sector (both in % of total employment and active population) above EU averages as well as ahead of comparative countries. Furthermore, in terms of academic educated people in the workforce has significantly increased since the beginning of the

[17] Oddershede, J. (2009): Danish universities – a sector in change; Universities Denmark
[18] Statistics Denmark: Research and development at http://www.dst.dk/en/Statistik/emner/forskning-udvikling-og-innovation/forskning-og-udvikling
[19] Klitkou, A. (2013): Mini Country Report Denmark– Thematic Report 2011 under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)

2000. Enrolment in tertiary education is booming especially in PhD-programmes, with focus on health, technical and natural sciences since 2007. This is accompanied by a massive increase in public financing for universities since 2006, since it is to a large part based on the number of intakes.

- Scientific output, impact and productivity of researchers are high. Denmark ranges among the top countries in the OECD regarding scientific publications per capita as well as citation impact figures. This could only partly be attributed to the 2009 implemented bibliometrical indicator. Some universities directly channel these funds as additional grants to high performing researchers, which causes enormous incentives for research productivity. In total, increasing the number of researchers at universities, also based on an increase in PhD-students, as well as the increased competition in funding, international collaboration as well as output-oriented collaboration with the industry are perceived as being major factors behind these developments.
- International collaboration in R&D and international attractiveness for PhD-Students: Since the beginning of 2000 the share of scientific publications with international co-authorship increased from 29% to 35% in 2011. Citations of publications with international co-authorship are higher than with just including national authors.[20] The share of doctoral students from non-EU-countries is, even if below the EU-average[21], significantly higher than in Austria and attracting high-skilled and educated people from abroad is high on governments' agenda. Explanations for Danish international attractiveness as research partner and location for researchers are seen in the structure of its doctoral education, with students being most regularly employed at universities and several funding mechanisms are being in place to boost excellent basic research e.g. DNRF Center of Excellence, Industrial PhD programme, Novo Nordisk Laureate Research etc. Total funding for PhD students at universities comprises around 4 billion DKK annually (536 million Euro) as part universities' basic financing.[22]
- Efficient funding structures and targeted schemes: R&D and Innovation funding by the public sector relies on clear division of labour between public sector funding agencies and councils. For further improvement of the system, emphasis is put on simplification and coordination of funding structures as well as on the implementation of new instruments for challenge-driven innovation. In line with that in April 2014 the Danish Council for Strategic Research, Danish Council for Technology and Innovation and the Danish National Advanced Technology Foundation were merged to create the Innovation Fund Denmark. Public emphasis in research funding, also coordination with private sources, is put on the optimal provision of schemes and funds among the three pillars -) education and individuals, -) research platforms, -) international collaboration and attraction of foreign researchers, with several dedicated measures in place.
- A characteristic of the Danish R&D and innovation funding landscape is the prominent role of private foundations, as independent funding bodies with specific objectives and fields of interest. In 2013 R&D-funding by the private non-profit sector accounted for 0.12% of GDP, compared to Austria with 0.01%. Prominent examples are the Novo

[20] Novo Nordisk Foundation
[21] Innovation Union Scoreboard 2015
[22] Statistics Denmark

Nordisk Foundation, funding mainly basic but also applied research with focus on medical sciences and technology and a budget of € 105 million in 2013. A prominent funding scheme is the Laureate Research Teams, where excellent researchers have the possibility to work on long term research projects (until 14 years) within self-selected teams. Other examples, pointing out the financial significance of the private foundations are Villum and Velux Foundation with an annual budget of around € 120 million or the Lundbeck Foundation, ranging above the budget of the Danish National Research Foundation (DNRF) of around € 60 million annually.[23] Collaboration between private and public foundations is emphasised e.g. via co-financing models. For example, universities and private funds co-finance academic programs such as PhD-programs and research projects when the universities and private funds share a common interest in the program or project. In total there are around 1000 small private philanthropic funding entities in place, financing education, research, innovation, social and humanitarian activities.

- Further emphasis on collaborative research between sciences and the business sector. Several evaluations report public-private research collaborations to have a positive effect on productivity of firms (TFP, labour productivity) as well as on scientific impact.[24] Statistics show a positive relationship between the amount of academic-industry collaboration and the quality of publication output, measured in % of top-10 highly cited publications, enforcing the concept of “use-inspired basic research”.[25] A successful measure to increase the interlinkages between the private and the academic sector is the Industrial PhD-program, funded by the Danish Innovation Fund. Students are employed both at a company and at the university (50/50) where they finish their degree. Partners from the private sector are mostly aware of the research obligation of theirs PhDs. Salaries are publicly subsidised at a rate of 30 – 50%. Participants of the Industrial PhD-programme have a higher tendency to be employed in the private sector. Furthermore, industrial PhD-projects are found to have a positive impact on firms patenting activity.[26] SMEs, using the innovation voucher tend to be more productive. Nevertheless, since R&D in the business sector is still concentrated in a few large and old companies, Denmark could not be described as a “start-up” nation, as experts stated. Though firms birth rates, especially for one-person-companies are high death rates are also and so overall employment in start-up-companies is weak, with Denmark lagging behind other Nordic countries, i.e. Norway, Sweden and Finland. [27] As possible implication a shift in weights between funding of individuals and funding of science-industry relations was suggested.

- ERA initiatives and funding are issues in the Danish RTI policy discussion but figure much less prominent than national funding sources and initiatives. Research Actors, e.g. the Danish Technical University (DTU) pointed out the highly complex structure of schemes like KICs[28], as well as up till now still unclear results. In general the perception seems to be, that the administrative burden for EU projects is high, and that as long as national

[23] DNRF Annual Report 2014
[24] Klitkou, A. (2013): Mini Country Report Denmark– Thematic Report 2011 under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)
[25] Technical University of Denmark DTU
[26] Danish Agency for Science, Technology and Innovation (2011): Analysis of the Industrial PhD Programme)
[27] Norden Nordic Innovation (2012): The Nordic Growth-Entrepreneurship Review 2012, Nordic Innovation Publication 2012:25
[28] Knowledge and Innovation Communities funded by the European Institute of Innovation and Technology

funds are sufficiently available, EU programs will play a less prominent role, especially for companies. This holds also true regarding the importance of challenge driven funding in line with EU-Grand Challenges. The perception is that with the existence of sufficient endowment of national funding, bi- and multi-lateral as well as European funding sources are of lesser importance. The major value added of EU funds and schemes are seen in the possibility to establish collaborations outside Denmark.

4 Structural comparison of Denmark, Sweden and Austria along selected areas of potential learnings

Taking the IUS as starting point for the analysis, in a first step an in-depth analysis on the RTI-systems of Denmark and Sweden, based on existing empirical studies and quantitative indicators from OECD, Eurostat and national sources, was undertaken. IUS dimensions were extended to issues concerning the ERA, as well as the governance structure for RTI-policies and funding-schemes. In line with the Austrian discussion about bottlenecks and weaknesses in the national RTI-landscape, emphasis was put especially on the role and structure of higher education institutions (HEIs) in the innovation system, regarding their performance in teaching, research and knowledge transfer, as well as on specialisation patterns, RTI performance and financing, and structural composition in the business sector, including industry structure and start-up-dynamics as well as the role of Venture Capital. Based on the findings of this comparative analysis, core areas, identifying potential areas for improvement against the performance of Denmark and Sweden, have been identified and will be presented in the following chapters. These comprise output and structure of tertiary education; science-industry linkages and commercialisation of research; funding for HEIs, basic and risky research; the role of performance based funding schemes for HEIs; business dynamics, R&D and innovation performance; the Role of ERA policies and instruments; mission-oriented R&D-funding; science-industry linkages and commercialisation of research. The analysis of these specific areas and their potential to provide lessons for Austria was a bi-directional process. Experienced performance differences of Austria against Denmark and Sweden from the quantitative comparison were discussed with national experts in Denmark and Sweden on their significance for research and innovation performance, aiming to identify reasons for these differences as well as recommendations that potentially could be drawn from that. To do so, the findings form the comparative analysis as well as potential explanations for the performance in Denmark and Sweden were reflected also against national characteristics in the specific fields in Austria to identify whether specific characteristics could be emulated.

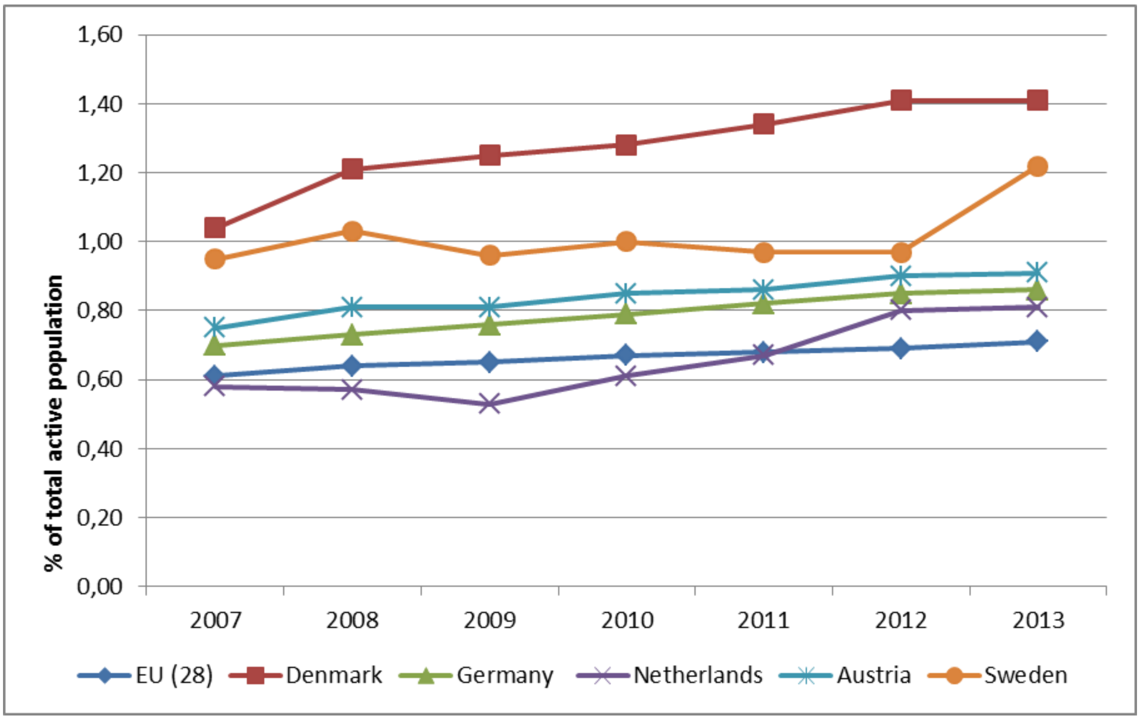
The chapters are therefore mainly structured as follows: At first, findings from the quantitative stocktaking on performance differences between those countries were presented. Wherever possible with comparative date being available also the Netherlands, Germany and Switzerland was taken into account as reference points (with Germany and the Switzerland being both in the group of the innovation leaders) for the positioning of Austria, Denmark and Sweden among other top-performers in the IUS. In a second step, national characteristics and discussions of Denmark and Sweden as well as of Austria on the specific topic are summarized. Synthesis, conclusions and were possible and reasonable recommendations are presented at the end of each of the respective chapters.

4.1 Output and structure of tertiary education

The IUS indicators that are related to tertiary education are frequently referred to be one major explanatory factor for Austria's weak performance, though focusing on very selective aspects, i.e. share of individuals with completed tertiary education (age group 30-34), the share of new doctorate graduates as well as non-EU-doctoral students.

Highly skilled human resources are a key input for R&D and the innovation capacity of a country. Figure 3 displays the share of researchers[29] (full-time-equivalents, FTE) in total active population (labour force). Sweden was over a long time a high-performer in terms of its resources of researchers. Whereas Austria closed the gap to Sweden in recent years, Denmark faced a massive increase in its share of researchers in active population since the mid of 2000. This was to a large part driven by emphasizing the intake of PhDs according to the targets formulated in the Globalisation strategy 2006.

*Figure 3: Total number of researchers (FTE) as % of active population, 2007-2013**



*due to breaks in time series, only for this period comparable figures are available
Source: Eurostat (2015)[30]

In the following therefore emphasis is put on the questions of whether the tertiary education sector is providing the necessary inputs for innovation via well-trained graduates in sufficient numbers, specialization and quality, as this seems to be a major issue in all analysis of Austrian innovation and economic performance. In the following, at first a comparative overview of Austria's performance along key indicators will be presented. In a second step, insights in national debates and reforms regarding tertiary education in Denmark and Sweden will be

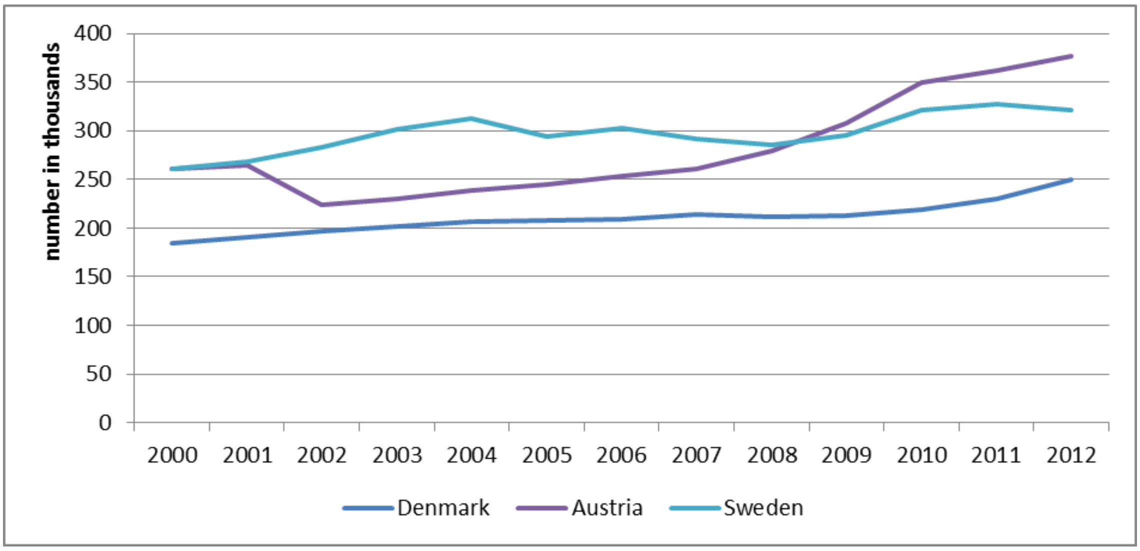
[29] Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned. This includes PhD-students working as researchers and scientific project managers according to OECD (2002): Frascati Manual.
[30] Eurostat (2015): Total R&D personnel and researchers by sectors of performance, as % of total labour force and total employment, and by sex [rd_p_perslf]

provided, followed by a synthesis of conclusions regarding potential learnings that could be drawn for Austria.

4.1.1 Educational outcome – a comparison

Compared to Denmark and Sweden, Austria faced the most dramatic increases in student numbers in the past decade (+44% between 2000 and 2012; DK +35%; SE +23%; see Figure 4).

Figure 4: Number of total students (full-time-equivalents) in thousands, 2000-2012

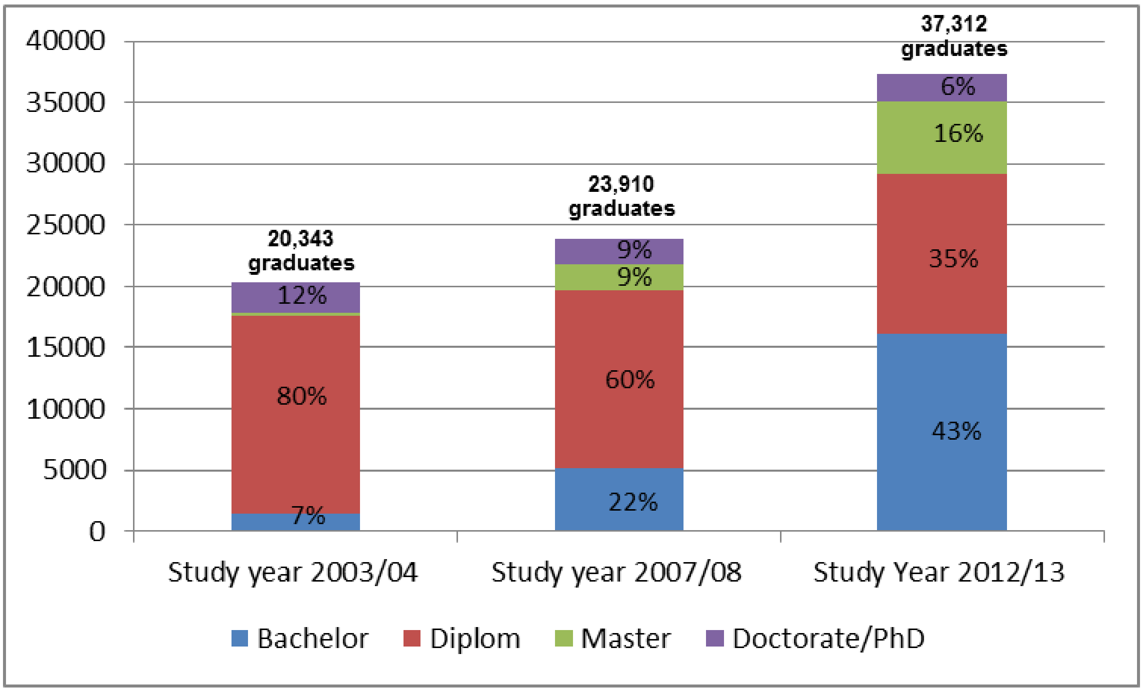


Source: Eurostat (2015)[31]

Also the number of total regular studies applied at Austrian public universities increased by 32%, from 262.957 in 2003 to 346,385 in 2012. In the study year 2012/13 51% of total studies applied account for Bachelor studies, 29% are Diploma studies, 12% Master. The share of doctoral studies increased from 6% in 2003 to 8% in 2012.[32] At the same time the share of total graduates increased by 83.4%, which is mainly due to the implementation of the bachelor-master structure ("Bologna" system) in 2006 (see Figure 5).

[31] Eurostat (2015): Students by ISCED level, type of institution (private or public) and study intensity (full-time, part-time) [educ_enrl1at]
[32] Statistik Austria (2015): Studien an öffentlichen Universitäten

Figure 5: Austrian university graduates by type of study and total graduates, 2003-2012



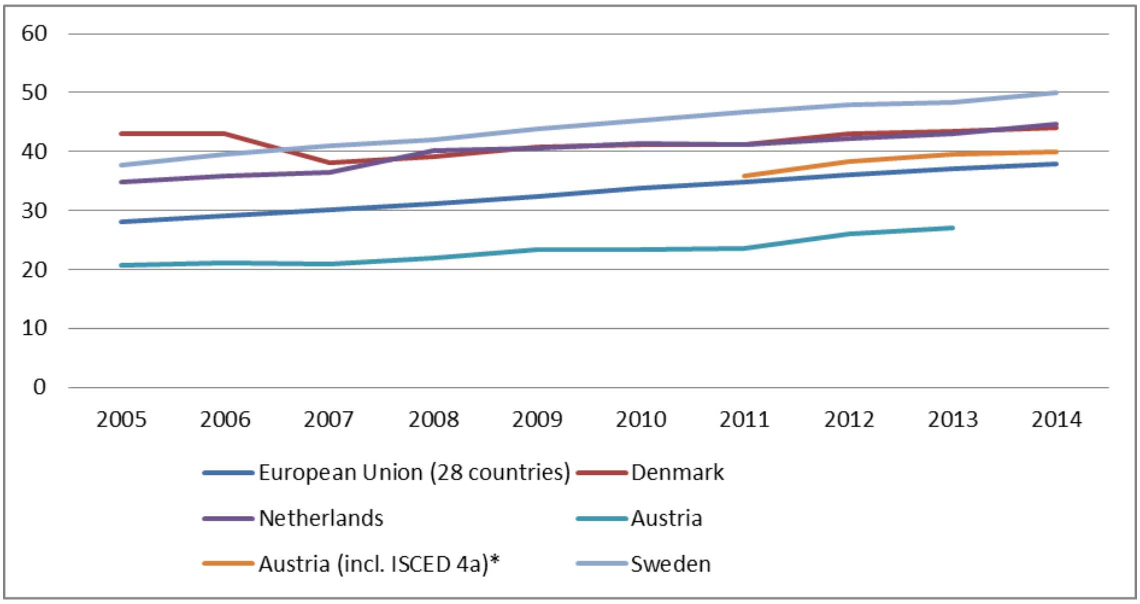
Source: Statistik Austria (2015)[33]

Though a significant increase in student numbers and graduates took place in the past decade, Austria still ranges among the OECD-countries with the lowest share of tertiary graduates in population, whereas both Denmark and Sweden perform at the upper edge of OECD-countries. The share of population with completed tertiary education aged 30-34, as performance measure in the IUS, increased from 20.5% in 2005 to 26.3% in 2012 but this dynamic has not been sufficient to catch up with the higher levels of innovation leaders so far. In Sweden the same indicator increased by 10 percentage points in the same period, from 37.6% to 47.9%.

Taking into account the important role of upper-secondary institutions for vocational education in Austria, comprising non-academic colleges for vocational education ("berufsbildende höhere Schulen") and non-academic schools for nursing that are at tertiary level in Denmark and Sweden, the European Commission decided to account for that by incorporating these educations (ISCED 4a) into Austria's tertiary attainment. Based on that, Austria met the EU 2020 target of 40% tertiary graduates in the age cohort 30-34 in 2014, but still ranges below Denmark and Sweden (see Figure 6).

[33] Statistik Austria (2015): Studienabschlüsse an öffentlichen Universitäten

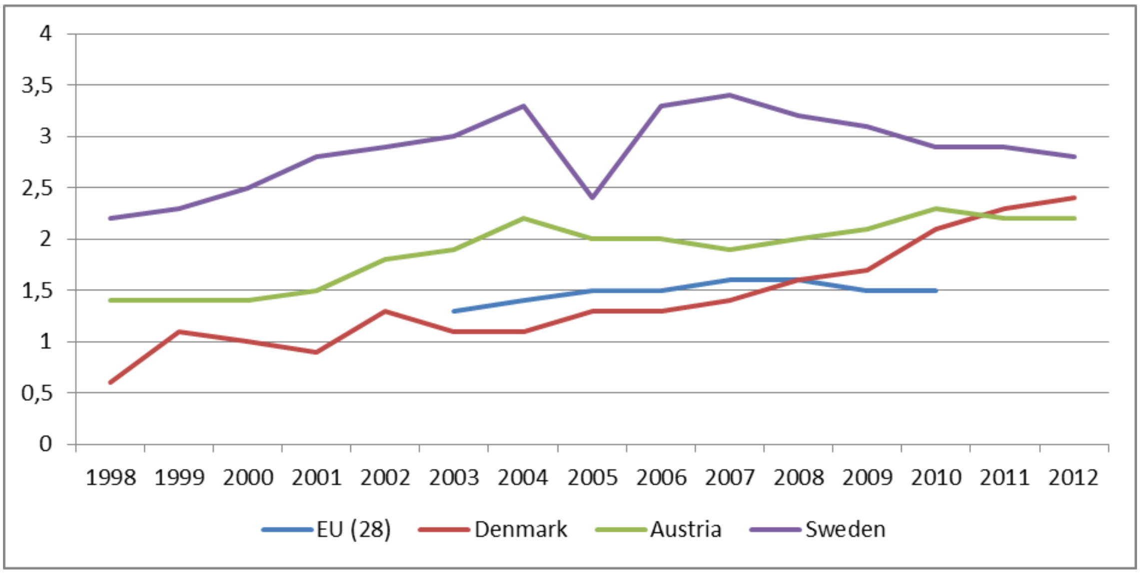
Figure 6: Population with tertiary educational attainment level (levels 5-8) by sex and age (30 to 34 years)



*for 2011 and 2012 figures from the Report on Austria's Scientific and Technological Capability 2013-2015 of the Austrian Council for Research and Technology Development
Source: Eurostat[34]

In terms of doctoral/PhD graduates Austria performed above Denmark and below Sweden until 2010 (see Figure 7). The investment in PhD-programmes and education in Denmark (see section on Danish tertiary education), brought at boost in the share of PhD graduates in Denmark since 2007, whereas Austria has been pretty much stagnating over the last decade.

Figure 7: PhD-graduates per 1000 of population in the age cohort 25-34*

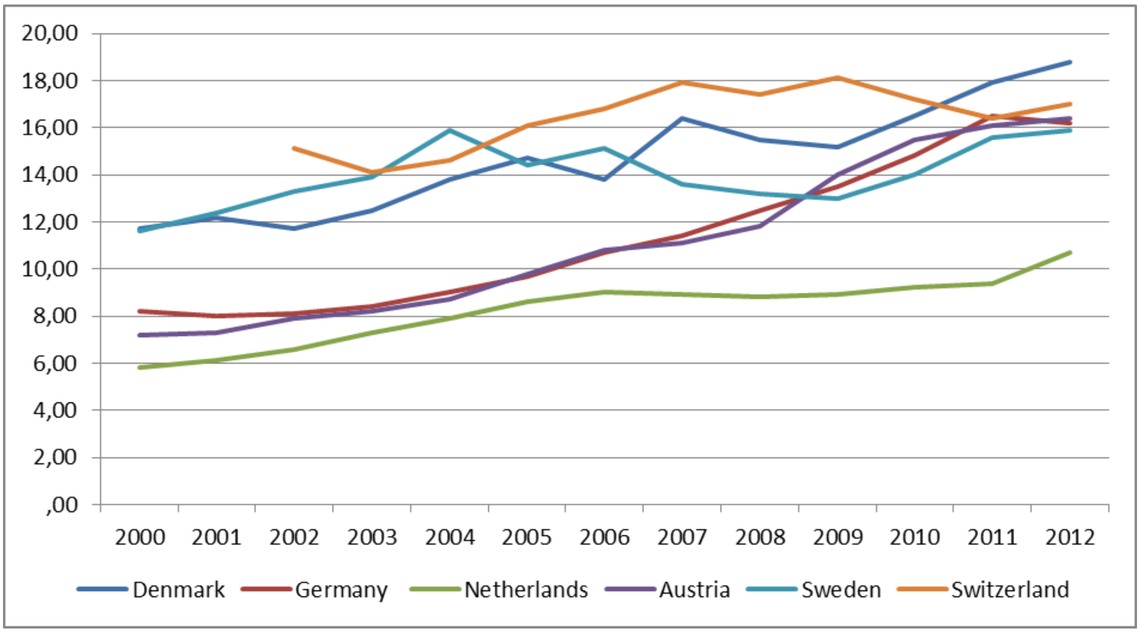


*ISCED-level 6, according to ISCED 1997
Source: Eurostat (2015)[35]

[34] Eurostat (2015): Population with tertiary educational attainment level (levels 5-8) by sex and age (15 to 64 years)
[35] Eurostat (2015): Tertiary education graduates [educ_itertc]

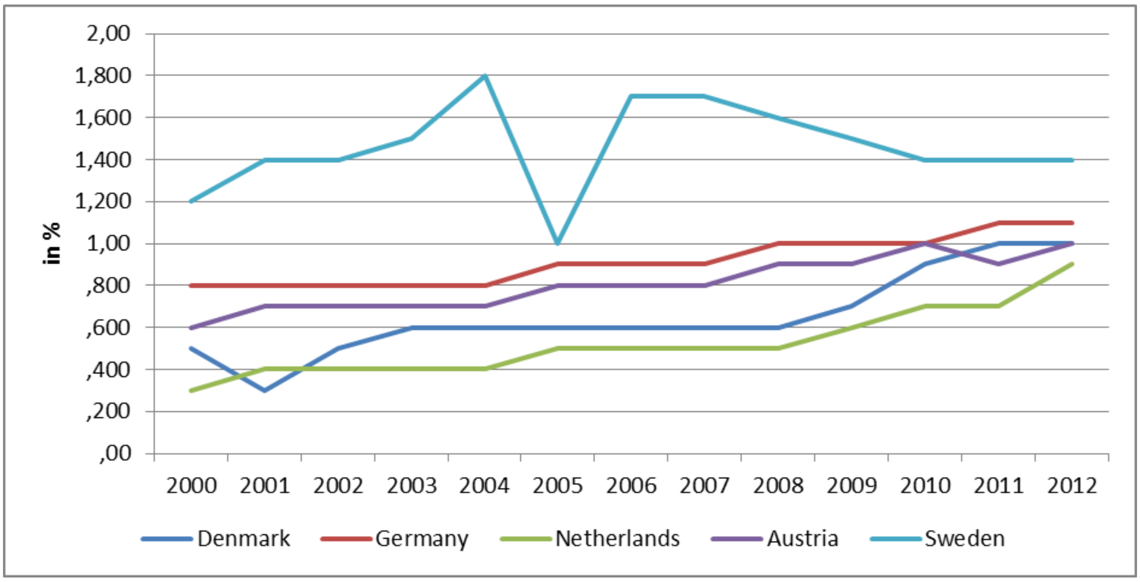
In total 55.4% of Austrian university students graduated in either Social Sciences or Humanities in the study year 2012/13. 25.8% graduated in the so-called STEM-subjects (Science, Technology, Engineering and Mathematic). Figure 8 displays the share of STEM-graduates per 1000 of population in the age-cohort of 20-29. It shows that Austria managed to catch with Sweden and reduced to gap to Denmark between 2000 and 2012. This holds also true for the share of STEM-graduates at PhD-level in the typical age cohort of 25 to 34 (see Figure 9).

Figure 8: STEM-graduates per 1000 of population in the age cohort 20-29



Source: Eurostat (2015)[36]

Figure 9: STEM-graduates at PhD-level per 1000 of population in the age cohort 25-34

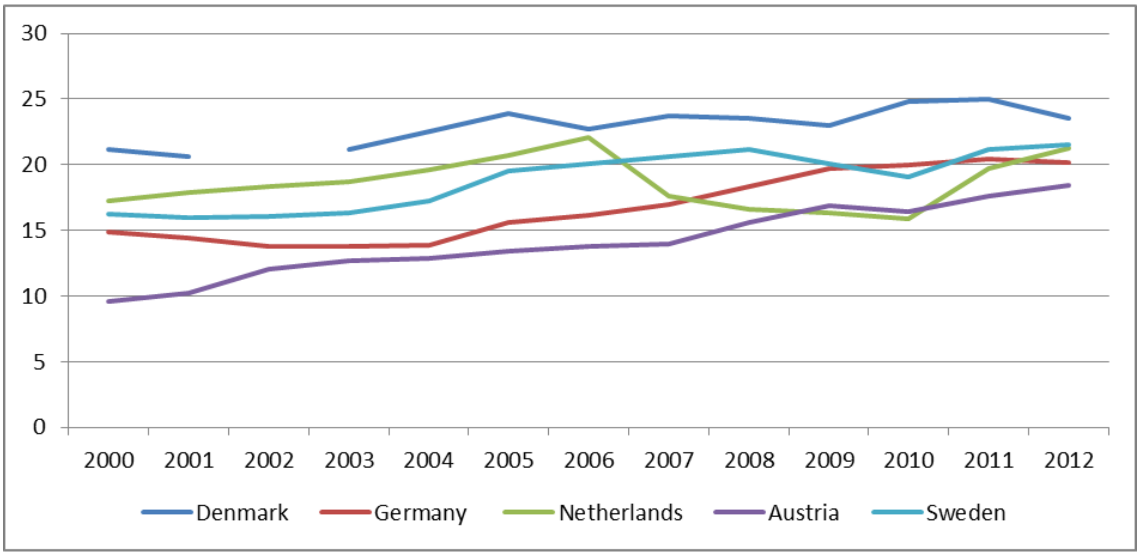


Source: Eurostat (2015)[37]

[36] Eurostat (2015): Tertiary education graduates [educ_itertc]
[37] Eurostat (2015): Tertiary education graduates [educ_itertc]

Taking the ratio of annual graduates to students enrolled as measure for the efficiency in the throughput of students, it shows, though an again observable increase in the Austrian performance, the gap between Denmark and Sweden is still persistent. Another indicator applied in Austria to measure the efficiency in the provision of graduates is the ratio of successfully finished studies to total studies quit. With 47.5% in the study year 2012/13[38] only have of total studies quit were finished with a degree.

Figure 10: Ratio of graduates per student, 2000-2012*



*Full-time equivalents
Source: Eurostat (2015)[39], calculation JOANNEUM RESEARCH

4.1.2 Structural composition of the tertiary education sector

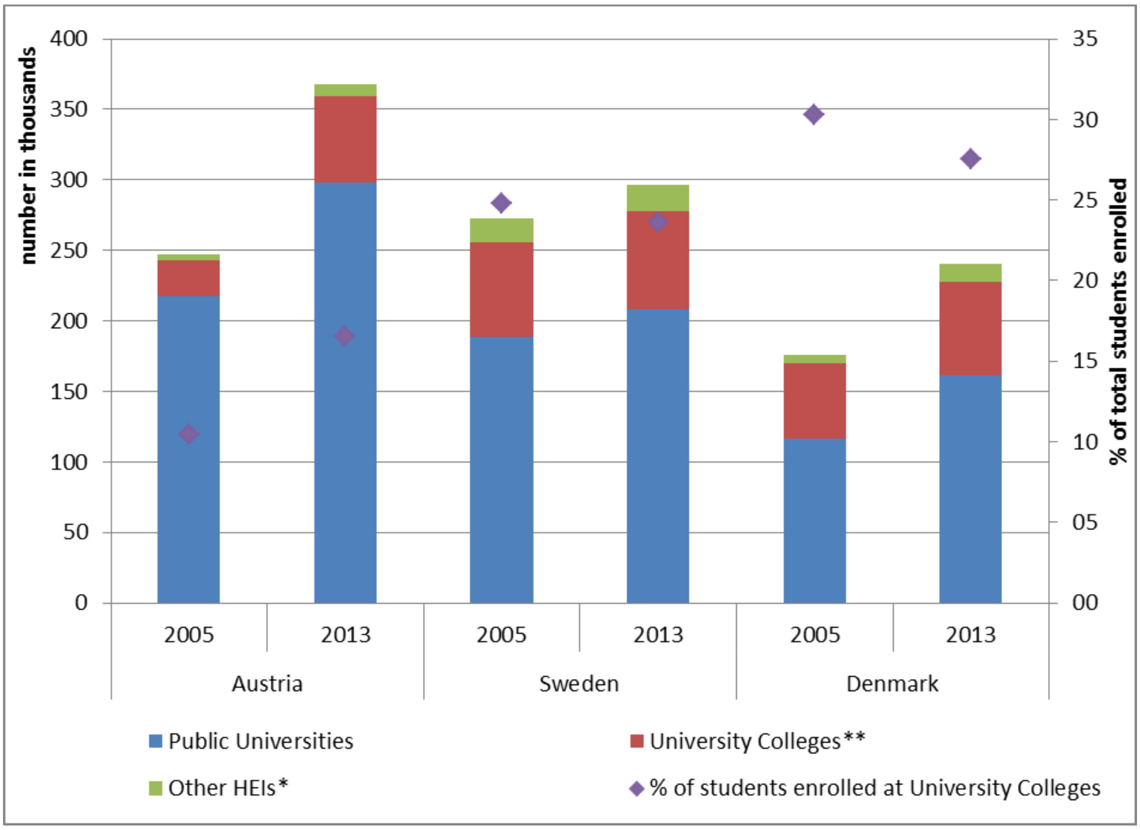
Since the beginning of the nineties some structural changes in the Austrian institution's landscape of the tertiary sector took place, accompanied by fundamental reforms in governance and financing mechanisms for universities. In 1994 universities of applied science (UAS) were established to complement the functions of universities in science-led education and scientific research by scientific based professional education and applied research. In 2004 former medical faculties of universities gained independence as medical universities. In 2007 former educational schools for teacher education for primary and non-academic secondary schools have been restructured as university colleges for teacher education with bachelor degrees as final degree. The accreditation of private universities in 1999 further increased to possibilities for gaining an academic degree in Austria.[40]

The Austrian tertiary sector is therefore characterized by a high number of medium and small institutions, comprising 22 public universities , 21 universities of applied science, 11 private universities and 14 university colleges for teacher education, with public universities still accounting for the highest share of both tertiary education and research.

[38] BMWFW (2014): Universitätsbericht 2014 Dem Nationalrat vom Bundesminister für Wissenschaft, Forschung und Wirtschaft gemäß § 11 Universitätsgesetz 2002, BGBl. I Nr. 120/2002, vorgelegt, p. 192
[39] Eurostat (2015): Graduates in ISCED 5 and 6 by age and sex [educ_grad4]
[40] BMWFW, BMVIT (2015): Austrian Research and Technology Report 2015. Report of the Federal Government to the Parliament (National Council): under Section 8(2): of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria

In Sweden and Denmark the provision of tertiary education is more diversified among different types of institutions, with especially in Denmark university colleges play a more prominent role than in Austria. Figure 11 displays the number of tertiary enrolled students by type of institutions for Austria, Sweden and Denmark for the years 2005 and 2013. Both in Austria and Denmark, student numbers faced a rapid increase in that period (+49% in AT; +36% in DK), whereas remaining pretty stable in Sweden (+9%).[41] Though the share of students being educated in University Colleges[42] in Austria increased it is still nearly half as much as in Denmark. Furthermore, public universities in Austria account for the largest share of tertiary graduates with 68.7% in 2012. 22.7% graduated at universities of applied sciences, 6.1% at university colleges for teacher education and 2.5% at private universities.[43]

Figure 11: Distribution of tertiary students (full-time) by type of institution



*Other HEIs comprise private universities and professional academies of business education in DK; **for reasons of comparability university colleges comprise universities of applied sciences and university colleges for teacher education in Austria
Source: Statistik Austria, Statistik Denmark, Swedish Higher Education Authority

Higher education in Denmark is offered by four types of higher education institutions:

1. Academies of Professional Higher Education (Erhvervsakademi) offering professionally oriented first cycle degree programs.

[41] Student number refer to regular, full-time students in Bachelor, Master and PhD-programs.
[42] for reasons of comparability University Colleges comprise Universities of Applied Sciences and University colleges for teacher education in Austria
[43] Statistik Austria (2015): Studierende an öffentlichen Universitäten –insgesamt; Studien an Fachhochschulen; Studien an Pädagogischen Hochschulen

2. University Colleges (Professionshøjskole) offering professionally oriented first cycle degree programs.
3. Research universities (Universitet) offering first, second and third cycle degree programs in all academic disciplines.
4. Other university level institutions offering first, second and third cycle degree programs in subject fields such as architecture, design, music and fine and performing arts.

In 2007 a major restructuring in the Danish university sector took place by merging former 12 universities and 13 national research institutes into 8 universities and 3 national research institutes.[44] Public universities are responsible for almost all public R&D performance in Denmark and comprise the largest share of public budgets for the tertiary sector (75% in 2015). Compared to Austria only 67% of students are enrolled at public universities (AT: 81%) in 2013, 28% at university colleges (AT: 17% incl. university colleges of teacher education). It was not only the universities and research institutes within the different sectors that underwent major changes. In addition, the Danish professional bachelor degrees in the areas of teaching, nursing and social education were gathered into seven big professional university colleges. In fact, enrolment in these subject accounts for the highest share of educations performed at Danish university colleges (64% in 2013).[45] Compared to that, enrolments in teacher education account for only 33% of total students at university colleges in Austria[46]. In the education of nurses in Austria, the provision in traditional schools for healthcare remains the dominant form of provision.[47]

In Sweden there are 44 HEIs that can issue a tertiary degree. Out of these 44 HEIs, 31 are public institutions (14 universities and 17 university colleges or “regional” universities). In total 29 HEIs are licensed to issue first-, second and third-cycle degrees (i.e. Bachelor, Master, PhD). The remaining ones are entitled just to issue first- and second-cycle degrees. In addition there are three independent HEIs that are entitled to award either all or some third-cycle qualifications: Chalmers University of Technology, the Stockholm School of Economics and Jönköping University. Furthermore, there are nine independent education providers entitled to award first-cycle, and in some cases second-cycle qualifications as well as four independent course providers entitled to award qualifications in psychotherapy. As in Denmark, the share of students being educated at university colleges is higher than in Austria, remaining pretty stable around 24% in recent years.

4.1.3 Inputs on tertiary education

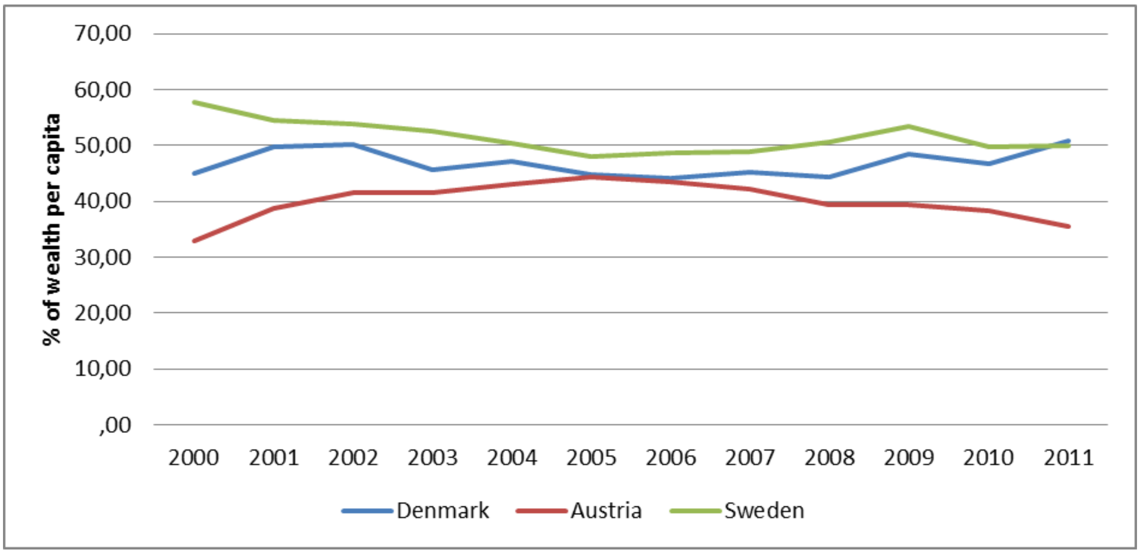
Expenditures for tertiary education per student (in PPP USD) are significantly higher in Denmark and in Sweden with USD 21253.83 (PPP) and USD 20818.27 (PPP) compared to Austria with USD 14894.89 (PPP) in 2011 (OECD average USD 13957.75 (PPP), EU-21: USD

[44] Oddershede, J. (2009): Danish universities – a sector in change; Universities Denmark
[45] Statistik Denmark (2015)
[46] Statistik Austria (2015): Studierende an öffentlichen Universitäten –insgesamt; Studien an Fachhochschulen; Studien an Pädagogischen Hochschulen
[47] Musset, P. et al. (2013): A Skills beyond School Review of Austria, OECD Reviews of Vocational Education and Training, OECD Publishing

13572.42 (PPP))[48]. In Austria around 2/3 of total expenditures per student are dedicated to core tertiary education activities (in line with most of the OECD countries), whereas in Sweden they are pretty equally distributed between research and education activities.[49] The unusual high share of research spending in Swedish higher education institutions is due to the fact that universities are the main performers of public funded R&D.

Figure 12 shows the development of total annual expenditure per student as percentage of GDP per capita (wealth), i.e. correcting for the different economic strengths of the economies. Whereas Austria managed to catch up on its expenditures per student with the innovation leaders in the mid of the 2000s, the gap is increasing since then. Both Denmark and Sweden managed to sustain and even improve funding levels for tertiary education by fundamental increases of public funding, based on the Danish Globalisation Strategy in 2006 and the Swedish Research Bills of 2008/09 and 2012/13. Furthermore, in both countries public basic funding for public higher education institutions is directly tied to the amount of intakes, as will be displayed in greater detail in the next chapter on the funding structure of HEIs.

Figure 12: Annual expenditure per student compared to GDP per capita, at tertiary level of education (ISCED 5-6), based on full-time equivalents



Source: Eurostat (2015)[50]

Financial aid to students is another important input factor to tertiary education, reducing the need to work during the period of studying. The highest share of public financial support for students in Austria is allocated on the basis family allowances and tax benefits for parents of students. Only 15% of tertiary students benefit from scholarships and merit-based grants in 2011. 85% of Austrian students do not receive any kind of support in terms of scholarships, grants of public loans.

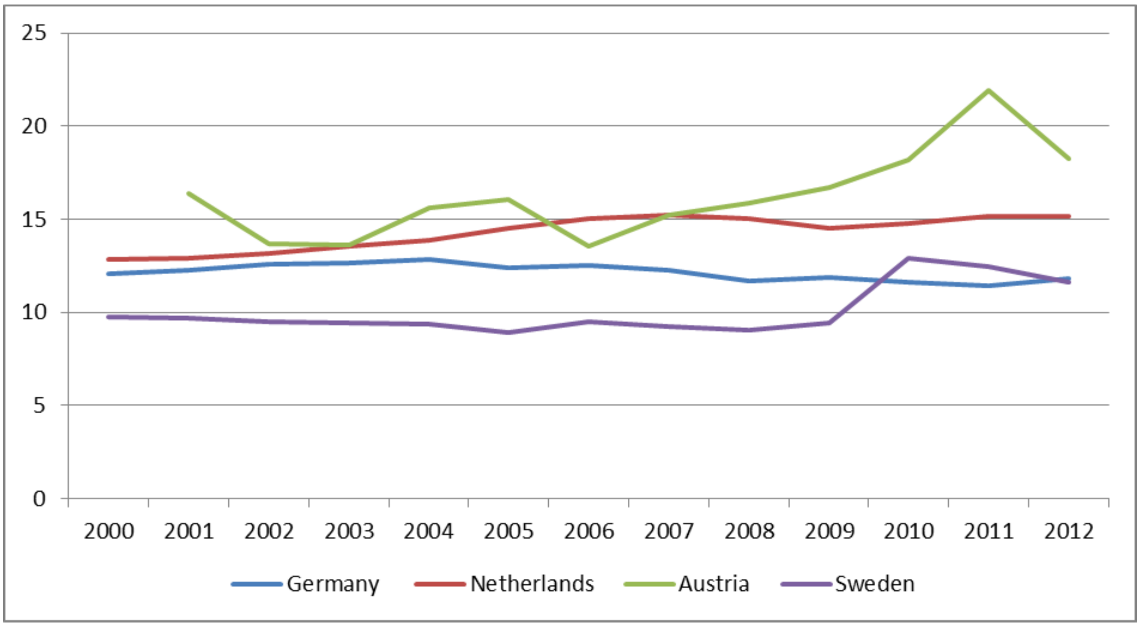
The situation is fundamentally different in Denmark and Sweden. In Sweden, 70% of all students finance themselves via public loans as well as scholarships or grants. 24% receive

[48] OECD (2014a): Education at Glance, Table B1.1a.
[49] OECD (2014a): Education at Glance, Table B1.2
[50] Eurostat (2015): Investments in education and training [educ_thexp]

scholarships or grants solely. In Denmark 53% of students benefit from scholarships or grants, 28% are receiving scholarships or grants and additionally finance themselves via public loans.[51]

An important factor, that is regarded to be decisive for the quality of tertiary education, is the student to staff ratio.[52]. Figure 13 shows the persistent gap and even further worsening of Austria's position in terms of its student/staff ratio.[53] Furthermore, the Austrian University Report 2014 reports a ratio between active regular studies applied and professors or equivalents, i.e. those who are actually allowed to supervise PhD or Master-Thesis, of 42.6 which is at largest so-called "general" universities, i.e. the University of Vienna (70.7), the University of Graz (51.8), the University of Innsbruck (51.4) and the University of Linz (46.3). At technical universities of Vienna and Graz the ratio is nearly 40.

Figure 13: Ratio of students per academic staff*, 2000-2012*



*Full-time equivalents
Source: Eurostat (2015)[54]; calculation JOANNEUM RESEARCH

Regarding the doctoral education a systematic difference between Austria and Nordic like Sweden and Denmark, but also the Netherlands is that PhD students are regularly employed at universities, research institutions or in case like the industrial PhD program, even in the business sector.[55] In Austria 7.486 doctoral students were directly employed at the university in 2013, which is a share of 26% of total doctoral studies applied. Around one half (51%) are employed on the basis of third-party funding (including funding from public agencies and foundations).[56]

[51] OECD Education at Glance (2014a): Table B5.2. Financial aid to students and tuition fees charged in tertiary-type A educational institutions in 2011
[52] E.g. as indicator in Times Higher Education Ranking
[53] Based on Eurostat, accounting for total academic staff
[54] Eurostat (2015): Teachers (ISCED 0-4) and academic staff (ISCED 5-6) by employment status (full-time, part-time, full-time equivalence) and sex [educ_pers1t]; Tertiary students (ISCED 5-6) by field of education and sex [educ_enrl5]
[55] Ecker, B.; Kottmann, A., Meyer, S. (2014): Evaluation of the FWF Doctoral Programme (DK Programme); IHS, CHEPS, AIT on behalf of the Austrian Science Fund (FWF)
[56] Uni:data: Kennzahl 2.B.2: Doktoratsstudierende mit Beschäftigungsverhältnis zur Universität

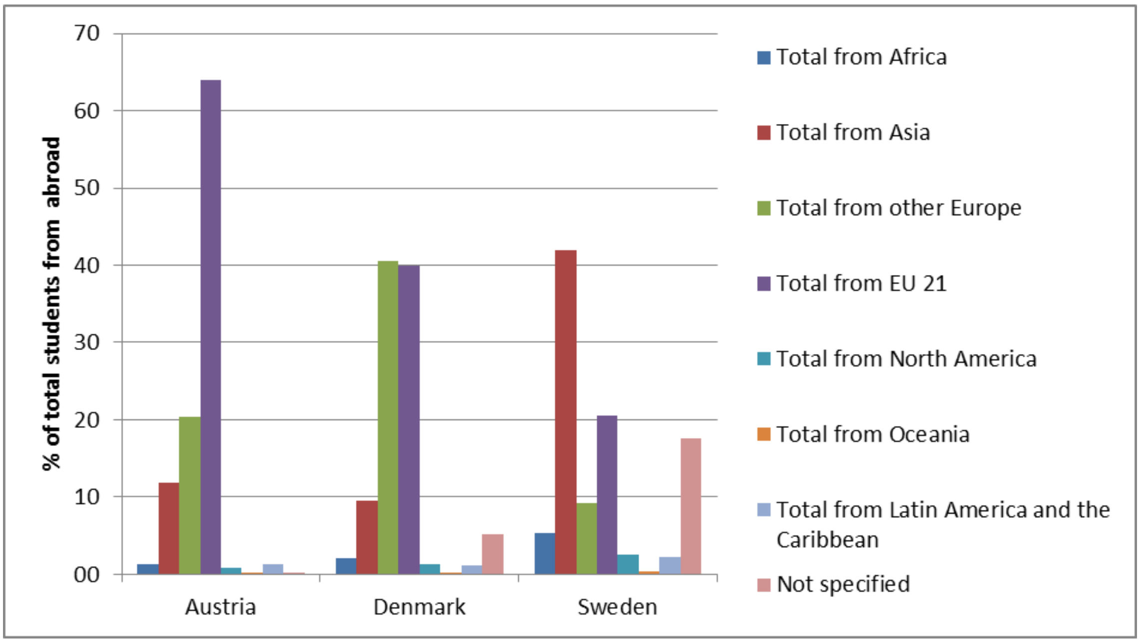
On success factor for raising the quality of doctoral education that is emphasized in the Austrian discussion are so called "structured doctoral programmes"[57], i.e. the possibility for doctoral students to work in teams at long term research projects and either being employed at the university for the time of their study or financed by competitive source on project basis, as it is done e.g. by the Austrian Research Fund (FWF) via its "doctoral college" program (DK).[58] Since the implementation of the programme in 2004 until 2013, 42 DKs have been established, with altogether 1121 students and total funding volume of € 130.6 million. Due to budgetary reasons, no new doctoral colleges could be installed since 2014.[59]

4.1.4 Internationalisation of tertiary education and research

Attracting talented international students and researchers has gained growing importance in recent years, first, as a high share of international students and researchers may be signal for a high reputation of a country's as education and research performance, second, because in times of globalization, competition on competencies and the race for the "best heads" has increased.[60] Skilled labor from abroad is seen to be an important factor for research and innovation performance. Austria ranges together with Switzerland among the OECD countries with the highest share of students from abroad with 15.4% in 2012 (58100 persons in total, CH: 16.5%, DK: 8.1%).[61] The highest share of foreign students in 2012 came from Germany with 43.2% of total students from abroad. Adding up all students from CEE countries, they comprise the second largest group of students from abroad with together 17%. 12.4% come from Italy. This data comprises students with "degree mobility", i.e. those aiming to complete a study in Austria, to be distinguished from those in exchange programs and people with a foreign citizenship but center of life in Austria before attending tertiary education. The share of total students from third countries at public universities in 2012/13 in total regular students in Austria was 3.3%.[62]

[57] E.g. AIT, JOANNEUM RESEARCH, IHS, WIFO, ZSI (2015): Stärkefelder im Innovationssystem: Wissenschaftliche Profilbildung und wirtschaftliche Synergien, im Auftrag des BMWFW, http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/publikationen/forschung/AT_Forschungsraum_Endbericht.pdf
[58] http://www.fwf.ac.at/en/research-funding/fwf-programmes/dks/
[59] BMWFW, BMVIT (2015): Austrian Research and Technology Report 2015. Report of the Federal Government to the Parliament (National Council): under Section 8(2): of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria
[60] Niederl, A., Bader, L. (2014): Maßnahmen zur Standortattraktivität aus internationaler Perspektive, JOANNEUM Research
[61] Niederl, A., Bader, L. (2014): Maßnahmen zur Standortattraktivität aus internationaler Perspektive, JOANNEUM Research
[62] Statistik Austria (2015): Studierende an öffentlichen Universitäten

Figure 14: Distribution of students from abroad by country of origin, main geographic areas, 2012



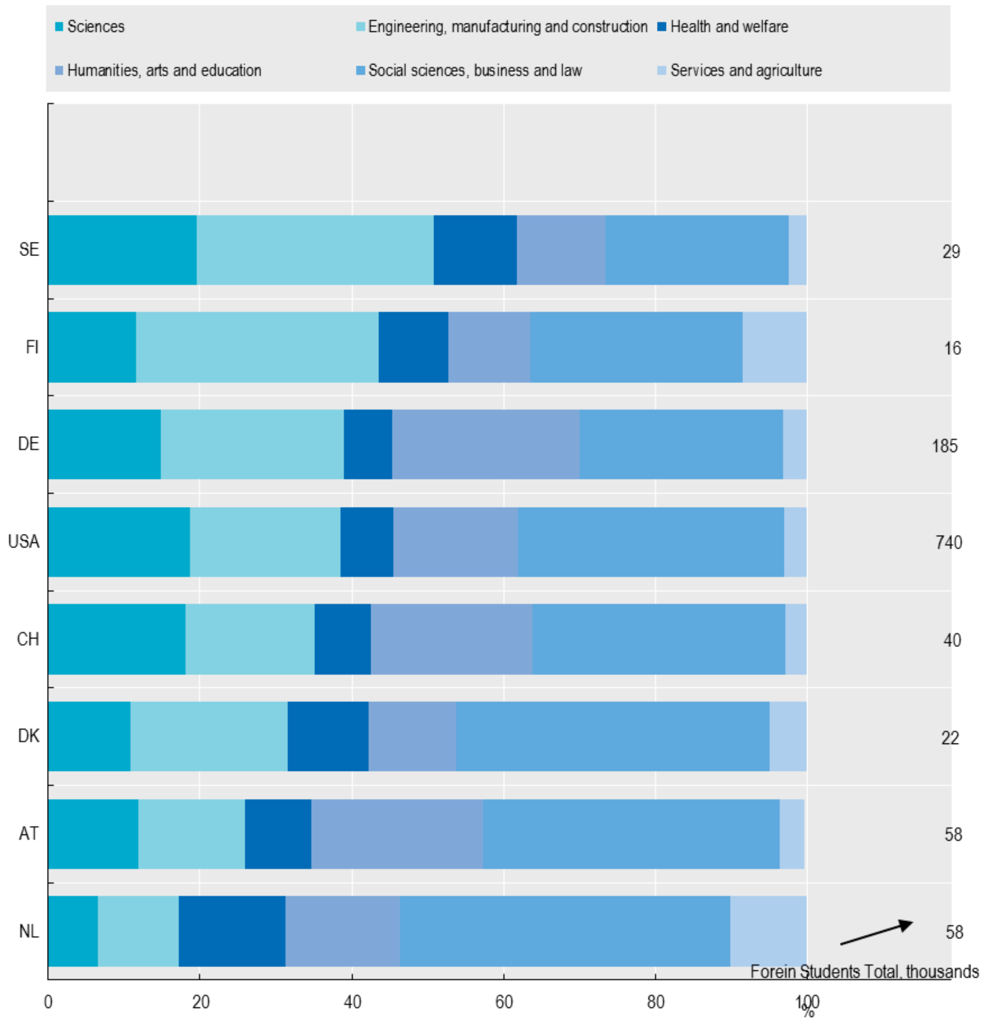
Source: OECD Education at Glance[63]

Figure 14 compares the distribution of students from abroad by country of origin between Austria, Denmark and Sweden in 2012. As already pointed out, the highest share of students from abroad comes from countries within the EU, the second largest share from other EU-countries. Also in Denmark the highest share of foreign students comes from European countries, but nearly equally distributed between EU and non-EU-countries. Sweden on the other hand shows a high attractiveness for Asian students.

When looking at the distribution international students in total studies applied in Austria in 2012/13, it appears that studies at the master level are the most "internationalized" with 20.3% of total master studies are attended by students from the EU (including Switzerland), and 8.81% by students from third countries. At Bachelor level 18.6% of total studies are attended by students from the EU (incl. CH) and 6.5% from third countries. The doctorate/PhD level is slightly lower internationalized, with 16.3% of total PhD studies are attended by students coming from the EU (incl. CH) and 9.5% from third countries.

[63] Table C4.3. Distribution of international and foreign students in tertiary education, by country of origin (2012)

Figure 15: Distribution of students from abroad by field of tertiary education, 2012



Source: OECD-STI-Scoreboard 2015[64]

The highest share of students from abroad is enrolled in the fields Social Sciences, business and law with 49%, and Humanities with 23%. Compared to Sweden only a low share of international students is enrolled to subjects of Sciences (AT: 12%; SE: 20%) and Engineering, manufacturing and construction (AT: 14%, SE: 31%).

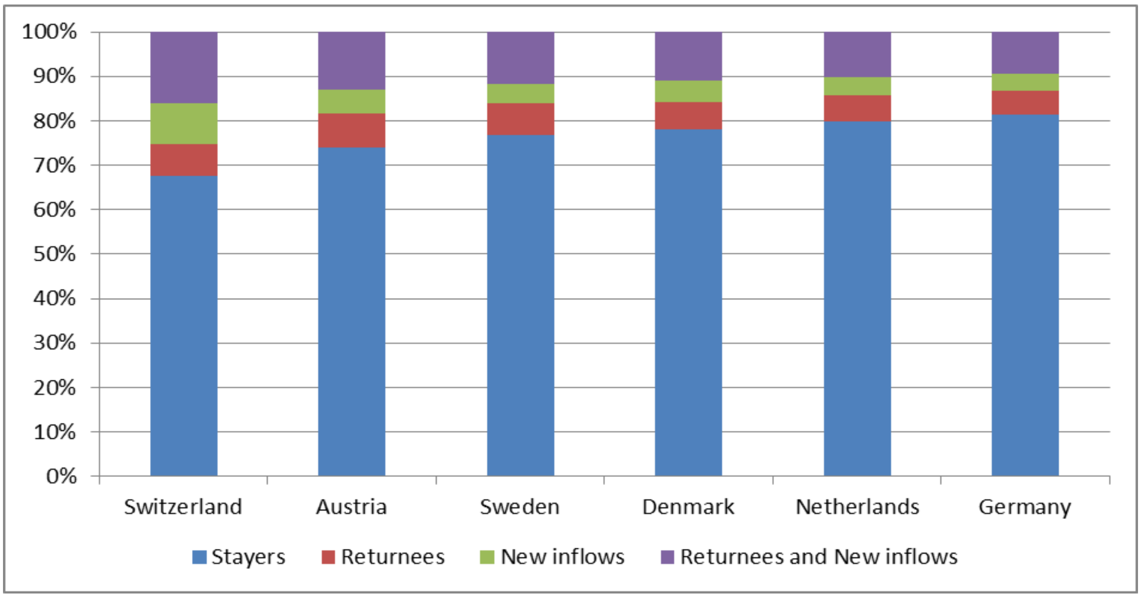
Regarding the share of graduates in 2012/13, 13% of total graduates come from EU countries, 2.3% from third countries. The highest share of students (44% of total graduates from abroad) from abroad graduated at bachelor level, with 89% of them coming from the EU (incl. CH). 30% graduated in Diploma studies, 20% at Master level, and 7 at PhD-level. At PhD level 34% of graduates from abroad came from third countries, which is quite large compared to the distributions in Bachelor, Diploma and Master studies, between 11% and 19% of total graduates from abroad. Master studies again are again to be the highest internationalized, with in total 18.9% of total graduates coming from abroad, followed by PhD graduates with 17.5% and compared to Bachelor graduates from abroad with 15.5%.[65]

[64] OECD-STI-Scoreboard 2015: 3.1.1 International and foreign students enrolled in tertiary education, 2012
[65] Statistik Austria (2015): Studienabschlüsse an öffentlichen Universitäten

A crucial issue that is raised in the Austrian discussion is the need to attract international talented human capital, and therefore increase the number international graduates retaining in Austria. The share of students from abroad, planning to stay in Austria is 28%.[66] The number of total graduates that retain in Austria is empirically only weakly captured. The retention rate calculated in the OECD Migration Outlook 2011, capturing the study year 2008/09, of 17% is discussed to be a poor measure, since it does not capture students from EU.[67] High entry barriers to the labor market are a potential weakness of Austria in attracting and retaining high-skilled internationals from third countries.[68] After finishing a study, graduates from third countries have 6 months to find a job that allows them to a apply for a so called Red-White-Card, a legal document that allows access to the labor market for high-qualified people and key workers.[69] Only graduates at Master's and PhD level are allowed to apply for a Red-White-Card. In the study year 2012/13 only 10% of graduates from third countries applied for a Red-White-Card.[70]

Figure 16 aims at providing a comparative picture of international researcher mobility, based on bibliometric indicators, measured as the percentage of authors with two or more publications by last report of affiliation.[71] Regarding the share of net inflows, Austria performs at the upper range of OECD-countries reported, with 6.3% of researchers of the group captured, compared to Switzerland with 10.8% and above Sweden and Denmark, with 5.1% and 5.4%.

Figure 16: International mobility of scientific authors, 1996-2011



Source: OECD-STI-Scoreboard 2013[72]

[66] UNIKO (2014): Internationalisierungspanorama, Publikationen I/2014
[67] UNIKO (2014): Internationalisierungspanorama, Publikationen I/2014
[68] Austrian Council for Research and Technology Development (2014): Report on Austria's Scientific and Technological Capability 2014, Vienna
[69] Beauftragter der Stadt Wien für Universitäten & Forschung (2015): Vierter Bericht des Beauftragten der Stadt Wien für Universitäten und Forschung. Wien: Stadt, die Wissen schafft. Finanzen, AkteurInnen, Visionen einer europäischen Forschungsmetropole
[70] UNIKO (2014): Internationalisierungspanorama, Publikationen I/2014
[71] based on Elsevier-2012-data in OECD-STI-Scoreboard 2013: 3.6.2 International mobility of scientific authors, 1996-2011
[72] OECD-STI-Scoreboard 2013: 3.6.2 International mobility of scientific authors, 1996-2011

4.1.5 The Danish tertiary education system

Tertiary education is high on the agenda of the Danish government, setting the target of at least 60% of young people should complete a tertiary education program[73], 25% with a master degree. In total, 95% of all educated people should engage in upper-secondary education. Since 2007 enrolment in upper-secondary as well as in tertiary education increased dramatically, accompanied by an increase in funding. Special focus was put on increasing the amount of PhD-students by investments in PhD-programs. This led to an increase in PhD-enrolments between 2002 and 2011 of 119%, especially in health, technological and natural sciences.[74] Also the number of people with higher education in the workforce is continuously increasing, with projections foreseeing them to double till 2030 compared to 2002[75]. Though this is a remarkable success in numbers, consequences of these developments with focus on the quality of tertiary education and provision of adequate skills for the labour market are heavily discussed in Denmark.

These developments are accompanied by an "academic drift"[76], with non-university institutions, comprising university colleges and academies for professional higher education, gathering increased importance in the provision of higher education. The role of university colleges is decisive for the high share of tertiary graduates since they comprise the largest share of study programs. The educational programmes of university colleges are characterised by a strong relationship with practice and specific professions, especially comprising educations for teachers, nurses and kindergartens. The university colleges, spread all over Denmark, also play an important role for regional development, allowing for a close dialogue with regional stakeholders and also help to attract people for higher education from families with a lower educational background. Though university colleges currently have only limited funds for R&D, they play an important role for the Danish innovation system, since they target sectors of social importance. The nine Business Academies are shown to be examples of how the needs of the business sector are driving the development of dedicated HE-programs, with a high likelihood for their graduates to be employed in their specific field.

The highest share of higher education graduates is absorbed by the public sector especially with bachelor-degrees[77]. This holds also true for PhD-graduates, with up-till now just few PhDs being employed in the private sector. Exceptions are graduates of the Industrial-PhD-program and in engineering that have a higher tendency to be employed in the private sector On the other hand the enrolment in vocational education and training is constantly decreasing since 2001. This is interpreted as a potential sign of a skill-mismatch in terms of an unbalance by fields as well as by type of education, as "…*industry could not produce solely with academics"*.[78]

[73] See Globalisation Strategy (2006)
[74] Statistics Denmark
[75] Nye Veje – Fremtidens videregående uddannelsessystem. Udvalg for Kvalitet og Relevans i de Videregående Uddannelser. 2014
[76] Academic drift is a concept used to describe academisation processes of institutions for higher professional education; see: Griffioen, D. M. E., De Jong, U. (2012): Academic Drift in Dutch Non-university Higher Education Evaluated: A Staff Perspective, Higher Education Policy.
[77] Nye Veje – Fremtidens videregående uddannelsessystem. Udvalg for Kvalitet og Relevans i de Videregående Uddannelser. 2014
[78] Stated in the Expert Webinar; 23th June 2015

A successful measure to increase the interlinkages between the private and the academic sector is the Industrial PhD-program, funded by the Danish Innovation Fund. Students are employed both at a company and at the university (50/50) where they finish their degree. Partners from the private sector are mostly aware of the research obligation of theirs PhDs. Salaries are publicly subsidised at a rate of 30 – 50%. Participants of the Industrial PhD-programme have a higher tendency to be employed in the private sector. Furthermore, industrial PhD-projects are found to have a positive impact on firms patenting activity.[79]

Since the targets of an increase of overall higher education have been met so far, further efforts need to focus on optimally utilizing these human resources. One objective of government initiatives is therefore devoted to increasing academic entrepreneurship and innovativeness by encouraging the spirit of risk taking and getting academic start-ups to create jobs, grow and survive. A prominent example in case is the Danish Growth Fund, which invests in newly started enterprises and thereby contributes to the creation of companies by providing capital and expertise. Entrepreneurial spirit of young people in higher education might be hindered by the low flexibility of academic programs, i.e. a "wrong" use of the bachelor/master-system. Still there is no tradition in Denmark to gather practice after finishing a bachelor study and then come back at a later stage for a master program. Further, concerns are raised that policy should aim also adjusting the student intake in certain fields, i.e. steering students to where it is likely for them to find a job (still more than half of total students are enrolled in social sciences and humanities).[80]

Denmark is one of the countries with the world's highest student grants that are open to every student regardless of financial background.[81] Based on the MORE2-survey PhD students in Denmark receive the highest Doctoral grant payments in a European comparison.[82] New measures foresee to tie scholarships to performance. On the other hand, access to universities is free since no tuition fees are charged[83].

A specific strength of Danish tertiary education system is said to be its high attractiveness for international students (in 2013, 1.9% of all students were international students from non-EU countries, AT: 3.2%)[84], especially in science and engineering (see Figure 15). Government considers foreign students as an important asset providing skills and knowledge to the national system. Several initiatives and strategic targets are therefore focusing on attracting foreign students, comprising the already mentioned PhD programs, increasing access to Danish student grants and the targeting of specific areas outside EU/EEA countries like China, Brazil and India[85]. Universities are financially incentivized to increase students' mobility, getting rewards for every incoming and outgoing student of DKK 5,000 as part of the taximeter grand funding system (see chapter on HEI-funding in Denmark).[86] Furthermore, retention and

[79] Danish Agency for Science, Technology and Innovation (2011): Analysis of the Industrial PhD Programme.
[80] Danish Ministry of Science and Education
[81] European Commission (2014/15): National Student Fee and Support Systems in Higher Education
[82] BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014. Status report in accordance with Section 8(1): of the Research Organisation Act on federally subsidised research, technology and innovation in Austria
[83] OECD (2014a): Education at a Glance 2014: OECD Indicators, OECD PublishingTable B5.1
[84] Statistics Denmark, calculation DAMVAD analytics; Statistik Austria
[85] Based on analysis from Ministry of Science and Education about the economic gains by attracting international students to Denmark (Danish Rational Economic Agents Model)
[86] Claeys-Kulik, A.-L.; Estermann, T. (2015): DEFINE Thematic Report: Performance-based funding of universities in Europe; European University Association

employment rates of foreign students and researchers in Denmark should be increased, also by providing study and job opportunities for spouses.

4.1.6 Tertiary Education in the Swedish system

Sweden has one of the highest levels of tertiary attainments among OECD countries. The proportion of the younger population with tertiary education is 45% while the older population with tertiary education corresponding to 29%[87] (OECD 2014). Higher education is mainly provided by public universities and public university colleges.

Sweden invests a relatively high share on tertiary education and research within the university. In 2011, only 7 countries in the OECD invested more than Sweden as a share of GDP. There are big differences between countries in the way of financing. Sweden and other Nordic countries are among the countries where largest share of financing for education is in the form of public funds, while countries such as Canada, South Korea, the US and Australia have predominantly private financing, mainly through student fees. In Sweden and Switzerland more than half of the total cost of tertiary education consists of costs for research, whereas in most other OECD countries, the cost for education comprises the bulk of the total cost.[88]

In recent years, the importance of research has grown in university colleges while training at the undergraduate and graduate levels has been reduced in scale. The reduction in education has led to a more program-oriented educational supply and appears to have had a positive impact on the throughput of students. At the same time, it has become harder to get into college and the number of courses, which usually is the first step to college, have declined. The increased resources for research have not led to increased dimensioning of doctoral education, but teaching and research employments have increased significantly[89].

It is mainly jobs that require doctorate qualification that has grown in HEIs and the educational staff has become increasingly well educated. Employees with other tasks have not increased as much and this means that the proportion of employees with teaching and research work has increased.[90]. This is also reflected in a steady improvement of the student-teacher ratio.[91]

The Swedish higher education system has recently faced two large reforms[92], implemented in 2011, namely the “autonomy reform” and the “quality reform”. Both reforms were introduced to make the system more market-oriented and enhance international competitiveness. The autonomy reform concerned the governance of higher education institutions by a deregulation of the internal organisation, giving universities more independence in terms of decision making procedures, employment procedures and careers paths with the aim to increase their ability to conduct training and research of internationally competitive quality. In terms of quality of education, until 2011 the focus was on how the universities implemented quality standards in

[87] OECD (2014a): Education at a Glance 2014: OECD Indicators, OECD Publishing
[88] OECD (2014), Education at Glance, Table B1.2
[89] Higher Education Authority (2015) Trender och tendenser i Högskolan 2015: http://www.uka.se/download/18.6e65a54814c9d64344d17c4f/1433148038697/sammanfattning-arsrapport-2015.pdf
[90] Swedish Higher Education Authority (2015b): Report on educational attainment and economic investment in the OECD, Tertiary education from an international perspective – a comparison based on Education at a Glance: http://uka.se/download/18.5bb4875214acdd3d8c854e85/1426234982290/rapport-2015-3-education-glance-eng-del1.pdf
[91] Swedish Authority of Higher Education
[92] First introduced in the Government Bill 2009/10:149 and 2009/10:139

their education. The quality reform from 2011 now emphasised students' actual learning improvements, measured by the achievement of learning objectives for a given training. This will be covered in more detail in the discussion of performance based funding mechanisms (see chapter 4.3).

As in Denmark, in general no tuition fees on tertiary education are charged in Sweden. In 2011 however, Sweden introduced tuition fees for third country nationals for first and second-cycle higher education courses and programs. HEIs are required to charge tuition fees that fully cover their costs for these students. Up to this reform, there was a clear increase of incoming students but since its implementation the number of students from third countries decreased significantly. However statistics from the Swedish Higher Education Authority shows that the number of fee-paying students has risen each year since tuition fees were introduced until autumn of 2014.[93]

4.1.7 Excursus: Female Scientists in Sweden

A high inclusion of the female workforce is seen as an important competitive advantage when looking for the best researchers in a global work place. The findings of the following chapter are based on a comparative study on women in the innovation process by Ihsen et al. (2014).[94] A remarkable feature that was highlighted in the study is the, compared to Austria, high share of female scientists in Sweden, especially in fields of natural sciences and engineering. This is based on a higher share of women among tertiary students in total as well as in respective subjects (see Table 3). Another interesting feature in Sweden is the high share of female researchers in the business sector (Table 4). Furthermore, the proportion of women in grade A academic positions as well as the share of women in leadership positions is a lot higher in Sweden than in Austria (see Table 5), though the glass ceiling index, which is an indicator for the vertical segregation of the Higher Education Sector, shows that in Sweden women have lower chances to advance to grade A academic positions. This might be driven mainly by the high share of female participation in science and research positions at all.[95]

[93] Swedish Higher Education Authority (2015): Annual report 2015
http://www.uka.se/download/18.68b9da0d14d8a7e2f5aab4e/1434628864514/eng-arsapport2015.pdf

[94] Ihsen, S., Schiffbänker, H., Holzinger, F., Jeanrenaud, Y., Sanwald, U., Scheibl, K., Schneider, W. (2014): Frauen im Innovationsprozess. Studien zum deutschen Innovationssystem Nr. 12-2014. Berlin: Expertenkommission Forschung und Innovation.

[95] The Glass Ceiling Index (GCI) measures the relative chance for women, as compared with men, of reaching a top position. A GCI of 1 indicates that there is no difference between women and men whereas a score of more than 1 indicates that women are underrepresented in grade A positions. In other words, the higher the value of the GCI, the lower the chances of women to move into a higher position. (European Commission 2013b)

Table 3: Female students in tertiary education, 2012

	Austria	Sweden
Share of women among tertiary students (ISCED 5-6)	53,4%	59,7%
Share of female students enrolled in science, mathematics and computing (ISCED 5-6)	35,8%	42,4%
Share of female students enrolled in engineering, manufacturing and construction (ISCED 5-6)	24,6%	29,4%

Source: Eurostat (2013) [96]

Table 4: Female researchers in tertiary education

	Austria	Sweden
Proportion of female researchers (2009)	28%	36%
Compound annual growth rate for female researchers (2002-2009)	11%	-3%
Share of female researchers in the Higher Education Sector	38%	44%
Share of female researchers in natural science in the Higher Education Sector	28%	35%
Share of female researchers in engineering and technology in the Higher Education Sector	21%	24%
Share of female researchers in the Business Enterprise Sector	16%	26%

Source: European Commission 2013[97]

Table 5: Female executives in science and research

	Austria	Sweden
Proportion of women in grade A academic positions (2010)	17,4%	20,0%
Proportion of female grade A staff in natural sciences	7,6%	14,3%
Proportion of female grade A staff in engineering and technology	7,7%	10,1%
Glass Ceiling Index	1,9	2,1
Proportion of female heads of institutions in the Higher Education Sector	16,2%	26,9%
Proportion of women on boards	31,0%	49,0%

Source: European Commission 2013[98]

In the following specific institutional and legal framework conditions as prerequisites for the high participation of Swedish women in R&D will be presented. Furthermore the Swedish R&D and education policy targets female students and researchers with several awareness measures and support structures for women. This is embedded in an early adoption of a

[96] http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00063&language=en
[97] European Commission (2013a): She Figures 2012: Gender in Research and Innovation. Statistics, and Indicators. Brussels.
[98] European Commission (2013a): She Figures 2012: Gender in Research and Innovation. Statistics, and Indicators. Brussels.

societal role model that emphasizes female participation in the work force as well as in an expanded understanding of innovation.

The long tradition of gender equality policies and laws has led to a high awareness for gender equality and an overcoming of traditional gender roles. Unpaid work is shared equally between men and women, moreover comprehensive child care facilities are provided by the state. This allows a high participation of women in the work force.

Compared to other European countries Sweden has the most fully developed infrastructure of childcare facilities. The cost of childcare compared to the average income is lower in Sweden than in Germany and Austria.

Generally, the share of part-time researchers is particularly low in Sweden. Also overtime hours are uncommon. The absence of an overtime culture benefits women – who usually have less time resources for paid work – and thus leads to a better integration of women into the innovation system.

In Sweden maternity protection applies two weeks before and after giving birth. There exists a well-developed system of parental leave which offers incentives for a stronger integration of fathers into childcare: on the one hand there is income-dependent parental leave compensation and on the other hand there are 60 days of leave which are exclusively reserved for fathers and not transferable to the mother. Moreover, the participation of men is promoted through a gender equality bonus which offers an economic incentive for parents to divide the parental leave more equally between the mother and the father. Furthermore, the Swedish parental leave system offers high flexibility. Its duration is calculated in days and does not have to be consumed in blocks of whole weeks or months. This promotes the participation of men in child care. Fathers in Sweden spend more time on child care and consume more paid parental leave days than in other countries.

Equal opportunities are an important goal of the Swedish education policy. There exists a comprehensive offer of career orientation for both men and women aiming to increase students interest for natural sciences and engineering. One reason for the higher share of female students in natural sciences and engineering than in other in countries is the offer of several “entry-points” into the STEM-pipeline. Universities, for example, have to offer one year specialized courses to impart the knowledge needed to study science or technology. Universities as employers have to display differences in earnings of men and women and since years, they have to implement gender equality plans.

It is an explicit political aim in Sweden to include more women into its innovation system. This is discussed in the context of an expanded understanding of innovation. Sweden has drawn up a strategy for increased service innovation which relativizes the strong high-tech focus and puts more emphasis on user-oriented and user-driven innovation. In order to implement the gender dimension in the Swedish innovation policy three steps were taken: 1) implementation of a promotion scheme to develop knowledge about innovation & gender, 2) implementation and gathering of practical experience, 3) transfer of practical knowledge to relevant actors. VINNOVA, Sweden’s innovation agency, provides examples and practical knowledge on topics like, for example, how to sensitize relevant actors for the gender topic or how new innovations arise. Furthermore, the topic of scientific excellence and gender was already discussed in

Sweden before the turn of the millennium after an analysis of Wennerås/Wold (1997)[99] pointing to the existence of a gender bias in research promotion. This led to increased attendance to the issue, with Sweden compared to Austria in 2005 showed a higher share of females in publications.[100] The "Centres of Gender Excellence", which were promoted by the Swedish Research council from 2006 to 2012 were another measure to promote innovative formats for gender and innovation. In the last years, the Swedish Research Council has made constant efforts to minimize any gender bias in research funding by conducting several studies[101]

4.1.8 Excursus: Structure of HEI-funding system for research and tertiary education in the Netherlands

University funding for research in the Netherlands is based on a 3-flow system: The 1st flow comprises government block funding (2012: 42% of total funding) based on a teaching and a research component. The 2nd flow consists of competitive public funding via NWO and KNAW and accounted for 25% of total funding in 2012. The 3rd flow finally relies on other national and international public and private sources (industry, ministries, EU funding, charities etc.) with in total 33% in 2012. Furthermore, quality assessments of both research and teaching are applied frequently, including internal evaluations of research and teaching performance of the scientific staff, as well external assessments every five years. Competitive, quality and performance based public financing might be an important factor to increase performance in university research.[102]

Tertiary Education in the Netherlands like in many other countries relies on a binary system with diversification between academic universities and universities of applied science. Whereas academic universities undertake scientific research and provide science-based teaching as well as knowledge and technology transfer for society and the business sector (so called valorisation), universities of applied sciences mainly provide application oriented teaching and practical and application based research, with a strong emphasis in recent years on supporting innovation capacities in SMEs. Other than in Austria, the highest share of students is enrolled at universities of applied science with around 64% in 2012.

A remarkable feature is the structure of doctoral education in the Netherlands with doctoral students being to the largest part employed at their institution, either as research assistant (AIO), research student (OIO) or grant funded student, normally for four years, including teaching duties.[103] Talented research assistants may apply for a so-called *National Research School*, inter-university research centres for high-quality research both in particular fields as

[99] Wennerås, C.,Wold, A. (1997): Nepotism and sexism in peer-review. Nature, 387/6631, pp. 341-343.
[100] Frietsch, R., Haller, I., Funke-Vrohlings, M., Grupp, H. (2009): Gender-specific patterns in patenting and publishing, Research Policy, Vol. 38 Nr. 4
[101] Ahlqvist, V.,Andersson, J.,Hahn Berg, C.,Kolm, C.,Söderqvist, L.,Tumpane, J. (2013): Observations on Gender Equality in a Selection of the Swedish Research Council's Evaluation Panels. Stockholm: Swedish Research Council; Ahlqvist, V., Andersson, J., Söderqvist, L., Tumpane, J. (2015): A Gender Neutral Process? – A qualitative study of the evaluation of research grant applications 2014. Stockholm: Swedish Research Council; Jacobsson, C., Glynn, C., Lundberg, E. (2007): Equality between men and women in Swedish research funding? – An analysis of the Swedish Research Council's first years (2003-2005): Stockholm: Swedish Research Council.
[102] OECD (2014): OECD Reviews of Innovation Policy: Netherlands 2014, OECD Publishing
[103] OECD (2008): OECD Reviews of Tertiary Education: The Netherlands

well multidisciplinary. In recent years the implementation of research schools at university level gained importance.[104] Doctoral theses have to be supervised by a professor with teaching awarding rights at one of the 13 Dutch research universities.[105] These professors might not be necessarily employed at the universities, but at other research institutes, providing supervision for PhDs that are employed at their institution. These external PhDs work at projects that are directly related to their thesis. Beside the financial effect of external supervision from a university perspective, this encourages the interlinkages between academic and non-university research. Universities receive a premium funding for each PhD awarded, covering the costs of supervision but no salaries, providing an extra incentive to increase the number of external PhDs. Some universities furthermore charge tuition fees to external PhDs.[106] The high emphasis being put on doctoral education, providing both employment and excellent research conditions, might be one explanation for the Netherlands outstanding performance regarding ERC-grants, especially for the high number of starting grants of 232 in FP7 (AT: 70, DK: 45, SE: 87).[107]

4.1.9 Synthesis, conclusions and potential learnings and recommendations for Austria

Both, in terms of total output in tertiary education as well in the specialization of graduates in terms STEM-subjects, Austria managed to catch up with the innovation leader countries in recent years (taking into account differences in the structure of tertiary education). Furthermore the employability of tertiary graduates in Austria, in terms of unemployment rates, is high in comparison with Denmark and on equal levels with Sweden. Nevertheless, structural weaknesses can be found in the significant lower amount of inputs on tertiary education as well as ratio of students to academic staff as indicator for the capabilities in students' supervision and support. Taking the ratio between graduates and total students as a measure for the efficiency in the provision of academics Austria is still lagging behind, though a significant increase in performance since the year 2000 can be observed. Summing up, Austria performs on comparable levels regarding total output in tertiary education, but endowment and efficiency of the system is weak.

Both in Denmark as well as in Sweden higher education has been high on governments' agenda for decades and having been very successful in raising enrolment and the number of graduates. In recent years a major shift of emphasis towards quality of education and the utilisation of education outcomes (research, jobs, and private market growth) can be observed. The increased intake of students is accompanied by dedicated funding mechanisms that directly link funding for HEIs with the number of intakes and graduates. In quantitative terms, university colleges providing professional education play a more prominent role in tertiary education, especially in Denmark but also in Sweden, than in Austria which is one important reason for the overall higher share of academics. Apart from the output in terms of

[104] Ecker, B., Kottmann, A., Meyer, S. (2014): Evaluation of the FWF Doctoral Programme (DK Programme); IHS, CHEPS, AIT on behalf of the Austrian Science Fund (FWF)
[105] Vossensteyn, H. (2011), The PhD system, policies and infrastructure of the Netherlands – A critical analysis; Report for the EMUNI PhD Policy Group
[106] Ibid.
[107] FFG, eCorda, 03/2015

number of graduates, the quality of teaching itself is receiving greater attention, as could be observed by the Swedish' implementation of measures to financially incentivise high quality in education. In both countries, education is seen to be core public service that serves not only high resources bat also high standards in the provision of those services.

Another interesting observation concerns the different structures and measures in place in Denmark regarding doctoral education. In general, as it is also the case for the Netherlands, PhDs are employed at their respective institution or participate in respective funding programs (i.e. industrial PhD). Structure and quality of doctoral education are seen to be a decisive factor for the attraction of international talents and also for the Danish research output. On the other hand, the great success in terms of quantity and quality of doctoral education in Denmark as well as in Sweden is being met by a growing political concern with respect to the employability of doctoral graduates on the labour market, since the public sector and the research sector (so far the main absorbers of PhDs) will probably not be able to fully absorb the growing number of PhD graduates in the future. Hence, in Sweden and Denmark there is an increasing focus on increasing the employability of PhD students in the private sector. This is seen in Sweden also to have a positive impact on the research and innovation capacity of the private sector, which has been declining recently.

In comparing tertiary education systems in Denmark and Sweden with Austria, one has to take into account differences in the respective institutional settings (especially in the area of professional education). In Austria by far the highest share of tertiary education is performed at universities which might be a less efficient and more costly way to produce graduates when employability is in focus. This balance in the distribution of students among several types of higher education institutions is different in Denmark and Sweden with university colleges playing a more prominent role, especial in professional tertiary education. If Austria were to follow the expansionary course of Sweden in its HEI-system, more emphasis needs to be put on the role of universities of applied sciences and other type of post-secondary education. At the same time, Austria shows a lower share of doctoral graduates, which are an important input for R&D activities. Following the Danish and Swedish examples, to increase the quality and structure of doctoral education should be a cornerstone of a HEI reform in Austria. In terms of increasing the international attractiveness for talents and skill, Austria should put emphasis on retain skilled and trained people from abroad in Austria after finishing their degrees.

Summarising the quantitative and qualitative findings from Denmark and Sweden the following recommendations regarding room for improvements in Austria could be drawn:

- In order to emulate the positive development of the HEI sector, Austria would have to increase its spending for HEI considerably to reach the level of Denmark and Sweden. While such an increase in public funding is necessary, it is not a sufficient condition for improvement. As we have seen from the examples of Denmark and Sweden, institutional changes have to accompany increased funding. Both Denmark and Sweden are characterized by a pronounced concentration of research in a smaller number of institutions. This concentration has grown 'organically' in Sweden, with a small number of 'old universities accounting for the bulk of R&D among HEI, while it was recently established through mayor institutional reforms in Denmark. These reforms – significantly reducing the number and increasing the size of research institutions - could be a role-model also for Austria.

- Austria would have to increase the number of tertiary graduate substantially though taking into account the differences in vocational and tertiary education systems of the countries compared, the performance in indicators on tertiary education in the IUS is not alarming.[108] Nevertheless, a clear division labour between universities and universities of applied science, with the aim to increase the importance of the latter in the provision of tertiary education, especially regarding professional education is required. Solely focusing on increasing the number of tertiary graduates might lead to an "inflation of graduations", that might not necessarily lead to an increased employability or provision of required skills in the business sector.

- Both Denmark and Sweden do not apply tuition fees or structurally different entry barriers to universities (like numerus clausus), but student intake is directly linked to financing for HEIs, i.e. allowing therefore to directly compensate increased student numbers by an increase financing. Austria should speed up its efforts to implement a student-place-based finance mechanism ("Studienplatzfinanzierung").

- Doctoral education in Austria needs to be restructured, focusing on increasing regular employment of doctoral students as well as the connectivity with industry/private sector (e.g. the Industrial PhD program). A standardization of PhD-courses between universities also concerning the permeability between universities and universities of applied science are a key prerequisite. Collaborative graduate and PhD/ doctoral schools/colleges directly linked to high level research (cross-institutional) infrastructure (at least two HEIs, if possible cross border) are recommended, both to increase permeability between institutions as well as between sectors.

- Austria needs to reduce entrance barriers to the labour market for graduates at Austrian HEIs from abroad. This requires an overhaul of the red-white-red card especially regarding minimum wage requirements and the limited time frame allowed for becoming employed.

[108] The EU 2020 indicator on tertiary education attainment since 2014 also takes into account the amount of upper-secondary graduates for Austria: http://ec.europa.eu/eurostat/web/europe-2020-indicators

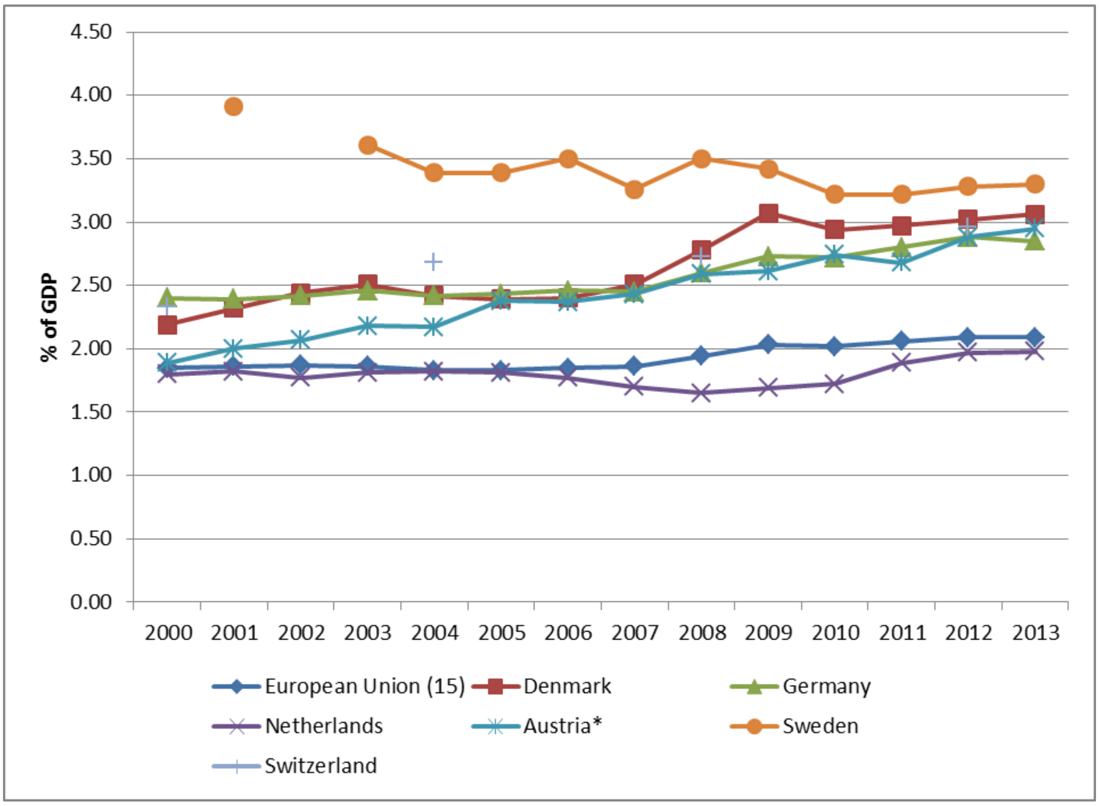
4.2 Governance and funding structure for HEIs, basic and risky research

This chapter aims to provide a comparative overview about main aspects of public and private research funding in the countries of comparison, and second, to discuss specific aspects of research funding in Denmark and Sweden that appeared to provide potential lessons for Austria, comprising the structure of competitive funding especially for higher education institutions (HEI) and the role of private foundations both in Denmark and Sweden.

4.2.1 The research funding system – a comparative overview

In the following a comparative overview about basic descriptive statistics on research funding is provided. In terms of total R&D intensity, Austria (2013: 2.95% of GDP) managed to narrow the gap to Sweden (2013: 3.3% of GDP) and Denmark (3.06%) (see Figure 17). This was accompanied by a significant increase of government funding for R&D in percentage of GPD in recent years (see Figure 18).

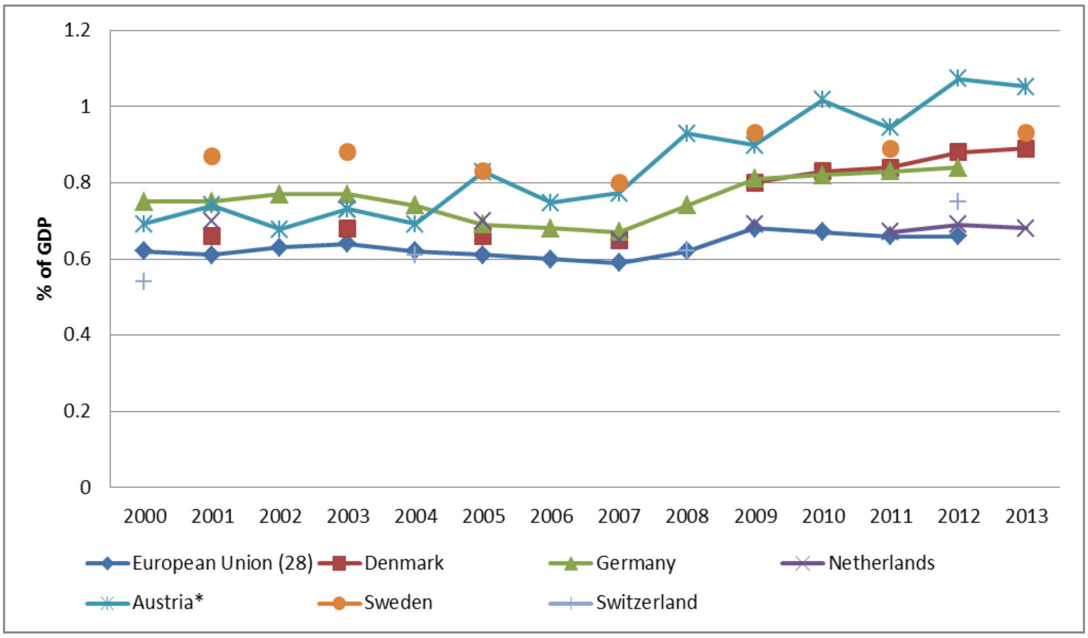
Figure 17: R&D intensity in selected countries



Source: Eurostat (2015)[109], *Statistik Austria, Global Estimate 2015

[109] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance

Figure 18: Government funding of total gross domestic R&D expenditures in % of GDP



Source: Eurostat, *Statistik Austria Global Estimate 2015[110]

Figure 19 – Figure 21 provide an overview of the structure for R&D funding (total intramural R&D-expenditures GERD) per sector of performance as well as its finance structure. Austria shows a higher share of business R&D-expenditures compared to Denmark and Sweden but a much lower degree of intramural self-financing of business R&D-expenditures with only 44% compared Sweden with 57.3% and Denmark with 60 % of GERD being financed by the national business sector.

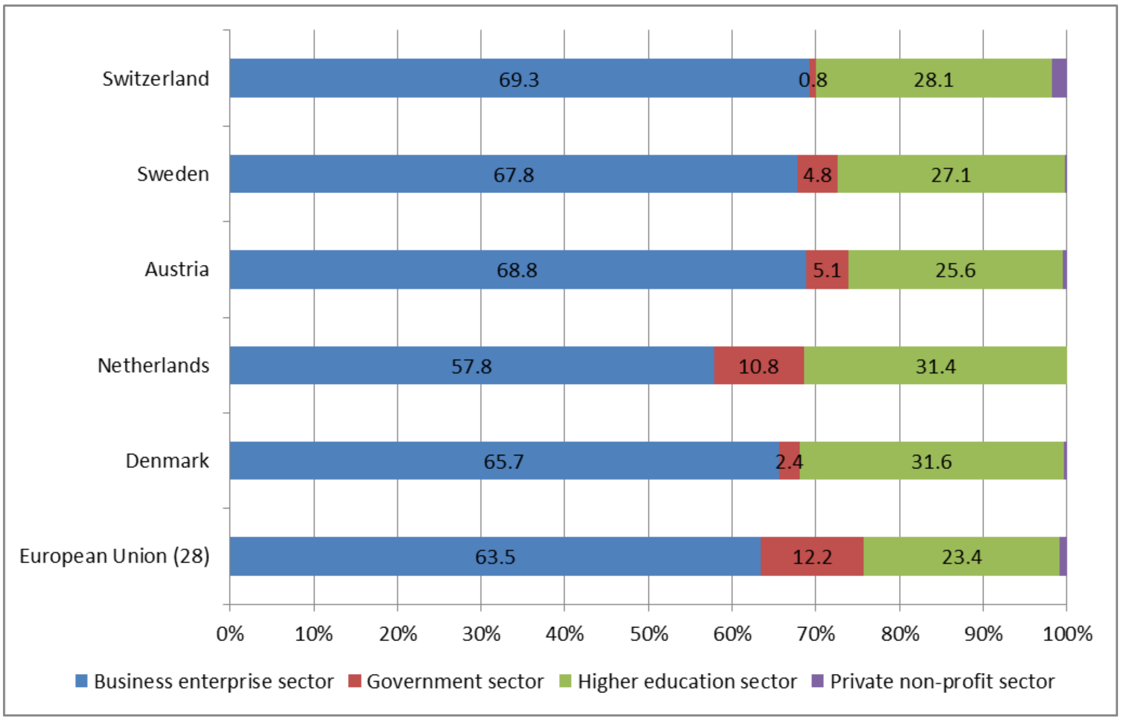
In Austria a high share of R&D is funded by the government with nearly 40% (1.1% of GDP) compared to Sweden and Denmark with nearly 30% in 2012 (around 0.9% of GDP). The largest share of government funding for R&D in Austria and Denmark comprises institutional block funding including, general university funds (GUF), with 74.5% of total government appropriations and outlays for R&D (GBOARD) in Austria and 64.7% in Denmark (see Table 6). The situation is somewhat different in Sweden with 45.6% of government funding allocated on competitive basis in 2012. Around 90% of Swedish government appropriations for R&D are dedicated to the academic sector.[111] Though a significant increase of government basic financing for R&D at universities could be observed following the Government Bills 2008/09 and 2012/13, less than half of universities' expenditures for R&D are financed by block funding grants (see also chapter on funding for HEI).[112]

Compared to Austria, private foundations play a significant role in research funding of both countries. In Austria total R&D funding of the private non-profit sector amounts to only 0.01% of GDP, compared to Sweden with 0.1% and Denmark with 0.12%.[113] A large amount of private funding is dedicated to higher education institutions in both countries, reflected in shares of HERD being financed by the private non-profit sector of nearly 10% in 2011 in both countries

[110] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance and source of funds
[111] Hollensten, O. (2014): ERAWATCH Country Reports 2013: Sweden; JRC Science and Technology Reports
[112] The Swedish Higher Education Authority
[113] Eurostat

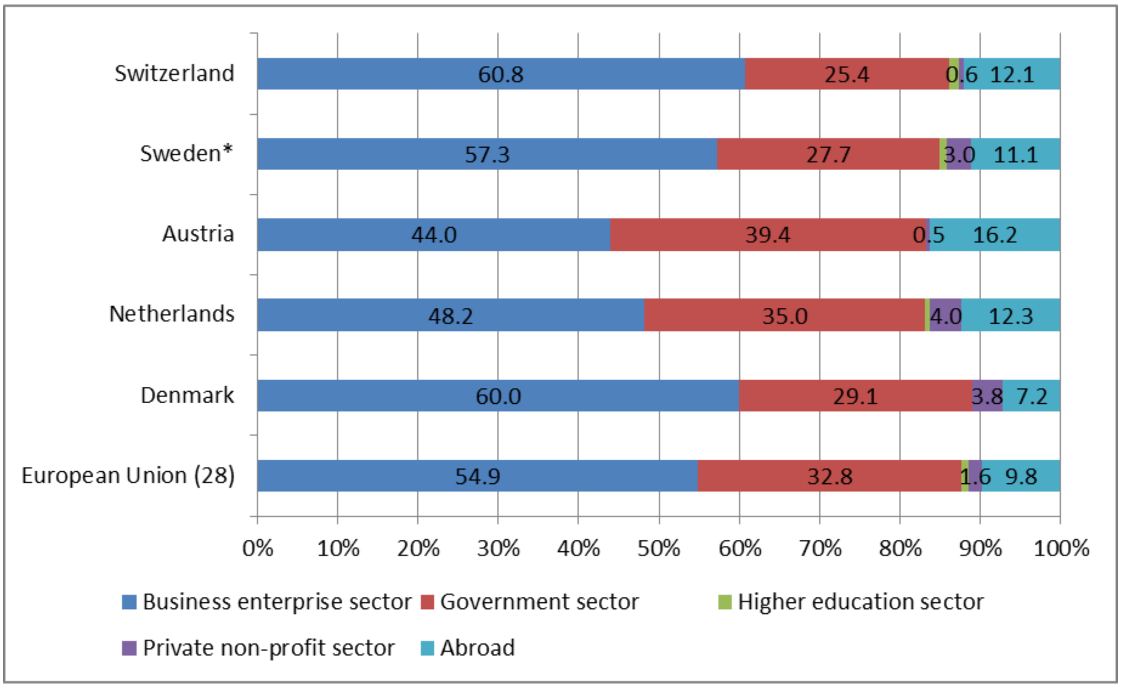
(see chapter on HEI-funding). The interplay of public and private competitive funding for research and the role of private foundations for the development of fields of excellence and the prioritisation of research areas will be discussed in the following chapters.

Figure 19: Total intramural R&D-Expenditures per Sector of Performance 2012



Source: Eurostat (2015)[114]

*Figure 20: R&D-Expenditures per Source of Funds 2012, *2011*

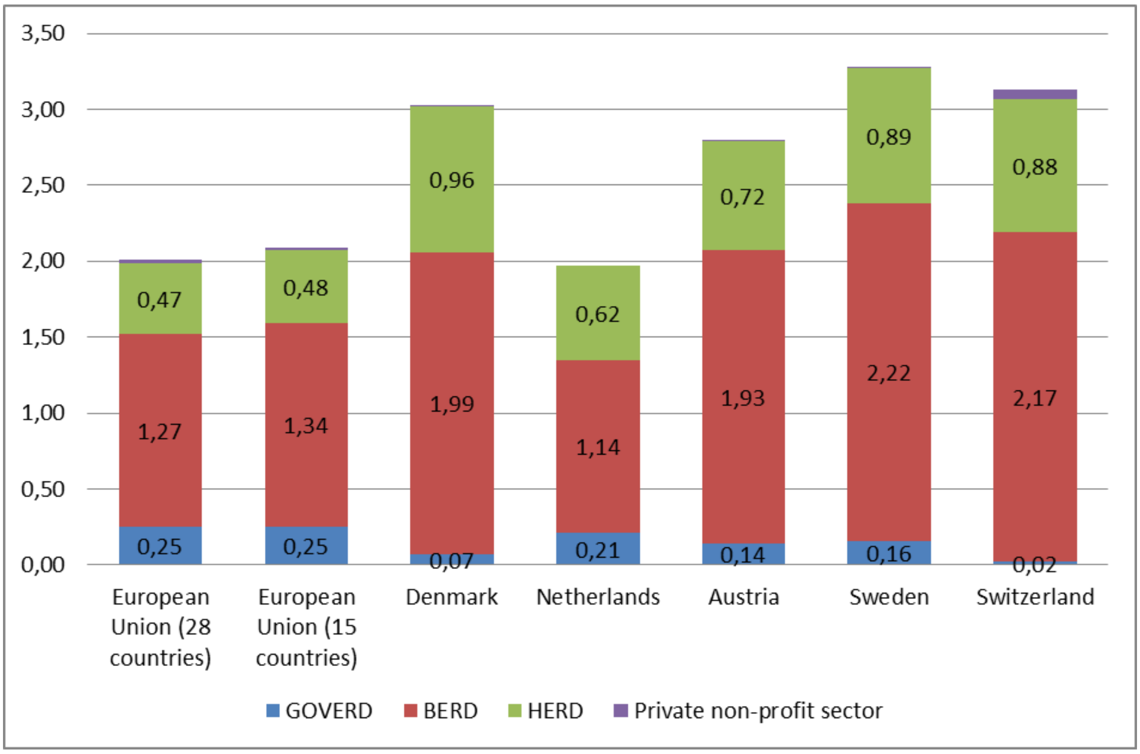


Source: Eurostat (2015)[115]

[114] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance

[115] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance and source of funds

Figure 21: GERD per Sector of Performance in percentage of GDP, 2011



Source: Eurostat (2015)[116]

Table 6: Basic features of public research funding, latest available

Indicator	HERD, % of public sector R&D expenditures (PSERD)	Basic research expenditures, public research, % of total public R&D	GBAORD, civil, % of total GBAORD	Generic public research (GUF and non-oriented GBAORD), as a percentage of Civil GBAORD	Institutional block funding, % of total funding to national performers
Austria	83.28	48.82	100	70.67	74.5
Denmark	93.54	44.19	99.69	61.34	64.7
Netherlands	75.27	53.4	98.43	71.91	71.2
Sweden	84.95	..	96.25	74.88	45.6*
Switzerland	97.4	76.97	99.,46	90.68	75
OECD – Total	..	..	75.33	43.17	..

Source: OECD STI-Outlook 2014, *Hollensten, O. (2014)

The higher shares of competitive public funding for R&D, especially in Sweden but also in Denmark via public funding intermediaries, mark another significant difference to the Austrian system of R&D-funding. In both countries, a variety of intermediary funding bodies, research councils acting on behalf of a respective ministry and independent public funding agencies are in place, providing different types of competitive funding schemes for basic and applied research, innovation and technological development. The great variety of different institutions and funding schemes in place makes it difficult to assess the overall effect of competitive public funding for basic research and is also a challenge for the governance of the HEI sector, as the funding bodies have different formal requirements, establish different incentives and funding rates and can tie up considerable amounts of base funding. The Swedish Research Council, as the largest governmental funding body for basic research had a budget of € 683.5

[116] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance

million in 2014 and is much better endowed than VINNOVA, the largest public funder for applied research and innovation (€ 288.3 million in 2014). In Denmark, the two largest public funders for basic research, the Danish National Research Foundation and the Danish Council for Independent Research, budgeted funding of around € 200 million for 2015, compared to the recently established Innovation Fund with € 213 million.

4.2.2 Funding for business sector R&D

25% of total public R&D funding in Austria is dedicated to the business sector either in direct or indirect way (e.g. tax incentives).[117] This is comparably high, with Austria ranking on position 6 among OECD countries (only Korea, France, Slovenia, Belgium, United States have higher shares) of public R&D funding for the business sector in% of GDP, and on the 11th position regarding the share of direct public funding (0.14% of GDP, compared to Denmark with 0.05% and Sweden with 0.11%) in 2012.[118] 41.6% of government support for business R&D accounts for tax incentives, placing Austria on the 15th position of OECD-countries compared, behind Denmark with 49.5%. In Sweden 100% of government support for Business R&D is distributed via direct instruments.[119]

The so-called R&D-premium-refunds by tax authorities effectively allow firms to benefit from incentives as if they were profitable (even if they are not at present). The premium can be deducted or claimed on internal as well as external R&D projects/expenditure, recently increased from 10% to 12%. The type of expenditure for “research and experimental development” eligible is set out and defined in national income tax laws (i.e. § 108c Abs 1 Z 1 “Einkommensteuergesetz” 1998). Since 2012 the FFG certifies and assesses the orientation and main focus of claimed company expenditure on the basis of OECD’s Frascati-Manual. In an international comparison the existing system does not seem to emphasise or favour specific actors, e.g. SMEs or large firms. Notably, € 572 million were allocated in this way to Austrian businesses in 2012. This constitutes a massive increase in absolute numbers by more than 80% when compared to the previous year (2011: € 313 million).[120]

Other tax incentive schemes such as explicit patent boxes have not been introduced so far. However, the Austrian tax system already offers specific regulation (i.e. favorable tax treatment) for corporate groups of firms and their headquarters when located in Austria. The current coalition agreement foresees a renewal of this “headquarter” initiative encouraging MNUs R&D activities in Austria, funded by Austrian Research Promotion Agency FFG. This initiative aims to (re-) strengthen R&D financed from abroad, foreign-owned innovation and employment activities in Austria as well as an increased public tax income.

[117] OECD STI-Outlook 2014, Country profile
[118] http://www.oecd.org/tax/rd-tax-stats.htm#design
[119] http://www.oecd.org/tax/rd-tax-stats.htm#design
[120] European Commission (2014b): RIO-Country Report 2014, Austria

4.2.3 Governance Structure of R&D funding in Austria

Responsibilities for research funding bodies are distributed among several ministries (see Figure 22). With the government agreement 2013, the former Ministry for Science and Research (BMWF) and the Ministry for Economy, Family and Youth (BMWFJ) have been merged to the Ministry for Science, Research and Economy (BMWFW) (without family and youth agendas). Nevertheless, responsibilities for funding agencies within the new ministry are still separately distributed between the administration areas for "science and research" and "economy" ("Verwaltungsbereiche" qua Geschäftseinteilung). Figure 22 gives an overview about the institutional interlinkages in terms of funding streams and responsibilities of ministries with the Austrian R&D&I funding bodies and R&D-performing entities. The responsible authority, in terms of reporting and the representation of owner's interest, for the Austrian Research Fund (FWF) is the "Science and Research"- administration area of the BMWFW, which also accounts for the largest part of funding.[121] Responsible for the Austrian Research Promotion Agency (FFG) as well as for the Austria Wirtschaftsservice GmbH (AWS) are the "economy"- administration area of the BMWFW together with the Ministry for Transport, Innovation and Economy (BMWVIT) on equal shares. Not in the picture, the Minister for Science, Research and the Economy established the ERA Council Forum Austria in 2014 as a further initiative to strengthen the ties between Austria's system of innovation and the European research institutions and to ensure the highest possible returns from the European level and proactively identify and monitor the relevance of European developments for Austria.

Funding for FFG programmes and instruments comes from several sources, including ministries on behalf of which the FFG administers programmes, the Austrian National Research Foundation, Federal States (in the COMET-Programme e.g.) and the EU. Furthermore the FFG serves as National Contact Point (NCP) for the 8th European Framework Programme HORIZON 2020. One major funding source of the AWS is the European Recovery Program (ERP) that is also a major funding source for the National Research Foundation. The AWS is at the same time responsible for the management of both, the National Research Foundation and the ERP. The management area "economy" of the BMWFW is also responsible for the Christian Doppler Agency, with its focus on basic but application oriented research, contributing half of its funding.

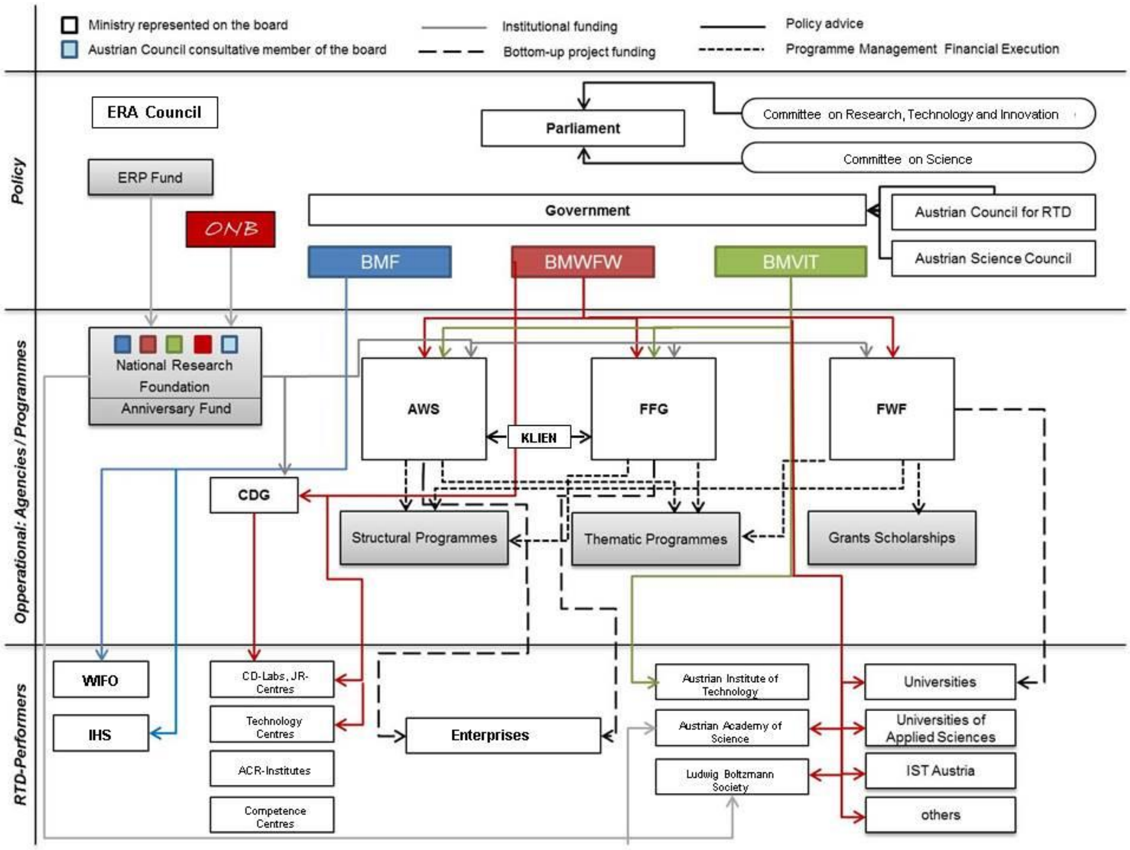
Beside their formal responsibility structures, other interlinkages exist in the research funding system, in terms of funding sources for programs or the formation of steering committees and bodies (Aufsichtsräte) that distribute power among the several levels of the Austrian Research funding system. Altogether, the actual structure of coordination and steering of the Austrian R&D-funding together with the formal distribution of responsibilities for basic and applied research and innovation among several ministries and funding bodies in parallel, forms a quite complex system of independencies, especially between the FFG and other agencies.[122] This fragmentation together with sometimes overlapping and less clear competencies, and complex, non-harmonised rules for individual instruments, especially in financing applied and

[121] FWF – Austrian Science Fund (2014): Annual Report 2014

[122] BMWFJ, BMVIT (2009): Systemevaluierung der österreichischen Forschungsförderung- und Finanzierung, Teilbericht 3

cooperative research is often identified to be a major bottleneck in developing a systemic view and an efficient and strategic use of finances for R&D in Austria.[123]

Figure 22: Governance structure of the Austrian research and innovation system



Legend: ÖNB (Austrian Federal Reserve), BMF (Ministry of Finance), BMWFW (Ministry of Science, Research and Economy), BMVIT (Ministry of Transport, Innovation and Technology), AWS (Austria Business Service), FFG (Austrian Research Promotion Agency), FWF (Austrian Science Fund), CDG (Christian Doppler Research Society), WIFO (Austrian Institute of Economic Research), IHS (Institute for Advanced Studies), ACR-Institutes (Austrian Cooperative Research Institutes), IST Austria (Institute of Science and Technology Austria)

Source: Cuntz, A. (2015): RIO Country Report 2014: Austria

In recent years, a stagnation or even decrease of budgets for competitive R&D-funding in terms of their share of total public funding for R&D was to be observed, with remaining emphasis on applied research. Taking the ratio between funding budgets of FWF and FFG as benchmark (1:2.2), there is a comparative low share of competitive funding for bottom-up basic research in Austria, compared e.g. to Switzerland with a ratio between funding budgets of SNF and CTI of 8:1.

The Austrian Science Fund (Fonds zur Förderung der wissenschaftlichen Forschung – FWF) is the country's central institution for the promotion of basic research. In total the funding portfolio comprises 15 schemes, with emphasis on funding for bottom-up scientific research, except the Clinical research program and the program for Communication in Sciences.[124] More than half of all funds distributed by the FWF in 2013, i.e. € 104 million (2012: € 98 million), were granted to individual scientists. Close to 20% of total funds supported the establishment

[123] See e.g. Austrian Council for Research and Technology Development (2014): Report on Austria's Scientific and Technological Capability 2014, Vienna, p. 57 ff

[124] FWF – Austrian Science Fund (2014): Annual Report 2014

of new or the continuation of structured doctoral training programmes in the higher education sector ("Doktoratskolleg"). This constitutes a strong increase compared to pre-period, i.e. only 5% of FWF funds targeted this area in 2012, and it is the main reasons why total FWF funding increases by more than 3% or € 6 million. Nevertheless, due to budgetary limitations, no new applications to doctoral colleges were possible in 2014. The same happened for the instrument of so-called special research projects. Though absolute budgets allocated to research funding were increasing since 2002 from € 91.53 million to 202.6 million in 2013, applications did too, causing a steady decrease in approval rates from 41.5% in 2006 to 25.8% 2013 in terms of project numbers. This is also true for projects that would be on principle eligible for funding, but are not funded due to budget limitations. The FWF also participates in ERA-Net-activities and Science Europe with the aim to encourage the internationalisation of Austrian research. In 2014 50% of all running projects had participants from abroad, with the highest share from Germany. Between 2013 and 2014, due to finance contributions to ERA-Nets, research funding dedicated to international activities increased by 75% from € 15.5 million to € 27.2 million. Furthermore the FWF cooperates with the US National Science Foundation for financing research stays of US-doctoral students.

The Austrian Research Promotion Agency (FFG) is the national funding agency for industrial research and development in Austria.[125] As a "one-stop shop" offering a diversified and targeted programme portfolio, the FFG gives Austrian businesses and research facilities quick and uncomplicated access to research funding. The FFG was founded on 1 September 2004 (pursuant to the FFG Act on establishing a research promotion agency, Federal Law Gazette I No. 73/2004). The FFG is wholly owned by the Republic of Austria, represented by the Federal Ministry for Transport, Innovation and Technology (bmvit) and the Federal Ministry of Science, Research and Economy (BMWFW). As a provider of funding services, however, the FFG also works for other national and international institutions. The FFG offers a portfolio of sophisticated and targeted instruments for funding research, technology and development at firms and research institutions along the entire innovation chain. FFG's funding divides into several programme topics. Total funding budgets of the FFG in 2014 comprised € 481.411 million in cash value (2013: € 364.195 million). Basic Programmes accounted for the largest part of FFGs funding in terms of funding volume in cash value of € 171.68 million in 2014. There are different programme lines with specific aims within the Basic Programmes. The largest is programme in the Basic Programme is the so so-called General Programme (Basisprogramm) with a funding volume of € 106.315 million in 2014. The funding strategy of the General Programme (individual project experimental development) is fundamentally based on the bottom-up principle and is therefore open all branches of industry, research topics and size of companies or projects. The funding instrument aims to strengthen the competiveness of companies based in Austria by funding the development of new products, processes and services. Co-operation with scientific partners as well as inclusion of young researchers are welcome. The topical (thematic) programmes represent the third-largest programme sector in the funding portfolio of the Austrian Research Promotion Agency (FFG) in 2014, with a cash value of € 139.63 million (2013: € 125.14 million). These programmes aim to support national

[125] BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014. Status report in accordance with Section 8(1): of the Research Organisation Act on federally subsidised research, technology and innovation in Austria

and international priority topics, including energy, ICT, production, and security research, which are all themes that are competitive at the European level, regarding the most successful topics of Austrian participation in the Framework Programmes. The share of topical programmes in FFG's total funding budget (cash value) is 26%, as proxy for the relevance of thematic funding in total agencies funding.

Since 2014, the FFG is also funding scientific personnel with the BMVIT funding for endowed chairs ("Stiftungsprofessuren") as well as doctoral thesis in the fields of science and engineering. In 2014 3 chairs were established.

Austria Wirtschaftsservice GmbH (aws) is the federal development and financing bank for the promotion and financing of companies. aws employs a broad range of instruments, such as grants, liabilities, and guarantees, as well as equity capital financing, to support firms in the financing and funding of their projects. Depending on the business stage and financial need, the bank develops a financing mix that takes into account the distribution of public and private risk. The bank also offers consulting services that specialise in large investment projects, innovation, and technology commercialisation.[126] Funding logic is strongly oriented towards growth and innovation, covering a broad range of topics from start-up preparation to market introduction, to larger leaps in growth such as internationalisation in later business stages. Table 1 gives an overview about the structure of the aws' funding portfolio. The highest share of funding accounts for the provision of loans and guarantees in 2014, summing up to 86.6% of total aws funding (€ 739.8 million in 2013). Increasing importance in aws-schemes gain funding mechanisms for the provision of equity capital (see Table 2), as will be further mentioned in the topic on venture capital. The existing portfolio of equity capital instruments, including the aws small business fund and the aws venture capital initiative, was expanded in 2013 to add two new instruments: the aws Start-up Fund, which invested in 8 participations in 2014, offering long-term growth capital through public silent partnerships. Another new addition is the Business Angel Fund, which aim is to double the capital that a Business Angel brings into a start-up company. The first co-financing contract was concluded with a Business Angel in 2013; in 2014 4 projects were committed to be funded.

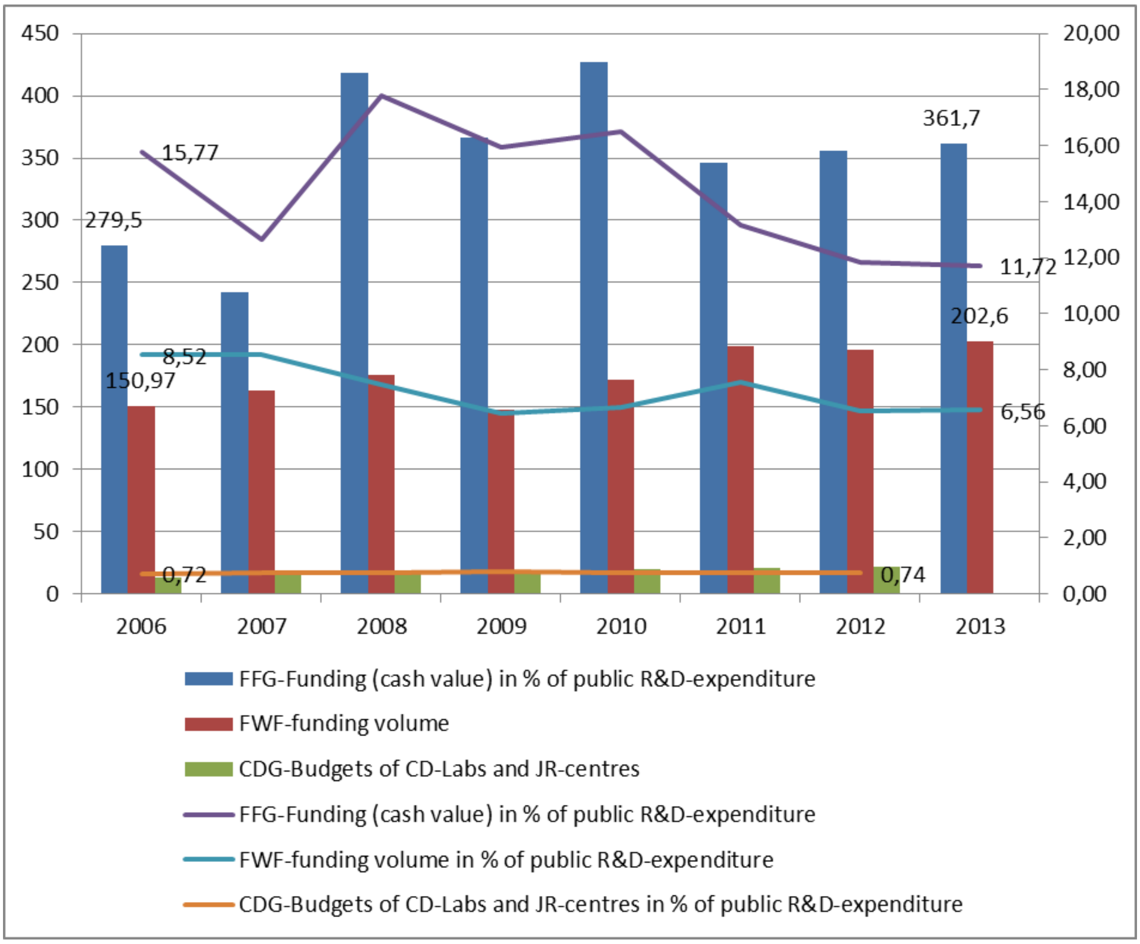
The Christian-Doppler Research Association (CDG) aims at promoting R&D in several areas of natural sciences, technology and economics by the implementation of long term research collaborations between academia and business via so-called strategic public-private partnerships. These strategic PPPs comprise independent research units, comprising so called Christian Doppler Laboratories (CD Laboratories) and Josef Ressel Centres (JR Centres), being funded by the CDG. CD Laboratories are focusing on application-oriented basic research, being hosted at universities or non-university research institutions. With the introduction of the model of JR Centres in 2012, being hosted at universities for applied science, research units solely focusing on applied research have been added to the funding portfolio of the CDG. Research topics of the CD-labs and JR-centres are defined bottom-up. The maximum funding period for CD-laboratories is 7 years, for JR-centres 5 years.127

[126] Ibid.

[127] Unger, M., Polt, W. (2014): OECD-TIP Case Study: Christian Doppler Research Association, on behalf of the Austrian Ministry for Science, Research and Economy.

Figure 23 provides an overview about total funding budgets of public R&D-funders FFG and FWF, as well as of the CDG in percentage of total public expenditures for R&D.

Figure 23: Share of funding volumes of FFG, FWF and CDG in total federal R&D-expenditures in %



Source: Statistik Austria; FFG, FWF, CDG Annual Reports; Austrian Research and Technology Report 2014

4.2.4 Governance Structure of R&D funding in Denmark

In the last decade, funding for R&D and innovation activities especially from the public sector increased substantially. This was accompanied also by a number of structural reforms in the system based on the assumption that an increase in inputs has to be aligned with more efficient institutional structures. A major reform comprised the restructuring of the higher education sector and public research performing institutions in 2007, reducing their number from almost 30 to eight public universities and three public research institutions.[128] Furthermore, there are nine so-called GTS-Institutes (Godkendt Teknologisk Service) in place which are comparable in their mission and structure to Fraunhofer Society as independent not-profit organisations whose purpose is to spread technical know-how, new methods and knowledge to industry and society in order to create and increase development.

The major target of public policies is to increase the impact of research on productivity and innovativeness, i.e. the better utilisation of (an already excellent) science base. The Globalisation Strategy of 2006[129], the starting point for much of the reforms, set the target to increase R&D-expenditures to 3% of GDP, which was already achieved with total R&D-expenditures of 8 billion € in 2014 (3.1% of GDP)[130]. Regarding the structure of R&D-expenditures, Denmark also meets the Barcelona-targets with public expenditures accounting 1.1% of GDP and private sector expenditures for roughly 2% of GDP in 2012. Funding for R&D (2.8 billion € in 2013) in the public sector mainly comes from public sources. 2.1 billion € comprise public expenditures, 0.4 billion € come from private foundations, 0.2 billion from abroad (incl. EU-Funding, Nordic Council of Ministries, UK and US) and 0.1 billion from private companies.

Against this background, in the Innovation Strategy of 2012, a new funding target of 3.5% of GDP was set. While the Globalisation Strategy 2006 was mainly focusing on improving the efficiency in public spending on research and education, the target of increasing the impact of research on productivity and innovation performance has not been achieved so far, as several evaluations pointed out.[131] The Danish Innovation Strategy of 2012 widened the emphasis on research and innovation to contribute to solutions to grand societal challenges as well as further increasing competitiveness of the business sector. Targets are stated that Denmark should catch up to Top-5 OECD-countries, regarding the share of innovative enterprises, the amount of private R&D-expenditures as well as the amount of people with higher education the private sector. Public R&D-expenditures in % of GDP are already the top 5 among OECD-countries.

R&D and Innovation funding by the public sector relies on clear division of labour between public sector funding agencies and councils. Figure 24 displays the structure of public funding for R&D in Denmark. Public emphasis in research funding and also in the coordination with private sources is put on the optimal provision of schemes and funds among the three pillars,

---

[128] Oddershede, J. (2009): Danish universities – a sector in change; Universities Denmark

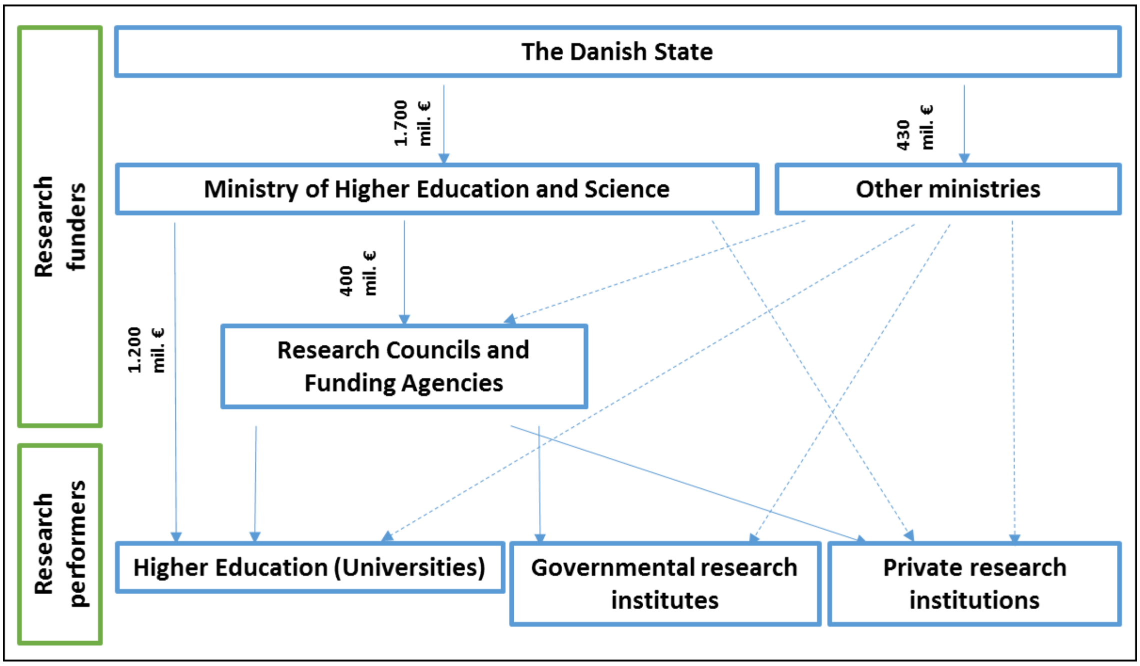
[129] Danish Government (2006): Progress, Innovation and Cohesion – Strategy for Denmark in the Global Economy, Kopenhagen

[130] Statistics Denmark: Research and development at http://www.dst.dk/en/Statistik/emner/forskning-udvikling-og-innovation/forskning-og-udvikling

[131] Klitkou, A. (2013): Mini Country Report Denmark– Thematic Report 2011 under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)

namely education and individuals, research platforms, international collaboration and attraction of foreign researchers, with several dedicated measures in place.

Figure 24: Structure of public R&D-funding 2014



Source: Statistics Denmark; compilation DAMVAD Analytics

The Ministry of Higher Education and Science is responsible body for policies and funding in the research and innovation system. Institutions for higher education as well as the research council's report to the Ministry. The Danish Agency for Science Technology and Innovation is a part of the Ministry of Higher Education and Science, though being separated from the department. The agency performs tasks relating to research and innovation policy and provides secretariat services and supervision for the research councils.

The Danish Council for Independent Research is the second largest public research foundation in Denmark, annually funding approximately 140 million euro in research. The Council is like Innovation Fund Denmark an independent institution referring to The Ministry of Higher Education and Science.

The Danish National Research Foundation (DNRF) differs from the council, since the Ministry of Higher Education and Science does not direct funds towards the foundation annually. Instead, the foundation has its own equity which state contributes to once in a while. The independency from the ministry is thus even higher compared to the Danish Council for Independent Research and Innovation Fund Denmark. On average, the foundation allocates 60 million euro towards basic research annually.

For further improvement of the system, emphasis is put on simplification and coordination of funding structures as well as on the implementation of new instruments for challenge-driven innovation. In line with that in April 2014 the Danish Council for Strategic Research, Danish Council for Technology and Innovation and the Danish National Advanced Technology

Foundation were merged to create the Innovation Fund Denmark. [132] The Innovation Fund Denmark is the largest research foundation in Denmark. The foundation is an independent institution under the responsibility of the Ministry of Higher Education and Science and will invest approximately 213 million euro in new research and related initiatives in 2015.

The Ministry of Business and Growth seeks to improve the conditions for growth in Denmark by conducting economic analyses and suggesting policy initiatives in areas imperative to economic growth, including business regulation, intellectual property rights and competition and consumer policy. The Ministry is further engaged with various international organizations enhancing international framework conditions for growth.

The Danish Business Authority is an agency under the responsibility of the Ministry of Business and Growth. The agency aims to create growth through effective regulation to ensure good conditions for businesses, but also by directly supporting businesses in different ways, including co-financing developmental projects, advising entrepreneurs and stimulating creativity in the business community.

The Danish Growth Fund is the Danish state's investment fund also in the responsibility of the Ministry of Business and Growth. It is an independent fund governed by an independent legal act and an independent board of directors. The act concerning the Danish Growth Fund stipulates that the fund must promote growth and renewal for small and medium-sized enterprises in order to achieve a greater socio-economic return. The fund contributes to the creation of new companies by providing capital and expertise. It is the main provider of public venture capital, as will be displayed in the respective chapter 4.4.3.

Each of the five Danish regions has established a regional growth forum consisting of members from business, scientific and educational institutions, employers and employees' organizations as well as municipalities and the regions themselves. The forums contribute to the regions strategic planning for growth and development by recommending projects for co-financing. The projects include entrepreneurs and new businesses, innovation and application of new technologies.

As in many OECD countries, demand side policies gain increased importance as instruments to stimulate innovation in Denmark. Demand side policies comprise e.g. innovation oriented public procurement, the use of regulations and standardization to enforce the need for innovative solutions, tax-incentives for innovative products or systematic policies for the development of new markets.[133] In recent years, the demand of user groups for innovative solutions and increased flexibility became important issues standardization processes.[134] Whereas in Sweden, policies like innovation oriented public procurement have not been very influential so far[135], in Denmark this topic is already high on the Agenda for quite a while,

[132] Innovation Fund Denmark 2015 Strategy: http://innovationsfonden.dk/sites/default/files/download/2015/02/04/InnovationsfondensstrategiEN.pdf

[133] Klitkou, A. (2013): Mini Country Report Denmark– Thematic Report 2011 under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)

[134] Scapolo, F., Churchill, P., Viaud, V., Antal, M., Cordova Gonzalez Castillo, H, L, De Smedt, P. (2014): How will standards facilitate new production systems in the context of EU innovation and competitiveness 2025?, JRC Foresight Study, Final Report

[135] Edquist, C. (2015): Striving towards a Holistic Innovation Policy in European Countries – But Linearity Still Prevails, STI Policy Review, Vol. 5, No. 2

comprising innovation oriented funding mechanism focusing on public-private partnerships of the Innovation Fund Denmark (and its precursor organisations)[136], or the development of a guide for user-driven innovation as foundation for standardization processes.[137] Another important mechanism is the Market Development fund, aiming to support enterprises to bring their new products to the market faster and to make it easier for public-sector institutions to obtain innovative solutions. Special emphasis is put on SMEs.[138]

Table 7 displays public research funding bodies, agencies and foundations including information of scope and target group of funding, also including core programs and schemes.

Table 7: Public funding bodies and agencies in Denmark for research, innovation and tertiary education

Organization/Foundation	Orientation	Funding (million euro)	Target of Funding	Instruments and schemes
Innovation Fund Denmark	Applied reasearch, innovation	213	Public research institutions, SME's, private sector research, individual researchers	• Large sale projects: Comprise projects along the entire value chain from basic research to the market • InnoBooster: Investments in SMEs with a viable proposition which have high development potential and which require venture capital and sparring to nurture their innovation capacity • Talents: Investments to support research and entrepreneurial talents • Industrial PhD program/Post Doc Entrepeneurs
Danish National Research Foundation	Basic research	60	Public research institutions	• Centers of Excellence: Research units based at research institutions • Niels Bohr Visiting Professorships • DNRF Professorships • NSF Graduate Research Opportunities Worldwide 2015: Research visits at a DNRF Center of Excellence for a period of 2-12 months • Danish-Chinese research centers • Danish-Indian Collaboration Program • Talent recruitment
The Danish Council for Independent Research	Basic research	140	Public research institutions	• Individual postdoctoral grant • MOBILEX mobility grant • Sapere Aude: Talent, starting, and advanced grants • Research project 1 and 2 • Research educations outside universities
The Danish Growth Fund	Market development	268	SMEs	• Fund to fund investments • Investments in start-ups • Loans and guarantees for established SMEs
The Danish Market Development Fund	Market development	18	SMEs	• Faster to market: Funding to enterprises for the testing and adapting of new products

[136] Klitkou, A. (2013): Mini Country Report Denmark– Thematic Report 2011 under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)
[137] Bloch, C. (2011): Measuring Public Innovation in the Nordic Countries (MEPIN); Nordic Innovation Centre
[138] http://markedsmodningsfonden.dk/in_english

Source: Innovation Fund Denmark 2015 Strategy, Danish National Research Foundation, The Danish Council for Independent Research Call for Proposals Autumn 2015 and Spring 2016, The Danish Growth Fund, The Danish Market Development Fund; compilation DAMVAD Analytics

4.2.5 The role of private foundations for Danish R&D funding

A characteristic of the Danish R&D and innovation funding landscape is the prominent role of private foundations, as independent funding bodies with specific objectives and fields of interest. Universities are the most important beneficiaries of private funding. The following section is based on the results of DG Research and Innovations' EUFORI-study 2015, examining different structures of private philanthropic funding for research and innovation in EU member states.[139] Private foundations in Denmark comprise two main types of institutions. Industrial foundations may own private companies or be directly involved in business activities. Beside commercial activities, dividends from business activities might be used to finance donations and charitable activities in education, research, innovation, social and humanitarian projects. Beside the long lasting tradition of private charitable funding in Danish history, especially the favourable tax conditions for foundations in the 1970s and 1980s were a main driver for the establishment of industrial foundations. Examples for this type of foundation comprise the Carlsberg foundation or the Novo Nordisk foundation. As also stated in the qualitative analysis, a key prerequisite for the development significant charitable sector is the existence of large nationally owned businesses. Other examples, pointing out the financial significance of the private foundations are Villum and Velux Foundation with an annual budget of around € 120 million or the Lundbeck Foundation, ranging above the funding budget of the Danish National Research Foundation (DNRF) of around € 60 million annually.[140] In total there are about 1300 industrial foundations in Denmark, with many but not all of them performing charitable activities. With the emphasis to increase transparency in private funding, industrial foundations are obliged to submit annual reports report to the Danish Business Authority within the Danish Ministry of Business.

Only little is known about activities and purposes of non-industrial foundations since they do not have to apply the same reporting standards as industrial foundations. These foundations also may not only have a charitable focus, but are also serving for other interests of its founder. There are about 10 000 non-industrial foundations with all kind of purposes.

Private foundations in Denmark are eligible to a variety of tax deductions. Expenses related to charitable activities could be deducted by a rate of 100 to 125%, with the limitations, that they might not exceed total revenues of the foundation. The first 25,000 DKK of revenue is free of taxes.[141]

Research funding of private foundations is especially concentrated in the fields of life sciences and biotechnology. Prominent examples are the Novo Nordisk Foundation, funding mainly basic but also applied research with focus on medical sciences and technology and a budget of € 105 million in 2013. A prominent funding scheme is the Laureate Research Teams, where

[139] Thomson et al. (2015): European Foundations for Research and Innovation – Denmark Country Report; European Commission EUFORI-Study
[140] DNRF Annual Report 2014: http://dg.dk/en/about-us/publications/annual-reports/
[141] Thomson et al. (2015): European Foundations for Research and Innovation – Denmark Country Report; European Commission EUFORI-Study

excellent researchers have the possibility to work on long term research projects (until 14 years) within self-selected teams.

Table 8: Private funding agencies in Denmark for research, innovation and tertiary education

Organization/Foundation	Orientation	Funding (million euro)	Target of Funding	Instruments and schemes
Lundbeck Foundation	Basic research, applied research	64	Public research institutions	• Personal grants: Funding of academic staff • Talent prizes • Strategic grants for research projects
Novo Nordisk Foundation	Basic research, applied research, innovation	105	Public research institutions	• Research projects • Scholarships • PostDoc fellowships • Investigator grants • Prizes
Carlsberg Foundation	Basic research, applied research, market development	30	Public research institutions, small and medium-sized enterprises	• Research projects
AP Møller Foundation	Basic research, applied research, innovation	121*	Public research institutions	• Grants for buildings and research equipment
Realdania	Innovation	112*	Enterprises	• Innovation programs
Villum Foundation	Basic research, applied research	59	Public research institutions	• Research projects • Research centers • PostDoc fellowships

Sources: Lundbeck Foundation 2014 Annual Report, Novo Nordisk Foundation Group Facts and Results 2013, Villum Fonden Årsskrift 2013, Carlsberg Foundation Årsskrift 2014, Realdania Årsrapport 2014, AP Møller Foundation
*All grants included, not only science and innovation grants

Private foundations play an increasing role especially in funding R&D at universities, with the amount of funding by the private-non-profit sector in 2013 was nearly 6-times higher than in 2000.[142] One reason for that is that related companies are doing well which increases the budgets of the respective foundations. Furthermore it was stated in the interviews, that the spirit for funding more risky projects has increased.

Role, impact and strategic interaction of private foundations with public interest and funding have been debated in Denmark for quite a while. The private research foundations do not increase in numbers but in size, meaning also that they are increasing funding of research year by year with their importance in the financing of research growing. This has also challenged the foundations to become more open. Several of the large research financing private foundations have to a large extent applied transparent systems for funding based on a large number of key-performance indicators (KPIs), that are measured and evaluated on annual basis.

[142] Eurostat: Total intramural R&D expenditure (GERD) by sectors of performance and source of funds

One of the issues being discussed in Denmark is how synergies can be established between the private foundations and government financing of research and innovation. Collaboration between private and public foundations is emphasised e.g. via co-financing models. For example, universities and private funds co-finance academic programs such as PhD-programs and research projects when the universities and private funds share a common interest in the program or project.

Funding from private foundations is an important supplement to public funding in universities research and also a major driver for the development of international competitive fields of excellence especially in the IT and Life Sciences (e.g. were universities are successful in H2020). One potential drawback of this increasing amount of private funding, stated often in interviews especially with universities, is that it might disproportionally favour certain areas, like ICT or the Life Sciences, at the expense of others (e.g. like Humanities or Social Sciences). In fact there are no big foundations in Denmark funding humanities to a larger extent. On the other hand, main funding organisations like Novo Nordisk are obliged by their statutes to fund only in certain areas. As funding from private sources also requires co-funding from base funding it may also reduce the freedom of universities to strategically decide on the investment in certain areas and it may reduce resources for other faculties. Hence, there is a widespread perception of the need for greater emphasis on the better alignment of public and private foundations' funding strategies in research.

4.2.6 Governance Structure of R&D funding in Sweden

Sweden is among the highest ranked countries in the world in R&D investments as percentage of GDP and is consequently well above EU average in this measure. Despite having managed the effects of the 2008-2012 economic crises better than most EU countries and despite thorough efforts in the past few years to counter these negative trends, Swedish annual investment in R&D has been in steady (relative) decline. The main reason for this is dropping private sector R&D expenditure. As a consequence the Swedish government committed itself to the ambitious target of "approximately" 4% R&D-intensity by 2020.[143] On the performer side, the private sector dominates, with around 60% of the total R&D investments, with a small number of very large companies accounting for the largest part of the private sector R&D activities. A strong academic sector consumes over 90% of the governmental appropriations for R&D and is thus responsible for most of the public R&D including not only basic research but also applied and strategic research programs for Swedish long-term competitiveness.[144]

A characteristic of the Swedish research and innovation system is the large number of private foundations, which act independent from official public policy making and will be highlighted in more detail in the next section. It is also important to note that the innovation policy has a strong geographical focus and misses an explicit overarching national Swedish research and innovation policy. The following actors are in the center of Swedish R&D and innovation policies terms of policy design, governance and funding.[145] Figure 25 displays an overview about main structures funding and governance of R&D and innovation policies and activities in Sweden.

[143] OECD (2012b): OECD Reviews of Innovation Policy: Sweden 2012, OECD Publishing
[144] European Commission (2014), ERAWATCH Country Reports 2013: Sweden, Luxembourg
[145] OECD (2012b): OECD Reviews of Innovation Policy: Sweden 2012, OECD Publishing, p. 224 ff.

As in Austria there are two ministries being mainly responsible for funding and policies of R&D and innovation. The Ministry for Education and Research is responsible for schools, universities science and research policies. The Swedish Research Council (Vetenskapsradet, VR) is an operative unit of the Ministry for Education and Research as a government agency that provides funding for basic research of the highest scientific quality in all disciplinary domains. Furthermore, it hosts the Swedish National Agency for Higher Education.

The Ministry of Enterprise, Energy and Communication is responsible for innovation policies, leading the development work for the innovation strategy from 2012. The Swedish Governmental Agency for Innovation Systems (VINNOVA) is Sweden's innovation agency under the Ministry of Enterprise, Energy and Communication, and the national contact agency for the EU Framework Program for R&D. Its activities comprise funding for applied research and innovation activities, with an annual budget of approximately € 220 million.[146] Around 45% of VINNOVA's budget was dedicated to universities in 2012, 30% to companies with 60% out of that to SMEs.[147]

Swedish Agency for Growth Policy Analyses is a national authority under the direction of the Ministry of Enterprise, Energy and Communications. They conduct evaluations, analyses and statistical studies with a broad Swedish and international perspective.

Swedish Agency for Economic and Regional Growth is a national agency under the Ministry of Enterprise, Energy and Communication, and has the role to strengthen regional development and facilitate enterprise and entrepreneurship throughout Sweden. They are, for example, active in areas as young entrepreneurs, promoting women's entrepreneurship and tourism, industry and regional development.

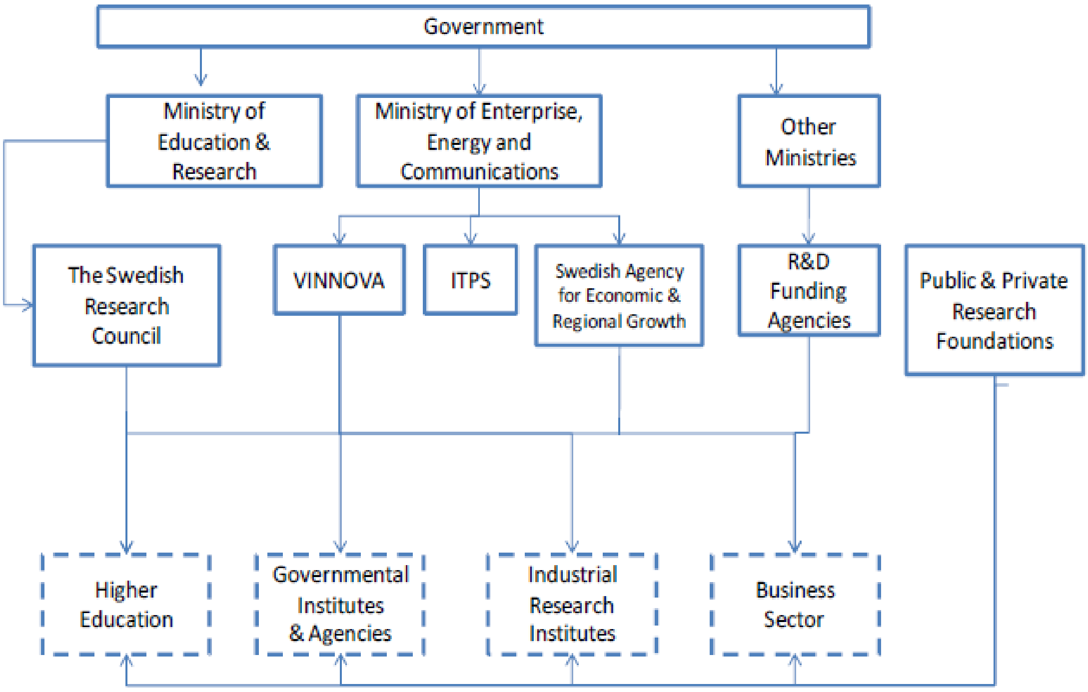
The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS) is under the responsibility of the Swedish Ministry of Environment with the purpose to promote and support basic research and need-driven research in the areas Environment, Agricultural Sciences and Spatial Planning.

Public funding for R&D by ministries, councils and agencies is supplemented by a variety of publicly controlled foundations. Both, the Knowledge Foundation as well the Swedish Foundation for Strategic Environmental Research (MISTRA), as one of the largest, were capitalized by the dissolution and restructuring of the Swedish wage-earner-fund into the so-called wage-earner fund foundations in the 1990s.[148] The Knowledge Foundation is a research financier for the 17 new universities in Sweden with the task of strengthening Sweden's competiveness and ability to create value. The Strategic Research Foundation finances strategic research centers and individual researchers through grants with a focus on biology and life sciences, systems and communication technology, materials development, process and product development technology. The research funded by MISTRA should contribute to a more efficient energy usage and transportation, healthy and resource-efficient cycles and sustainable production, consumption, and natural resource management.

---

[146] Ibid.
[147] Ibid.
[148] Einarsson, S.; Wijström, F. (2015): European Foundations for Research and Innovation – Sweden Country Report; European Commission EUFORI-Study

Figure 25: Governance and funding structure of the Swedish research and innovation system



Source: Chaminade et al. (2010)[149] adopted and updated from Roos et al. (2005)

The 20 county administrative boards in Sweden are the representatives of the government in the region and the coordinating body for state activities in the county, with resources to run programs, counselling and financial support to develop the business in the region including services. Almi[150] is owned by the state and is the mother company of 17 regional subsidiaries partly owned by the regional county boards and regions, supporting regional business development with counselling and financial support (loans and equity).

4.2.7 The role of private foundations for Swedish R&D funding

As in Denmark, private foundations play a prominent role in research funding in Sweden, especially the Knut and Alice Wallenberg Foundation with an annual budget of approximate budget of SEK 1.3 billion (€ 140 million)[151]. The development of the influential landscape of private philanthropic funding in Sweden was driven not only by the legal and political environment, but also by societal traditions ascribing foundations an important complementary role in the welfare state.[152] Whereas it was a private philanthropic spirit mainly driving the development of private foundations in the mid-19th century, independent publicly funded foundations bodies became of importance especially in the second half of the 20th century. This was in accordance with the development of the Swedish welfare state model. Nevertheless, the largest and in terms of funding most influential share of Swedish foundations is still under private control, comprising philanthropic individuals or families as

[149] Chaminade, C., Zabala, J.M., Treccani, A. (2010): The Swedish national innovation system and its relevance for the emergence of global innovation networks, Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE): Lund University, Paper no. 2010/09

[150] http://www.almi.se/English/, September 21st 2015, 16:59

[151] https://www.wallenberg.com/KAW/en/foundation/knut-and-alice-wallenberg-foundation, extracted on September, 21st 2015, 13:37

[152] Einarsson, S., Wijström, F. (2004): Foundations in Sweden – Their Scope, Roles and Vision, Stockholm School of Economics

well as for- and non-profit businesses. In total there are about 13,100 larger philanthropic foundations in Sweden, with the largest part of them performing funding activities. In 2012 accumulated reported assets amounted up to € 26 billion.[153] About 75% of total population of foundations (accounting for 90% of total assets) date back to 20th century, the largest part being established between 1950 and 1999.[154] Table 9 displays important examples of influential private funding institutions in their respective field.

According to Swedish Foundation Law, foundations must a) have an asset of property, b) set aside from the donor, c) to be administered independently, c) and with the aim of serving a specific purpose.[155] Swedish tax law favours certain charitable activities of foundations by an exemption from capital income tax. Those activities must refer to common public purposes, comprising beside health care, education and others scientific research (since 1942).[156] Beside the provision of social services, funding for research and education comprise by far the largest individual activities of Swedish foundations (public and private). According to the findings of the Swedish EUFORI-Study based on a survey among a sample of 70 representative foundations, R&D funding of foundations in Sweden is basically dedicated to all fields of Science, though again as in Denmark with a high concentration in medical research.[157]

As in Denmark, the role and impact of private foundations is seen mainly to complement public sector research funding, especially regarding the provision of funds for expensive equipment and buildings.[158] Competitive funding might furthermore increase competition among researchers and may encourage risk taking and pluralism in scientific research. On the other hand it was stated that especially in recent years the pendulum is swinging towards more application oriented projects. Similar to Denmark, the concern was raised that in accordance to the new R&D-funding mode for HEIs (see chapter on HEI-funding) and the requirements for increasing external funding, degrees of freedom for the allocation of base funding are reduced by the increased necessity for the provision of co-funding.

[153] Einarsson, S.; Wijström, F. (2015): European Foundations for Research and Innovation – Sweden Country Report; European Commission EUFORI-Study
[154] Ibid.
[155] Ibid.
[156] Ibid.
[157] Ibid.
[158] Ibid.

Table 9: Private funding bodies in Sweden for research, innovation and tertiary education

Organization/ Foundation	Aim and Target	Funding	Orientation	Instruments and schemes
Knut och Alice Wallenbergs stiftelse	The Foundation is one of the biggest foundations to distribute grants and R&D funding to Swedish HEIs and corresponding R&D institutes. The goal is to strengthen scientific research and educational activities of national interests.	SEK 1.3 billion on an annual basis (€ 140 million)	Medicine and health Natural sciences and technology	Funding natural sciences and technology, and biomedicine in basic research and expensive science equipment.
Riksbankens Jubileumsfond – The Swedish Foundation for Social Sciences and Humanities	The foundation is one of the largest funder of research outside the universities and colleges in the humanities and social sciences. RJ seeks to help generate new research and to consolidate and develop existing academic knowledge. The objective is to enable Swedish research in RJ's sphere of activity to attain international prominence.	SEK 380 million annually (2012) (€ 40.7 million)	Social Sciences and Humanities	Basic and Applied Research, Infrastructure for research => The Foundation supports scientific research by awarding project grants to individual researchers and research groups, mainly in the humanities, theology, social sciences and law.
Cancerfonden Insamlingsorganisation (Fundraising organisation)	Cancerfonden is an independent fund raising organization with focus on R&D funding and creating public awareness. The fund is the largest fund in this area.	SEK 415 million 2014 (€ 44.5 million)	Medicine and health	Providing funds for basic-, clinical and epidemical cancer research and care development projects in cancer research
Hjärt-Lungfonden Insamlingsorganisation (Fundraising organisation)	Funding medicine research in health sciences (heart and lung)	SEK 225 million 2014 (€ 24.1 million)	Cardiology and pulmonary research (largest fund in this area).	Primarily supports clinical research to quickly be implemented in practical use
Barncancerfonden Insamlingsorganisation (Fundraising organisation)	The aim of Barncancerfonden is to fund research that helps curing children with cancer and prevent future cases of cancer among children.	SEK 84.2 million (2014) (€ 9 million)	Medicine and health	

Sources: Annual Reports, compilation DAMVAD analytics.

4.2.8 Synthesis, conclusions and potential learnings for the Austrian research funding system

Competitive funding, both from public and private sources is much more pronounced in Denmark and Sweden, whereas in Austria budgets for competitive financing for R&D have stagnating or even decreasing. An important pillar in Danish' as well as in Swedish' funding system for research are large private foundations. Though their effects on specializations in research funding as well as the necessity for aligning them with public interests and policies is a current ongoing discussion both in Denmark as well as Sweden, it is indisputable that they are important backbones of the financial basis for R&D in both countries. In the coming years the research financing from private foundations is projected to increase enormously taking into consideration the turnover generated by the large corporations that has to be channelled to the foundations. Steps in these directions have recently been made in Austria, the effects of which should be revisited and assessed in some years. But given the amount of the gap between Austria and innovation leaders, and the time it took to develop the landscape of private foundations, a quick closing of this gap seems unrealistic.

The Austrian research funding system in terms of funding agencies and schemes in place is attested to be highly fragmented with parallels in competencies, and complex, non-harmonised rules for individual instruments, especially in financing applied and cooperative research. The reason for this might be mainly the dissection of several aspects of the innovation system, regarding scientific research, business and applied R&D and technology development and innovation among several ministries and duties, which hinders a systemic view on total measures in place and their optimal utilization. [159]

In following, potential lessons from a comparative assessment of the research funding landscapes of Austria, Denmark and Sweden are presented:

- In terms of quality of the policy processes, some lessons could be drawn e.g. from the rich evidence-based policy process on which the Swedish Government Bills for research to the parliament are formulated and the emphasis on impact assessment in the case of Danish assessments of individual measures as well as from the streamlined policy and funding structures in Denmark: the majority of all innovation and research policy support measures is concentrated in one Danish ministry and delivered through two main councils. Furthermore, a streamlining and clear division of labour between public funding schemes for both innovation and research was established in recent years. Austria might learn from these policy processes, e.g. by taking it as a starting point for a discussion about a more optimal division of labour between ministries and an adjustment of its funding portfolios (e.g. split of innovation and start-up funding between FFG and aws).
- Austria needs to further aim to encourage private philanthropic funding, taking into account the long tradition and economic structural background this sector is relying on in Denmark and Sweden, which will not possible be emulated in the short run. But as both Denmark and Sweden provide tax exemptions up to a rate of 125% of research

[159] BMWFJ, BMVIT (2009): Systemevaluierung der österreichischen Forschungsförderung- und Finanzierung, Teilbericht 3

expenditures on capital income of private foundations, a further enforcement of tax exemptions on private philanthropic funding for research is required.

- Private philanthropic can be successful in complementing public endowment for R&D. On the other hand in Denmark and Sweden the increase in mostly competitively awarded funding has raised also questions of co-funding requirements and reduced degrees of freedom (in the Danish case with respect to the scientific specialization through the impact of the NOVO NORDISK foundation). Emphasis has therefore to be put on developing monitoring mechanisms and alignment strategies of private funding with public interest.
- In terms of broadening the financial base in Austria, public competitive funding has as well to be increased significantly. A key prerequisite is the implementation of full-cost accounting at all public universities.

4.3 The role of performance based funding schemes for HEIs in Denmark, Sweden and Austria

The question of how much public steering of higher education institutions together with the provision of public funds is optimal and required, and how to incentivise high level education and research are key issues in many countries, especially in times of scarce public budgets. Since the 1980, along with the up-coming popularity of the new-public management approach, the implementation of performance based funding mechanisms together with an increased autonomy of universities and higher education institutions in terms of their administrative interlinkage with a respective ministry could be discovered. Hicks (2011)[160] identified six key rationalities for governments for the implementation of performance based funding schemes:

1. Incentivising increased productivity
2. Replacing traditional command-and-control systems with market-like incentives
3. Incentivise a stronger service orientation
4. Devolution of administrative autonomy to higher education institutions
5. Contracting services
6. Enhance accountability to outputs and outcomes provided

In the following the question will be raised, whether not only the amount of public funds, but also the introduction of key performance indicators both on teaching and research, as well as the governance structure of the higher education system are explanatory for the comparatively better scientific performance of Danish and Swedish universities and what potential lessons for Austria could be drawn from that.

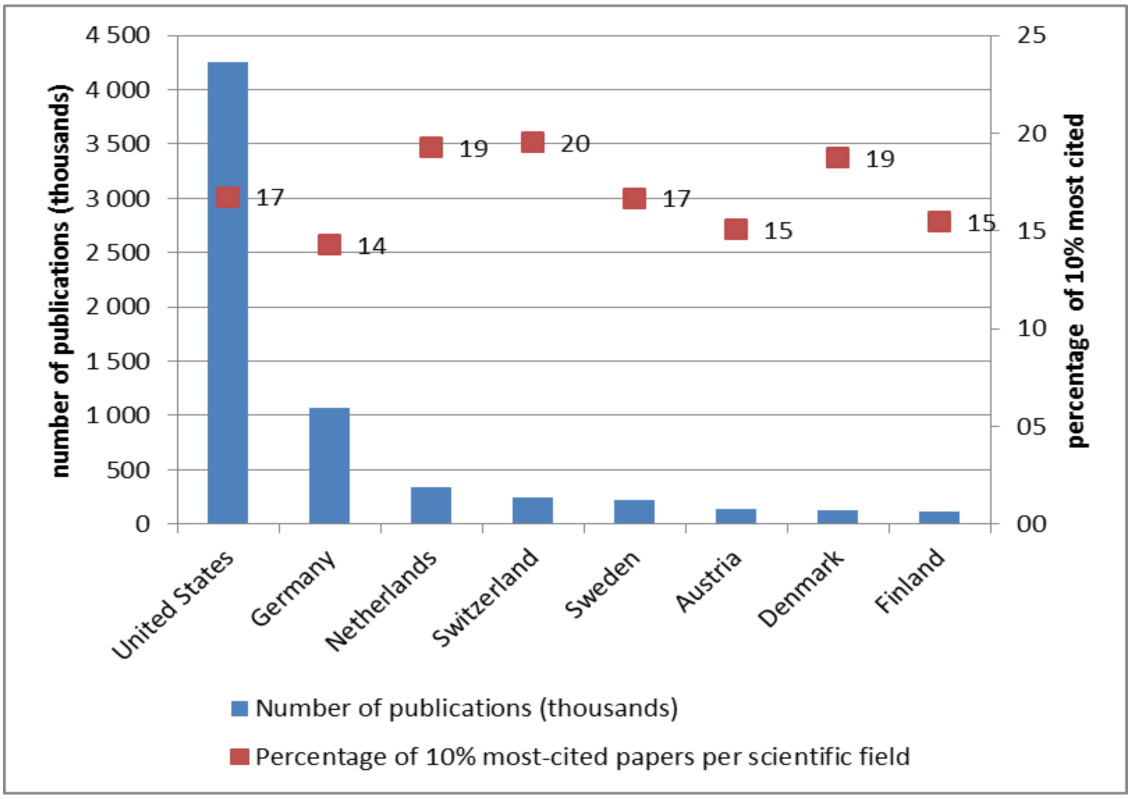
4.3.1 Scientific output and funding for HEIs – a comparison

Both Denmark and Sweden perform on the upper edge of European and OECD-countries regarding indicators on scientific output and quality (citations, specialisation indices), though Sweden lost some dynamism in recent years. This is very much due to their excellent university research. The picture for Austria is somewhat mixed, e.g. comparing the quality of scientific production in terms of Top-10%-most cited publications in the CWTS Leiden Ranking. Only the University of Graz performs among the top 200 on 150th position, compared to Sweden with the Karolinska Institute at position 125 and the University of Stockholm on position 140.[161] In Denmark, three universities are listed among the top 200, the Technical University of Denmark on position 73, University of Copenhagen on position 128 and University of Aarhus on position 131. In total, eight Austrian universities are listed in the Leiden Ranking beside the University of Graz: Medical University of Vienna (224), University of Vienna (242), Medical University Innsbruck (258), University of Innsbruck (271), Technical University Vienna (282), Technical University Graz (422) and the Medical University Graz. Figure 26 displays an international comparison of national scientific output and quality or research measured in the cumulative share of national publication among the top 10-most cited worldwide. This picture reflects the massive improvement in performance of Denmark in terms of its production of highly cited

[160] Hicks, D. (2011): Performance-based university research funding systems; Research Policy 41 (2012), p. 251-261
[161] http://www.leidenranking.com/ranking/2014

papers in the past two decades. Though Sweden still performs on the upper edge of OECD-countries in terms of scientific quality, it had difficulties in maintaining its level in recent years.[162]

Figure 26: The quantity and quality of scientific production, 2003-11

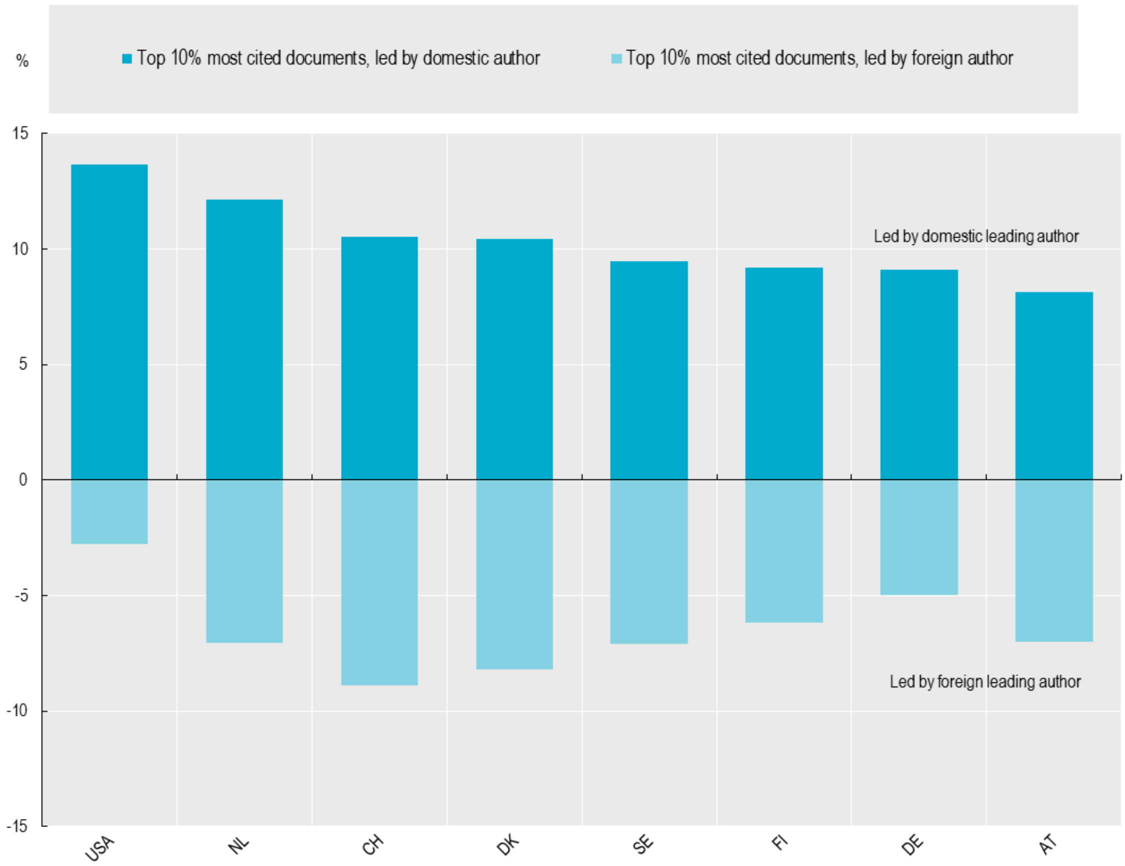


As an indicator of research excellence, the "top-cited publications" are the 10% most cited papers in each scientific field. Estimates are based on whole counts of documents by authors affiliated to institutions in each economy.
Source: OECD-STI-Scoreboard 2013[163]

By comparing universities' degree of scientific international collaboration, Austria's position in the CWTS-Leiden ranking changes completely, with six Austrian universities among the top-50, with the Universities of Vienna and Graz on position 4 and 5. Similar patterns could be shown for Denmark and Sweden, with 5 Swedish and 2 Danish Universities among the top 50. This picture of somewhat weaker Austrian performance in terms of scientific excellence (but among an international comparison being placed in the upper third of OECD countries) and a very high internationalization of scientific research, similar to Denmark and Sweden[164], is supported by longer term views on internationalization patterns of scientific production according to the OECD-STI-Scoreboard (see Figure 27).

[162] Ödquist, B., Benner, M. (2012): Fostering breakthrough research: a comparative study, https://www.kva.se/globalassets/vetenskap_samhallet/forskningspolitik/2012/akademirapport_breakthrough_research_121209.pdf
[163] OECD-STI-Scoreboard 2013: 3.7.1 The quantity and quality of scientific production, 2003-11
[164] AIT, JOANNEUM RESEARCH, IHS, WIFO, ZSI (2015): Stärkefelder im Innovationssystem: Wissenschaftliche Profilbildung und wirtschaftliche Synergien, im Auftrag des BMWFW, 124 http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/publikationen/forschung/AT_Forschungsraum_Endbericht.pdf,

Figure 27: Top 10% most cited documents and scientific leading authorship as a percentage of all documents (whole counts), 2003-12

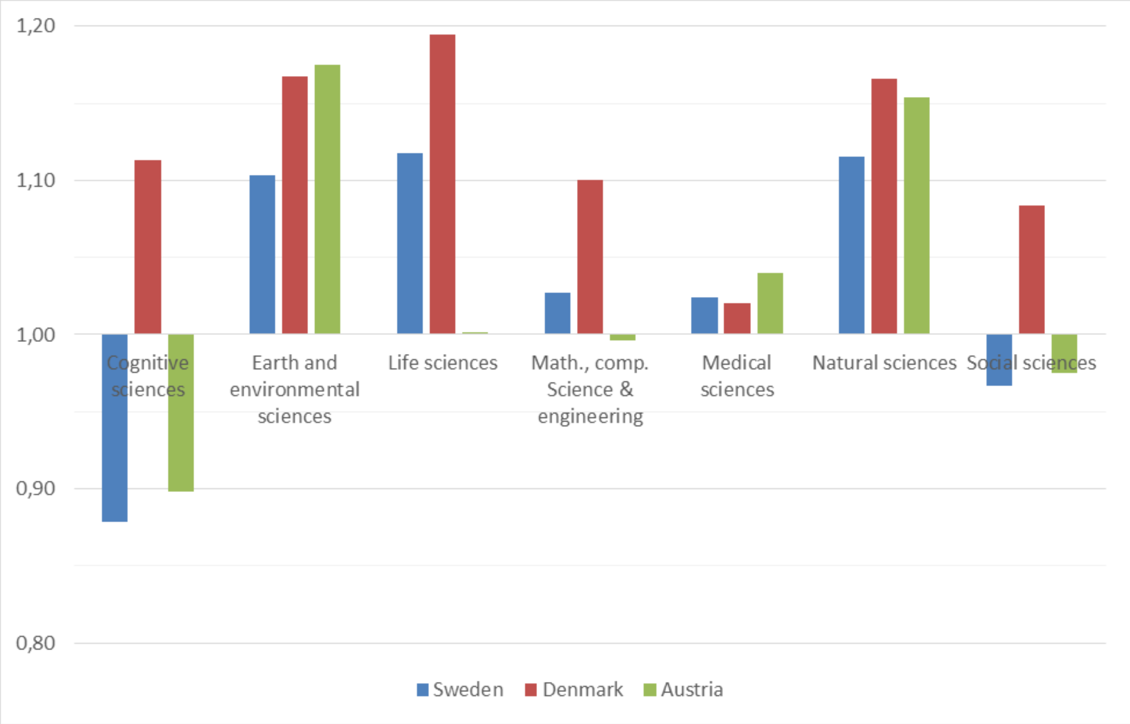


Top-cited ("excellence") publications attributed to a given economy are defined as having a domestic leading author when the document's corresponding author is affiliated to a domestic institution. Collaboration is defined at institutional level. A scientific document is deemed to involve collaboration if there are multiple institutions in the list of affiliations reported by a single or multiple authors.
Source: OECD-STI-Scoreboard 2015[165]

Figure 28 is based on the mean normalized citation score (MNCS) as it is applied in the 2014 Leiden Ranking. The figure illustrates the average number of citations of the publications of a country normalized for different publication patterns in scientific fields and publication year[166]. A MNCS value of two means that the publications of a country have been cited twice above world average in the scientific field. The Leiden Ranking 2014 is based on publications in Thomson Reuters' Web of Science database in the period 2009–2012. Citations are counted until the end of 2013.

[165] OECD-STI-Scoreboard 2015: 3.3.3 Top 10% most cited documents and scientific leading authorship, 2003-12
[166] A university needs to have a minimum of 100 publications in the scientific field to be included in the MNCS calculation.

Figure 28: Country mean normalized citation score (MNCS) in seven different scientific fields



Source: Thomson Reuters' Web of Science database; calculation DAMVAD Analytics

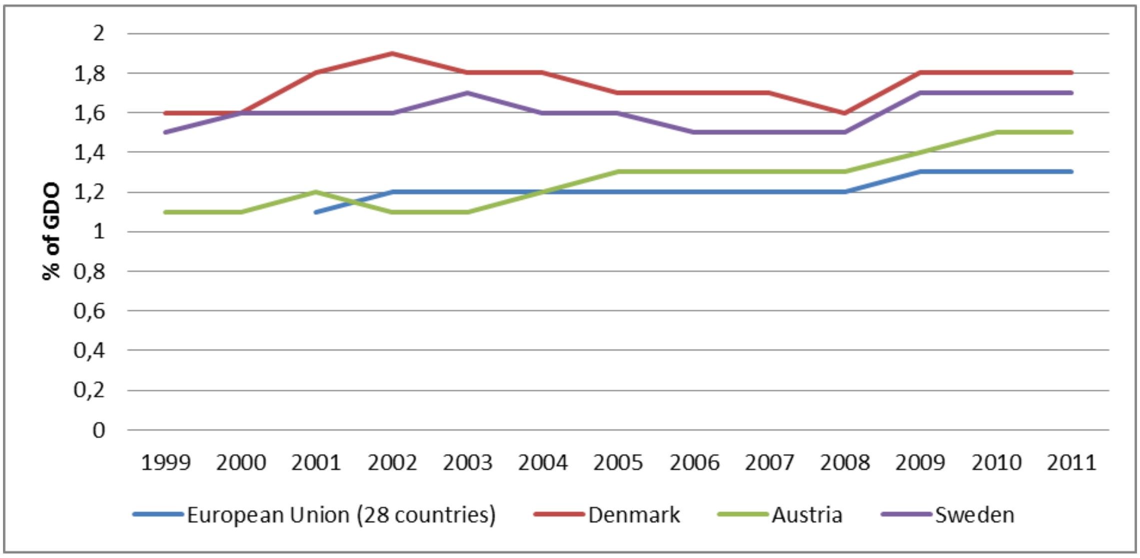
Relative to Sweden and Denmark, Austrian strengths could be identified in the fields of earth and environmental sciences as well as, compared to Sweden, also in the natural sciences. Relative to Sweden and Austria, we can identify Danish scientific strengths in the fields of cognitive science, life sciences, mathematics, computer science engineering and social sciences. Like Austria, Denmark also shows scientific strength in earth and environmental sciences and natural sciences. The Danish specialization in a publication intensive sector like life sciences might be a major explanatory factor for the significant catch up to the upper edge of OECD-countries in terms of publications and citations.

The debate of raising the quality in scientific research in Austria is very much focused on increasing funding. Austrian research and innovation policy committed itself to the target of rising total spending (in 2011 1.4 percent of GDP) for HEIs to 2 percent of GDP until 2020, which would require a substantial increase of public spending.[167] Figure 29 shows the development of total national funding dedicated to higher education institutions in % of GDP. Though Austria faced a persistent catching up process in its funding for HEIs in percentage of GDP since 1999, it still far below the 2%-target. Though neither Sweden (1.7 percent) nor Denmark (1.8 percent) is currently reaching 2 percent of GDP, total spending on tertiary education institution is significantly higher. Both Denmark and Sweden furthermore experienced rapid increases in public financing for universities in the recent past, in Denmark focused towards education (+46% of students between 2008 and 2014)[168], in Sweden towards R&D (increase in student numbers between 2008 and 2014 only +6.1%)[169]. According to the

[167] OECD (2014a): Education at a Glance, Chart B2.2
[168] European University Association (2015): Public Funding Observatory; http://www.eua.be/publicfundingobservatory
[169] Swedish Government Bill 2008/09 and 2012/13

public funding observatory of the European University Association (solely including funding for universities), both countries belong to the group (together with Germany and Norway) with the most pronounced increases in public funding for universities in Europe between 2008 and 2014 (inflation adjusted: DK +20%, SE +22%).[170] This increase in funding included a restructuring of the funding mechanism, increasing the importance of quality and performance measures of the HEIs in both countries (see subsequent chapters). Though the increase of funding in this period 2008-2014 was also of comparative significant nature (inflation adjusted +17%) it still was not pronounced enough to close the gap in levels compared to Denmark and Sweden. It was also accompanied by a, in an EU comparison, high increase of student numbers (+24% from 2008-2014)[171]. Further, university funding in Austria is still mainly based on institutional block funding with only 5 percent of public basic funding being tied to performance indicators in the performance agreement period 2013-15.[172]

Figure 29: Annual expenditure on public and private educational institutions as percentage of GDP, at tertiary level of education (ISCED 5-6)



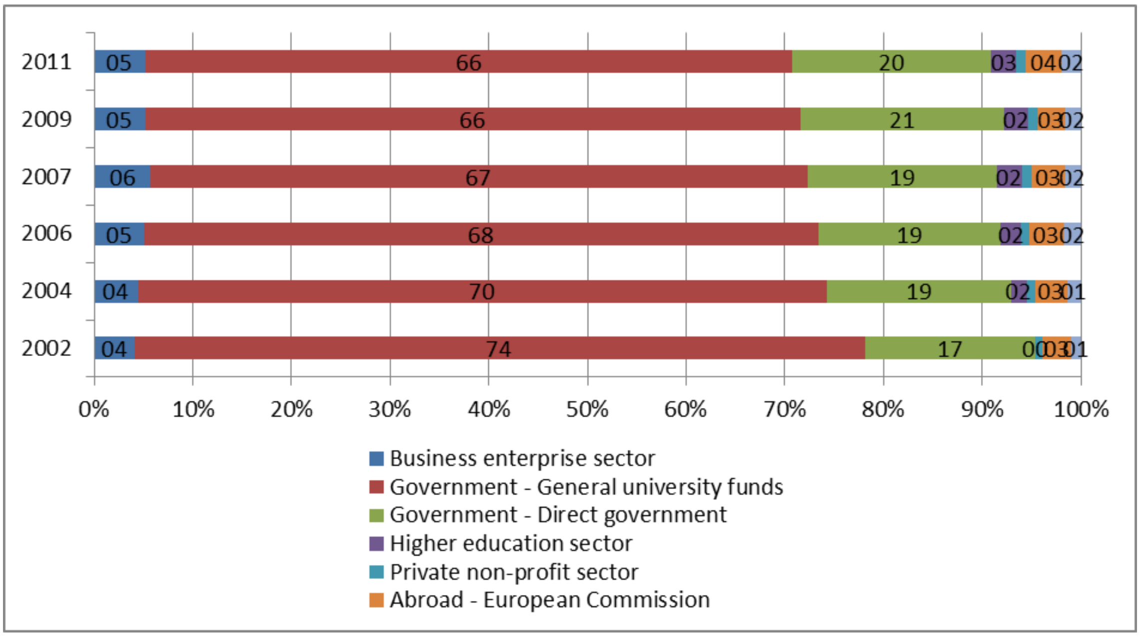
Source: Eurostat (2015)[173]

Looking at the structure of R&D-funding for HEIs in Austria, since the implementation of the University Act 2002 a steady decrease in the share of public funding for R&D-expenditures in the HEI-sectors could be discovered (see Figure 30). Nevertheless it still accounts for 86% of total higher education R&D-expenditures, compared to 91% in 2002. The largest part of 66% is distributed via general university funds (GUF). In total, 0.66% GDP was spent by the government for financing R&D in the Higher-Education-Sector in 2011. Denmark and Sweden in comparison have much smaller shares of HERD being financed by the government with 79.9% respectively 76.7% (Figure 31). Austria has a comparatively high share of financing by the business sectors with 5.2%. As already discussed in detail in the chapters on the role of private foundations, in Denmark and Sweden the private-non-profit sectors accounts for

[170] European University Association (2015): Public Funding Observatory; http://www.eua.be/publicfundingobservatory
[171] Ibid.
[172] BMWFW (2014): Universitätsbericht 2014 Dem Nationalrat vom Bundesminister für Wissenschaft, Forschung und Wirtschaft gemäß § 11 Universitätsgesetz 2002, BGBl. I Nr. 120/2002, vorgelegt
[173] Eurostat (2015): Annual expenditure on public and private educational institutions [educ_fitotin]

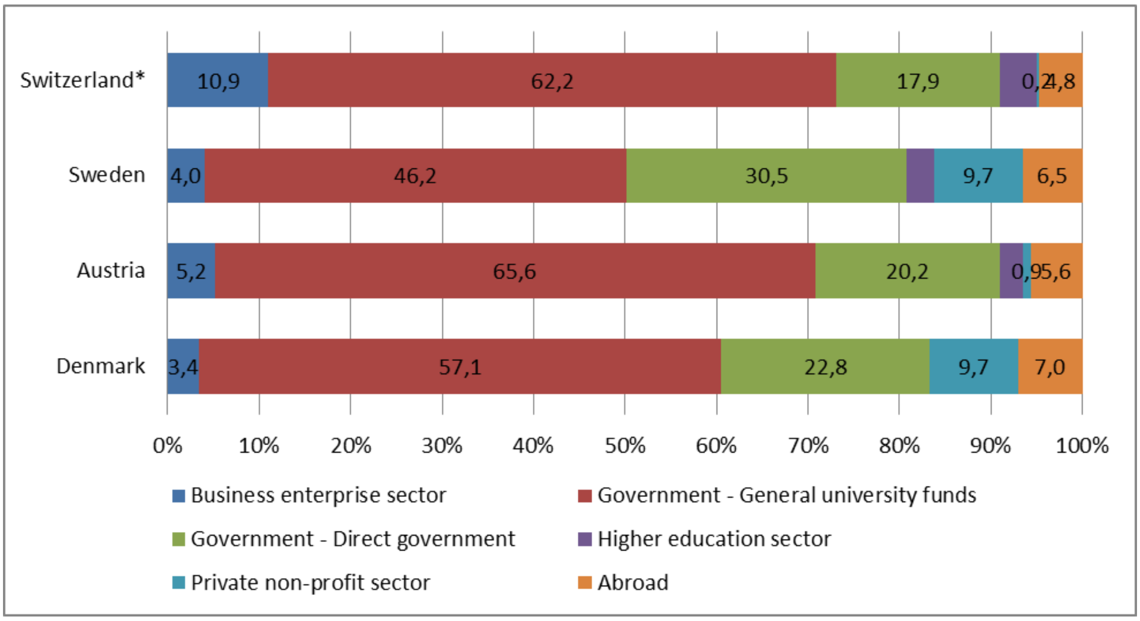
nearly 10% of HERD in 2011, which is around ten-times higher than in Austria with 0.9%. The share of competitive public funding for R&D, i.e. what is not distributed via basic funding mechanisms, is significantly higher in Sweden (30.5% of HERD) and in also in Denmark (22.8% of HERD).

Figure 30: Austrian HERD by source of funds, 2002-11



Source: Eurostat (2015)[174]

Figure 31: HERD by source of funds, 2011



**2012*

Source: Eurostat (2015)[175]

[174] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance and source of funds
[175] Eurostat (2015): Total intramural R&D expenditure (GERD) by sectors of performance and source of funds

4.3.2 Finance structure of public universities in Austria

With the implementation of the University Act 2002 (“UG 2002”) a fundamental change regarding governance and finance structures of Austrian public universities took place. With the establishment of public universities as independent bodies of public law with full legal capacity (“Vollrechtsfähigkeit“), releasing them from public administration, they are now able to autonomously sign contracts (e.g. for cooperation) and hire personal on private law basis. The introduction of so called performance contracts (“Leistungsvereinbarungen“) as central instruments for the distribution of institutional public funding (“Globalbudget“) marks an important step towards a performance based budgeting of universities. The performance agreements help to allocate global budgets for universities over a period of three years which are tied to concrete strategic targets, negotiated with the Federal Ministry of Science, Research and Economy (BMWFW) and performance measures, allocating a certain amount of funding based on transparent set of indicators. In the performance-agreement period, 2013-15, about 5% (€450 million) of the Austrian government institutional funding for universities were allocated via the so called “higher education structural funds”-mechanism (“Hochschulraumstrukturmittel”). 60% of the indicator-based budgets were distributed based on the number of total regular students, engaging in tertiary courses (“prüfungsaktiv”). 14% were distributed based on the amount of third-party funding of universities acquired for R&D-projects. 10% were allocated, based on the number of graduates. 14% served as public start-up financing for cooperation projects, handed in by universities on competitive basis. Finally, 2% were distributed based on the amount of private donations acquired by universities. Strategic targets and measures implemented in the performance agreements should be based on so-called development plans, which every university has to provide, that serve as medium term strategic documents, giving an overview about universities profile and medium term development goals.

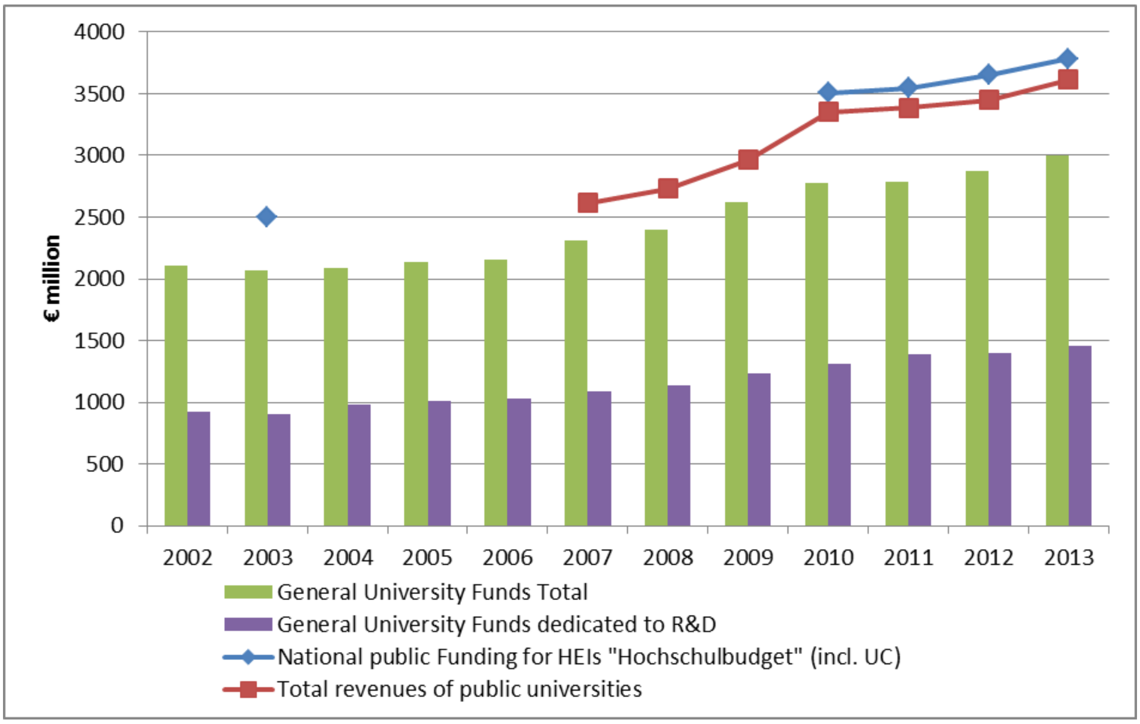
Figure 32 displays the development of total government funding for higher-education institutions (HEI) as well as of total university revenues, including general university funds. General university funds being dedicated to R&D are reported, though universities receive GUF as a lumps sum and universities are free to decide among the internal distribution. The largest part of government funding for tertiary education institutions (“Hochschulbudget”) goes to universities (84% 2013), which is 4.2% of total government spending and 1.2% of GDP in 2013. Since 2003 public funding for universities increased significantly by 58.4%. Regarding universities’ budgets in the performance period 2010-2012, 73% of total revenues came from institutional funding of the government. 16% have been acquired via competitive revenues for third-party financed R&D-projects (“F&E-Drittmittel”). Revenues from tuition fees (inclusive public substitutes) account for just 2% of total university revenues.[176]

Total university revenues comprise among others competitive revenues from R&D-projects (, which significantly increased in absolute volumes by 47.1% between 2007 and 2013, from 402.6 to € 597.5 million, though their share in total universities’ revenues remained pretty constant over time, ranging around 16%. Furthermore, the largest part of competitive funding is acquired via public sources, i.e. the two national public research funding agencies FFG, FWF

[176] BMWFW (2014): Universitätsbericht 2014 Dem Nationalrat vom Bundesminister für Wissenschaft, Forschung und Wirtschaft gemäß § 11 Universitätsgesetz 2002, BGBl. I Nr. 120/2002, vorgelegt

(see chapter on agencies), national authorities (government, states, communities), other public funds (Jubiläumsfonds, ÖAW) with 43.2% in 2013 with 25% attributing to the FWF solely. 13.9% have been received from EU funding schemes. The share of competitive funding by the business sector only slightly increased compared to 2007 from 25.7% to 26% in 2013, after a sharp decline in 2008 that might be attributable to the crisis. 4% of competitive funding comes from private foundations.[177] To increase the share of private funding at universities is a major target not only in the Austrian RTDI-Strategy but also in the recently published "action-plan for research" by the Austrian Federal Ministry of Science, Research and Economy (BMWFW). Beside the discussion about tuition fees as on vehicle for private university financing, especially philanthropic financing from private persons as well as entrepreneurial sponsoring should be increased, mainly by a new regulation on funding via foundations.[178]

Figure 32: Development of public funding for HEIs and university R&D in Austria



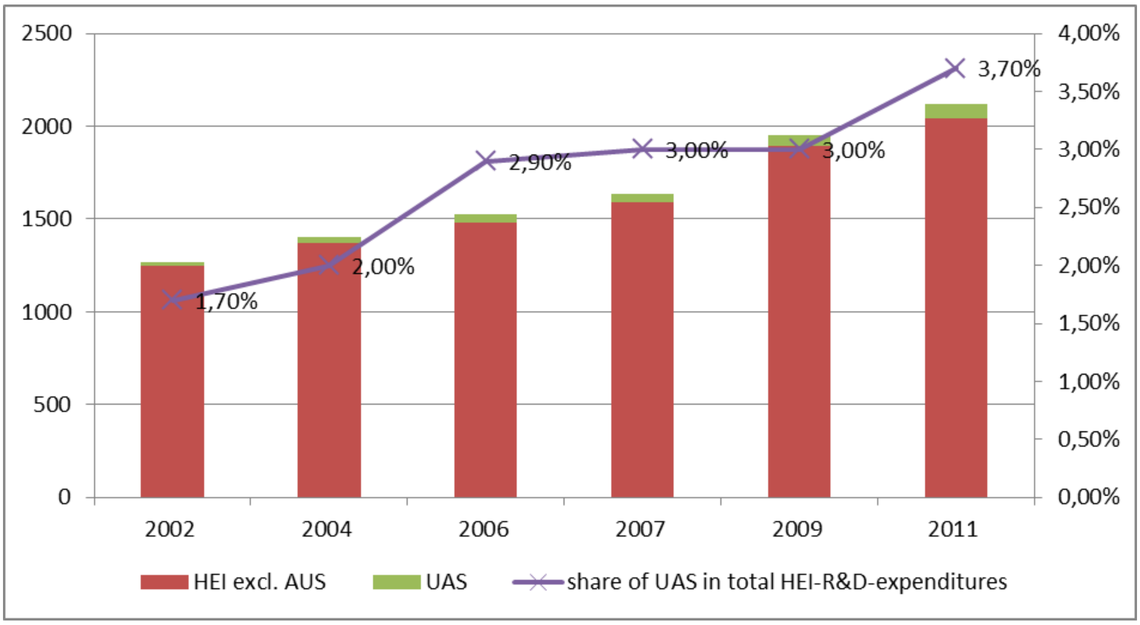
Source: University Report 2014; Statistik Austria[179]

As could be discovered from Figure 32 the highest share of federal government funding for HEIs is dedicated to the 22 public universities. This is due to the difference finance structure of universities of applied scienes (UAS, "Fachhochschulen") that is based on a variety of sources depending on their ownership-structure, comprising tuition fees, global funding from regional governments and municipalities, student-place based funding from the national and regional government as well as public and private research funds.[180] Though universities of applied science are legally obliged to perform research and teaching, their share in total R&D-

[177] BMWFW, BMVIT (2015): Austrian Research and Technology Report 2015. Report of the Federal Government to the Parliament (National Council): under Section 8(2): of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria
[178] BMWFW (2015): Aktionsplan für einen Wettbewerbsfähigen Forschungsraum
[179] Statistik Austria (2015) based on Annex T of the Auxiliary Document for the Federal Finances Act
[180] Österreichischer Wissenschaftsrat (2012): Fachhochschulen im österreichischen Hochschulsystem – Analysen, Perspektiven, Empfehlungen; Wien.

expenditures of the higher education sectors is, though increasing, still low, compared to public universities.

Figure 33: R&D expenditures in the HEI-sector in million € and share of UAS



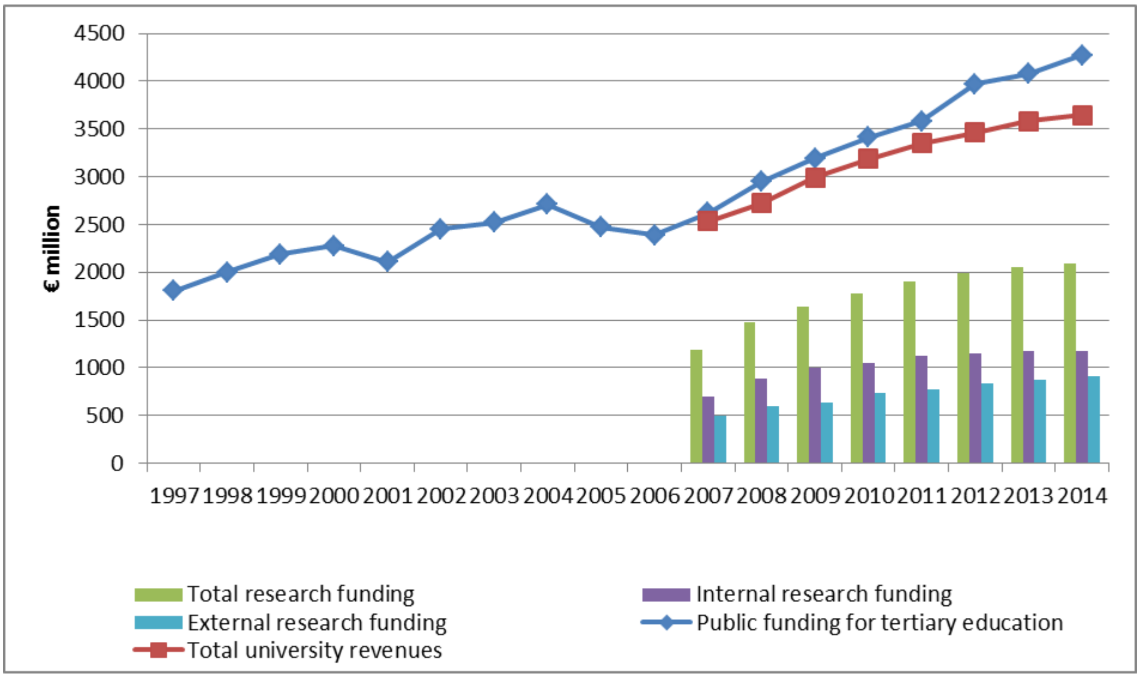
Source: Statistik Austria, Austrian Research and Technology Report 2014

4.3.3 Finance structure and funding mechanisms of HEIs in Denmark

In the past 15 years the Danish higher education sector faced a variety of structural changes. Based on an evaluation of the OECD in 2004 pointing to the exceptionally high number faculty institutions in the Danish Minister for Science initiated a major restructuring of the university landscape in Denmark. Based on a decision by the parliament in 2006, universities and public research institutes were obliged to merge in a process based on the self-determination of partners in 2007.[181] As already mentioned, the number of 12 universities and 13 research institutes was reduced to 8 universities 3 national research institutes. This was accompanied by a significant increase in government funding for higher education institutions (see Figure 34). The economic base for the universities has not only increased with the mergers, but has also become more diversified. In 2009 a new funding mode was implemented, introducing performance indicators as basis for the allocation of public basic funding for research.

In the same vein, in 2003 the appointment procedures for the management body of universities were fundamentally overhauled. Since 1993 university rector was elected internally by collegial body of students. With the reform in 2003 a government board of mostly external members was established, similarly to the Austrian "Universitätsrat", to decide about the appointment of the rector. The rector again hires its Deans, that might also come from outside, and is itself responsible for the appointment of the heads of departments. These positions have limited duration of three to 9 years.[182] According to university members, the opening of the universities for the intake of external knowledge was decisive for an increase in dynamism and professionalization of university management and therefore an important prerequisite for the second large reform, the merger of universities in 2006-07.

Figure 34: Development of public funding for HEIs and university R&D in Denmark



Source: Statistics Denmark (2015), calculation DAMVAD Analytics

[181] Danish Ministry of Science, Technology and Evaluation (2009): The University Evaluation 2009, Evaluation Report, Kopenhagen

[182] Oddershede, J. (2009): Danish universities – a sector in change; Universities Denmark

The revenue structure of Danish universities relies on 5 major pillars:[183]

- Performance based public budgets for education (around 30%)
- Performance based public budgets for research (around 30%)
- Competitive public funding for research (around 25%)
- Research related services for the public sector (around 5%)
- Other (around 10%)

A major driving factor for the increase in public financing since 2006 was the increased intake of new students at the universities, since public funding is tied to number of students. All educating institutions receive so called taximeter grants (already established in 1993 with the implementation of Bachelor/Master/PhD-structure) for each fulltime student they educate in a year, measured by the number of passed ECTS-points. This compensates for teaching, administration and infrastructure expenditures. The taximeter grants vary in three different sizes. For full time students within the social sciences and humanities, the universities typically receive the smallest or the medium sized grant, while educations within science, health and technology typically leads to the largest grant. The institutions further receive a grant for successful completion of studies within a given period, for BA-Students till one year after, for Master-Students within the standard period of study.

Basic funding for research (*internal research funding* in Figure 34) is allocated among the eight universities by the Ministry of Higher Education and Science using a so called 45-20-25-10-model:[184]

- 45% of the funds are allocated on the basis of the number of students at each university, reflecting the researchers' obligation to teach at the universities.
- 20% are allocated on the basis of the universities' ability to gain external funds for research (competitive national sources, EU etc.).
- 25% are allocated based on a so-called bibliometric research indicator. The indicator is measuring each university's scientific impact by counting the number of publications and the number of citations.
- 10% are allocated on the basis of the number of Ph.D. graduates.

Funding based on bibliometric indicators is diversified to take into account different types of publications and publication characteristics of scientific disciplines as well as the reputation of journals and publishers. The latter is divided in two levels, of which level 2 comprises publications in top 20% high reputation journals with a greater lever on funding, and Level 1 comprising all the others. Thus, the main part of universities' income in research is to a large degree performance based, since each university's amount of funding is dependent on its performance in research and research related education as well as on its ability to obtain external funding. In 2013 also university colleges have been eligible in a singular event of public funding for R&D-activities to the amount of € 36 million.

The second public source of the universities' R&D is funding by research councils and funding agencies. The universities are obliged to apply for funding for specific research projects in

[183] Ibid.
[184] Niederl, A., Breitfuss, M., Ecker, B., Leitner, K-H. (2011): Modelle der Universitären Forschungsfinanzierung: Ausgewählte internationale Erfahrungen, AIT, JOANNEUM RESEARCH, Wien.

competition with other research institutions, both private and governmental. Research collaboration with private companies plays an increasingly important role for the universities. Usually such collaboration is organised as joint initiatives. The universities are building still more efficient and competent technology transfer offices with the aim of commercialising and ensuring that research results are brought to the market.

Overall the mergers of universities and research institutions were perceived to be a success, both by national policy makers as well by the institutions themselves. Merges helped to efficiently exploit synergies between institutions and there fields of activities that are decisive for the creation of institutions of international relevance. Especially the inclusion of research institutes was pointed out as best practice example for the efficient restructuring of existing environments. With the substantial increase in resources together with larger entities as result of the merger, furthermore the room for strategic prioritization of research for the university management is increased, compared to smaller units. On the other hand it is not clear, whether the concentration process also let to a reduction of administrative costs. A greater variety of small institutions causes parallels in management structures whereas large entities might be more complex and therefore not necessarily more cost effective.

The introduction of the new funding mode for research is ambiguously assessed. On the one hand, the bibliometrical indicators might have some positive effects on researcher's productivity, especially when it is dedicated as direct financial incentive for researchers. On the other hand, the overall amount is small compared to the total budget of universities (20% out of 30% of total budgets for research funding) to really have an impact. Furthermore, since being implemented in 2009, the Danish catch-up and performance in research output and quality starting at the beginning of the nineties could not be ascribed to the implementation of the new allocation mechanism.[185] This is mainly attributed to the government's commitment for long-term and stable funding being dedicated for research, as well as the restructuring processes in universities management and autonomy starting in 1993.

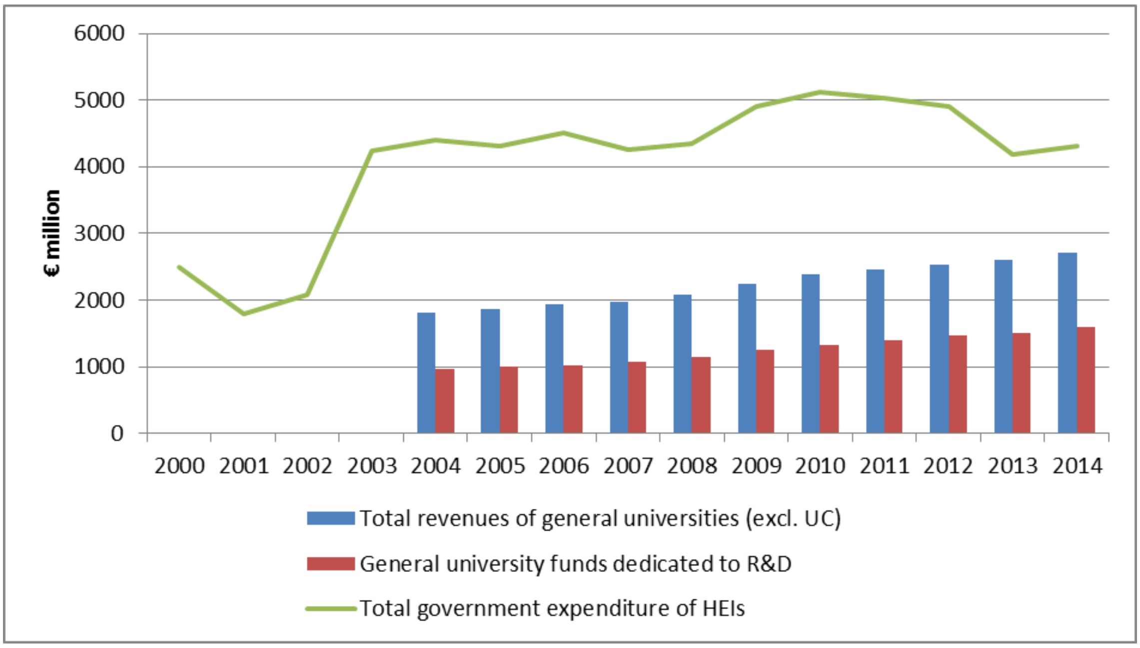
The funding mechanism as such is sometimes criticized for putting too much emphasis solely on education and research. The amount of funding allocated on the basis of external funds is very small. Though it was stated that universities increasingly perceive themselves as contributors to innovation, the funding mechanism, being based mostly relying on the number and throughput of students as well as to a smaller amount on research output, does not incentivize innovation and collaboration activities. Furthermore, it leads to a sometimes wasteful competition for students, e.g. when universities chose for locations of departments to be nearby potential competitors (as has happened in several instances). To extend the scope of activities that are targeted under the current funding scheme, indicators towards a greater market orientation of universities like the creation of spin-offs would be required.

[185] Ödquist, B., Benner, M. (2012): Fostering breakthrough research: a comparative study, https://www.kva.se/globalassets/vetenskap_samhallet/forskningspolitik/2012/akademirapport_breakthrough_research_121209.pdf

4.3.4 Finance structure and funding mechanisms of HEIs in Sweden

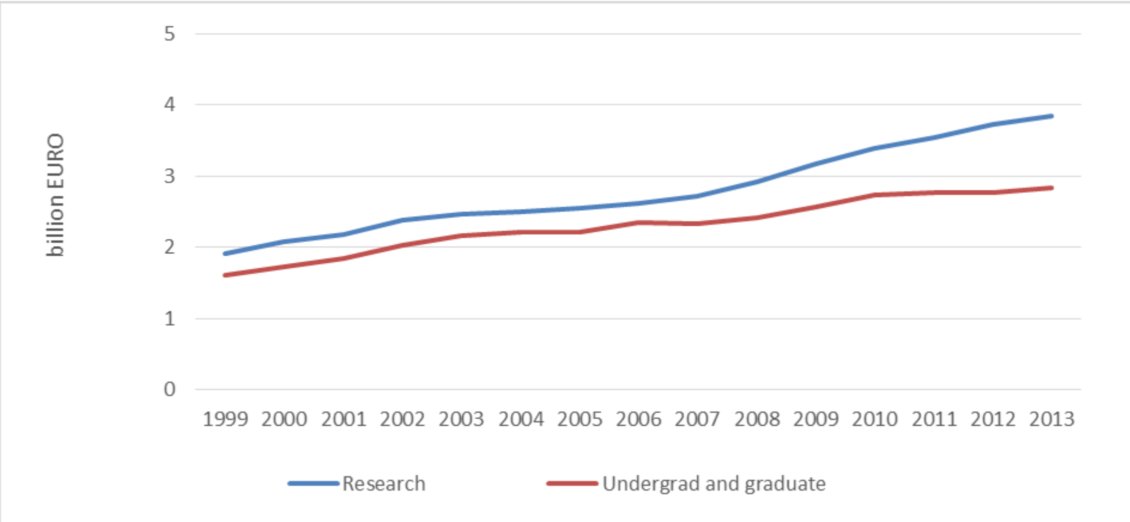
Public expenditures for HEIs have been increasing substantially in the last 15 year, with a period of stagnation in the mid of the 2000nds (see Figure 35). The increase in 2008 was a direct reaction to the crisis.[186] In 2014 total revenues for HEI's estimated to SEK 65.5 billion (around € 7 billion), of which 80 percent was government funding.[187] As in Denmark public funding for HEIs is divided between resources for education and research (see Figure 38).

Figure 35: Development of public funding for HEIs and university R&D in Sweden



Source: Swedish Higher Education Authority (2014); calculation DAMVAD Analytics

Figure 36: Total revenue for HEIs by research and undergraduate and graduate level



Source: Swedish Higher Education Authority; calculation DAMVAD Analytics

Similarly to Denmark, in Sweden resources for tertiary education are allocated to the institutions for first- and second-cycle courses (undergraduate and graduate) and programs on

[186] OECD (2012): Reviews of Innovation Policy: Sweden; OECD Publishing, p. 169 ff.
[187] Swedish Higher Education Authority (2015a): Higher Education in Sweden: 2015 Status Report

the basis of the number of students enrolled in each cycle, expressed in terms of full-time equivalents (FTEs) and the number of credits attained (annual performance equivalents). The amount of funding varies depending on the disciplinary domain. There is also a funding cap that limits the size of funding a HEI may receive.[188]

A policy debate in Sweden dating back to a proposition written in 2008[189] stipulates that the funding of HEIs should be more quality based, albeit all HEIs would get at minimum funding allocated per full-time equivalent (FTE) student. Another proposition in 2009 suggested an entirely new national quality-assurance system.[190] This led to a Parliament decision in June 2010, implementing a funding allocation system so that some of the funding is distributed based on results of quality evaluations. Universities with programs, which receive the highest quality-score in these reviews, should be incentivized by the provision of additional funding.[191] The decision was applied in 2011 and the reform was planned to be finalized in 2015. The assessment ranks the quality of HEIs into three different categories for each relevant examination goal, namely: Very high quality, high quality and lack of quality, also taking into account differences in educational programs. Education programs that score at very high quality in the evaluation undertaken by the Higher Education Authority's will get additional financial support. Examples of the examination goals for a bachelor degree and master degree are[192]:

Bachelor:

- The student shall show knowledge and understanding within the major field of the education, including knowledge of the scientific grounds, applicable methods in the field and a depth within some part of the field and orientation of actual research questions.
- The student shall display the ability to search, gather, evaluate and critically assess relevant information in a research question/problem and critically discuss occurrences, research questions and different scenarios

Master:

- The student shall show knowledge and understanding within the major field of education, including a broader knowledge of the scientific field as well as deeper knowledge about specific areas and insight into current research and its development.
- The student shall display the ability to critically, independently, and creatively identify and formulate research questions; to plan and apply adequate methods, conduct qualified tasks within given time frames and thereby contribute to the knowledge development. The student shall also be able to evaluate such work.

---

[188] Ibid.

[189] Government Bill 2008/09:50, Ett lyft för forskning och innovation (translation: A rise for research and innovation) p. 51-66 http://www.regeringen.se/contentassets/05cb6c62a34e4b37a114611a3ebcbd5b/ett-lyft-for-forskning-och-innovation-prop.-20080950

[190] Government Bill 2009/10:139, Focus on knowledge – quality in higher education http://www.regeringen.se/contentassets/d82a2b51013248f799ccde61f329d3f3/fokus-pa-kunskap---kvalitet-i-den-hogre-utbildningen-prop.-200910139

[191] https://www.uk-ambetet.se/download/18.1c251de913ecebc40e78000854/Arsrapport-2013.pdf

[192] Swedish Higher education authority (2013a): Decisions on criterions for evaluation 2013: http://www.uka.se/download/18.6c7a6cce13fa8f6b8e6232/1403093613298/412-582-13-beslut-generell-yrkesexamen-omg6-ny.pdf

Due to limited resources evaluations of postgraduate studies have not been carried out during the period 2011-2014. All the public HEIs as well as Chalmers Tekniska Högskola and Jönköpings Högskola are eligible for this quality based funding mode. The quality assessment was planned in 4-year cycles. The first cycle started in 2011 and was finished in 2014. The quality based amount distributed in that period comprised in total € 29 million of the total of period (compared to total revenues of Swedish HEIs in 2014 of around € 7 billion or SEK 65.5 billion).

The direct funding for research and third-cycle courses and programmes is to a large part determined by the historical structure of on universities' size. For 2009-12 all research performing HEIs receive 8000 SEK per full-time-equivalent student on 2007 basis, except for art and defence colleges. With the Government Bills of 2008/09 and 2012/13 a new funding mode was introduced to allocate government funding to HEIs (universities and colleges) for research and postgraduate education based on competitive quality based indicators for a 4 year period, which were applied for about 10% of total government funding for the period 2009-14. The performance-based system involves the distribution of both new resources and the redistribution of existing resources based on two indicators of quality: the ability to attract external funding and scientific production and citations. The aim is to create stronger incentives for prioritization and specialization in the areas that have the highest potential to be internationally competitive.[193] In 2014 the share of performance based funding was increased to 20%. Indicators comprise:

- External funds (weight 50%) – The indicator is based on the attraction of external funds from both foreign and domestic financiers. The purpose of a wide range of funders was to some extent also asses the ability to interact with the community
- Scientific publications (weight 50%) – A bibliometric index is calculated on the basis of the number of publication and citations as well as an estimate of the average number of publications a researcher produce in various subject fields.

The introduction of a new funding mechanism was accompanied by an increase in public resources for funding research at HEIs, totaling € 2.1 billion between 2011 and 2014. A recent report from June 2015 of the Swedish Higher Education Authority (UKA) showed that the allocation of new resources was of greater importance than redistribution. Only about € 125 million (close to 6 percent) have switched recipient in the redistribution. Most University colleges and universities received increased resources during the period 2009-2014, even those institutions that did not benefit from redistributions.

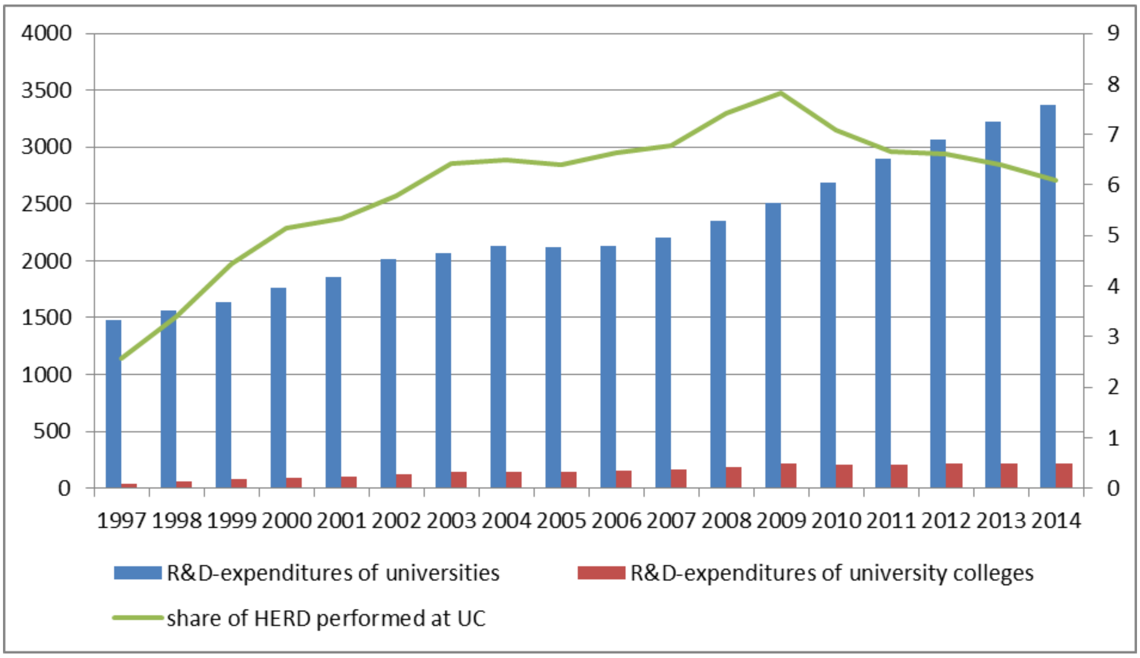
The Government is by far the largest financier of research at HEIs with funding amounting to almost SEK 26 billion in 2013, comprising almost 72 percent of the total revenues for research at HEIs.[194] As mentioned earlier, the majority of the publicly funded research in Sweden is performed at universities and university colleges, and only to a limited extent in research institutes, which differentiates Sweden in an international comparison. 60% of public funds go

[193] Government Bill 2008/09:50 http://www.regeringen.se/contentassets/05cb6c62a34e4b37a114611a3ebcbd5b/ett-lyft-for-forskning-och-innovation-prop.-20080950

[194] http://www.uka.se/arkiv/effektivitet/forskningsfinansieringviduniversitetochhogskolor.5.10c9f1e5145028239db38.html

to only five universities comprising the Karolinska Institute, Uppsala University, Lund University, Stockholm University as well University of Gothenburg. The so-called "new" universities or university colleges only play a little role in the performance of R&D compared to the "traditional" universities. (see Figure 37). This term comprises in total 17 institutions that have been established since the mid of the 70-ties, showing a strong regional embedding regarding the provision of education as well as the connection with regional business and industry.[195] They are not allowed to examine PhDs. The concentration of funding and performance of R&D among the Swedish HEIs is also reflected in their publication patters. About 60% of highly cited papers are produced by the traditional old universities, 30% at the specialized (Karolinska Institute, University of Agricultural Sciences SLU) and technical universities and only 10% at university colleges.[196]

Figure 37: share of R&D performed at university colleges



Source: Swedish Higher Education Authority (2014); calculation DAMVAD Analytics

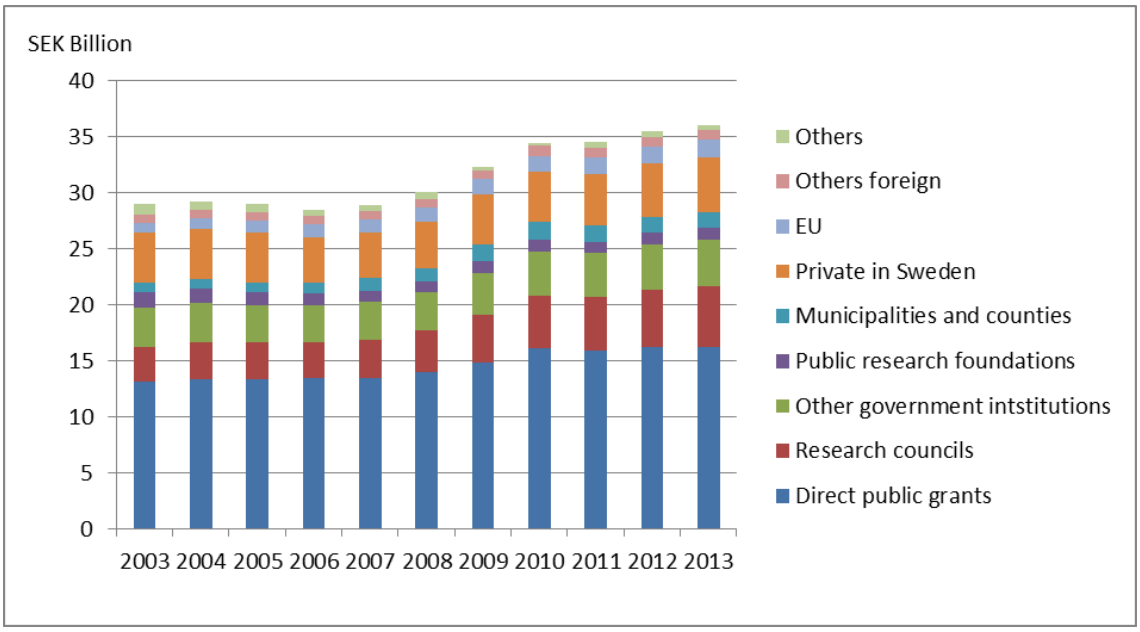
Figure 38 displays HEIs income for research by source of funds. Beside basic performance based government grants, public funding for research is also distributed via public agencies and councils such as VINNOVA (Government Agency under the Ministry of Enterprise and Innovation), FORTE (Swedish Research Council for Health, Working Life and Welfare), FORMAS (The Swedish Research Council FORMAS), Vetenskapsrådet (The Swedish Research Council) and Energimyndigheten (the Swedish Energy Agency). In addition, there are a number of public research foundations amounting to just over SEK 1 billion of funding per year between 2011 and 2013 (see chapter on funding institutions)[197]. The Knowledge Foundation (KK-stifelsen) plays a crucial role in funding R&D at university colleges. The Knowledge foundation funds regional science-industry relation with a variety of instruments, including grants for collaborative research projects as well as financing for PhD-programs with industrial relevance

[195] OECD (2012): Reviews of Innovation Policy: Sweden; OECD Publishing, p. 169 ff.
[196] Sandström, U. (2015): Är forskning med svagt genomslag; Report for the Knowledge Foundation.
[197]Swedish Higher education authority: http://www.uk-ambetet.se/download/18.7ff11ece146297d1aa6138/1421418513553/ekonomi-arsrapport-2014.pdf p.88

(Industrial graduate schools) and strategic recruitment of staff at the regional universities. In 2007 the Institute Excellence Program was launched, providing funding for the establishment of collaborative research centers including actors from research institutes, academia and the business sector in strategic areas until 2012. With the SIDUS program support to research networks in the field of IT is provided. An analysis of KK's activities published in 2014 showed, that collaborations with HEIs funded by the Knowledge Foundation, led to an increase in productivity of participating companies of up 60%.[198] In total the Knowledge Foundation invested SEK 8.4 billion (€ 886 million) from its implementation in 1994 till present, with SEK 529 million (€ 56 million) in 2014 only.[199]

As already mentioned in the chapter on the Swedish funding system, the Swedish HEIs also receive funding from private sources such as private companies, private foundations and fundraising organizations. In total private non-profit organizations contributed with approximately SEK 3.9 billion in 2013 to R&D at HEIs**.** Especially prominent among Swedish foundations is the Knut and Alice Wallenberg Foundation (KAW). KAW invest nearly SEK 1 billion a year in various large scale research projects and infrastructure investments like the national center for molecular biosciences SciLifeLab. Counties and municipalities also fund research, primarily connected to health care.

*Figure 38: HEI income for research and education on research level 2003-2013, SEK billions in 2013 prices**



*Direct public grants also includes compensation for clinical research (so called ALF-medel) and grants funded by Kammarkollegiet. The category "Private in Sweden" mainly comprises contributions from private foundations and non-profit organizations.
Source: Swedish Higher Education Authority (2014) [200]

[198] Source: DAMVAD (2014): Samproduktion för tillväxt – Resultat och effekter av forskningsfinansiering. Resultatrapport till KK-stiftelsen

[199] Swedish Knowledge Foundation (2014): Annual Report 2014 http://www.kks.se/om/SiteAssets/SitePages/In%20English/2014%20Annual%20Report.pdf

[200] Fact and figures from this graph come from the annual status report for 2014 from the Swedish Higher Education Authority.

Policy makers and stakeholders (universities) in Sweden hinted to the fact that the recent government initiatives in restructuring funding of universities are a heavily debated topic in Sweden. There is as of yet no clear evidence about their success, though it is common sense that reforms were necessary to keep the currently high status in scientific production and quality. The following main issues were raised in the debate:

- **No effect on redistribution:** Overall, the increase in funding led to an expansion of the existing structures (i.e. hiring new staff), with just little or no impact on the distribution of funds between different universities. Furthermore, the fragmentation within and between universities is still high in terms of the strategic prioritisation of research topics.
- **Accumulation of funds at large universities:** The increase in block funding led to an excess in funds (unused funds for indirect costs of funding from research council and competitive revenue) at large universities rather than to a redistribution towards smaller, more regionalised universities.
- **High fragmentation of public funding source:** Funding is distributed between several ministries and agencies and councils, which complicates strategic alignment processes between university researches. Recent reforms did not sufficiently address this fragmentation.
- **No clear impact of distribution based on bibliometric indicators so far**
- **Increase in external and competitive funding reduced universities capabilities for longer-term strategic planning.** A large amount of the increase in block funding was dedicated to co-funding for external funds. Furthermore, the target of increasing utilisation and commercialisation activities in a more strategic manner, i.e. giving universities the financial possibilities to strategically interact with the industry, could not be assessed to be met so far. Those activities are still very much based on individual researcher's activity (professor's privilege). External funding is still very focused on the individual researcher and faculties, with a high path dependency of funding.

4.3.5 Synthesis, conclusions and potential learnings and recommendations for Austria

In comparing mechanisms of university funding and public steering of higher education institutions one has to keep in mind the heterogeneity and historical background of how higher education institutions are embedded in national R&D and innovation system. On the other hand similarities and common features that serve as the basis for deriving recommendations for Austria could be identified.

Both Denmark and Sweden have a tradition of providing funds separately for research and teaching, with the latter being dedicated on the basis of student-place and student-success financing mechanisms. Furthermore, as emphasized both by the empirical findings in Denmark and Sweden as well by the assessment of stakeholders, strategic concentration and the establishment of a critical mass are key for the performance of international competitive research. In Denmark universities were financially incentivised to merge, in Sweden, research funding and performance is traditionally concentrated at a few, old "traditional" institutions. New universities in Sweden are mainly forced to finance their research from competitive sources and in collaboration with the industry.

The level of autonomy of institutions is high in both countries, with in Sweden, also governance mechanisms within universities are relatively weak ("professors privilege"). However, both HEI systems in Sweden and Denmark are characterized by a much greater steering capacity of public funding through the application of key performance indicators attached to public funding. Also a higher share of competitive public funding is allocated on competitive basis. The assessments on the newly established funding modes for research at higher education institutions in both countries are both ambiguous and limited due to the inherent time lags in the impact of such measures on the performance and outcome of research. Furthermore, since they have been implemented quite recently, they have no explanatory power for the performance of the Danish and Swedish universities in the past two decades. This performance may be better explained by the sustained long-term funding and the institutional setting favouring concentration.

Against this background, the Austrian mechanisms for university financing are assessed and the following recommendations could be drawn.

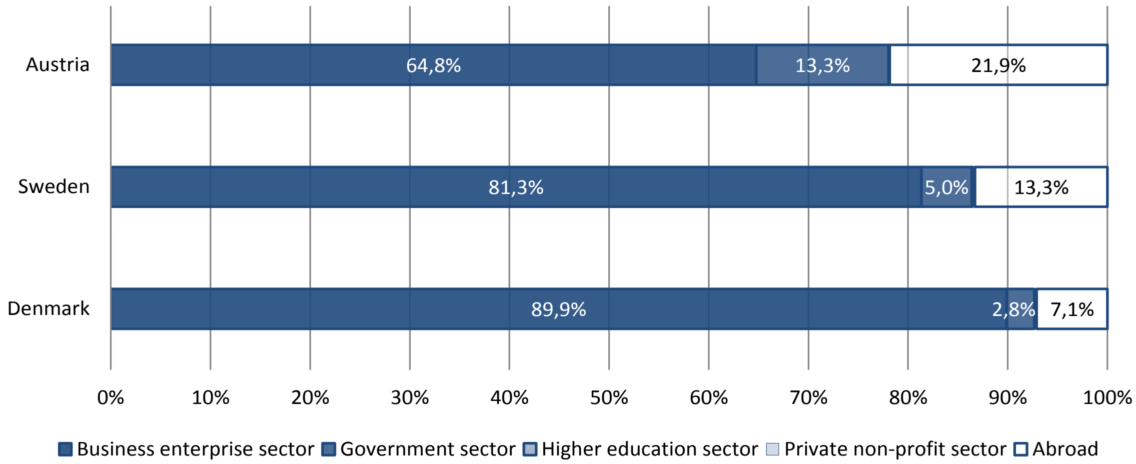
- Austria provides a nearly equal amount of funding for R&D, compared to Denmark, to 22 universities, whereas Denmark does for eight. Furthermore, competition between institutions, both about public basic funding as well as about a variety of public and private sources from agency and foundations is higher developed both in Denmark and Sweden. The establishment of international competitive and visible research requires an overhaul of the Austrian university landscape, including strategic alliances or merger of universities, faculties or departments. A required increase of the share of competitive funding needs to be complemented by measures implementing full cost calculations in public areas.
- The Austrian system of performance contracts as administrative justification of block grants has no feature of actual performance based budgeting as long as milestones in the performance contracts are not directly contingent to public funding. A solution might be a more pronounced increase of the "Hochschulraumstrukturmittel". Separate accounting for teaching a research is also required. The establishment of a performance based measure for the financing of student places ("Studienplatzfinanzierung") according to the Austrian "Hochschulplan" of 2011 has to be speeded up.[201]
- Furthermore, the interaction between university colleges and universities of applied science has to be assessed and clarified regarding the definition of respective roles (duties of teaching and duties of research).
- A required increase of the share of competitive funding needs to be complemented by measures implementing full cost calculation in public areas.

[201] BMWF, UNIKO (2011): Kapazitätsorientierte Universitätsfinanzierung, Wien, Dezember 2011.

4.4 Business dynamics, R&D and innovation performance

Since the end of the nineties, the share of Business R&D expenditures in Austria as percentage of GDP is persistently increasing, closing the gap to the levels of Denmark and Switzerland in the last few years. Since 2002 it is also performing constantly above EU-averages. In terms of funding structure, Austria shows comparatively low shares of BERD funded by the business sector, but high research funding from abroad (see Figure 39), which is due to is the high share R&D performed by foreign controlled firms in the business sector. The share of BERD funded by the national business sector is significantly lower in Austria than in Denmark and Sweden, also decreasing from 2004 to 2011 by 2.4%. Though decreasing since 1998 from 30.1% to 21.9% in 2011, the share of Business R&D funded from abroad it is still very high compared to Denmark and Sweden (see Figure 39), as well as to EU28- and EU15-averages of 10.3% btw. 10%.[202] This is an indication for a (still) high attractiveness of Austria as location for R&D-activities of multinational firms.[203]

Figure 39: BERD by source of funds 2011



Source: EUROSTAT (2015).[204]

R&D expenditures from abroad are mainly channelled to high and medium high technology sectors in manufacturing, i.e. pharmaceuticals, manufacture of transport equipment, machinery and equipment and computers, electronic and optical products.[205] Thus, the Austrian research and innovation system significantly gained from successful 'passive' foreign direct investments. Currently, 56.8% (45% in 2004) of business R&D-expenditures are undertaken by foreign controlled firms.[206] Compared to that, Swedish R&D expenditures are very much concentrated in a few, large MNEs located in Sweden, such as AstraZeneca, Ericsson

[202] EUROSTAT (2015): Total intramural R&D expenditure (GERD) by sectors of performance and source of funds.
[203] Austrian Council for Research and Technology Development (2014): Report on Austria's Scientific and Technological Capability 2014, Vienna; p. 42
[204] EUROSTAT (2015): Total intramural R&D expenditure (GERD) by sectors of performance and source of funds.
[205] BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014. Status report in accordance with Section 8(1): of the Research Organisation Act on federally subsidised research, technology and innovation in Austria, chapter 4.1; AIT, JOANNEUM RESEARCH, IHS, WIFO, ZSI (2015): Stärkefelder im Innovationssystem: Wissenschaftliche Profilbildung und wirtschaftliche Synergien, im Auftrag des BMWFW, p. 86. http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/publikationen/forschung/AT_Forschungsraum_Endbericht.pdf
[206] OECD (2015): Main Science and Technology Indicators Database: R&D expenditure of foreign affiliates as % of BERD.

AB, ABB, Scania and Sandvik, which historically have been very important for the Swedish economy. Denmark on the other hand shows a higher concentration of BERD in the knowledge intensive service sector than Austria.

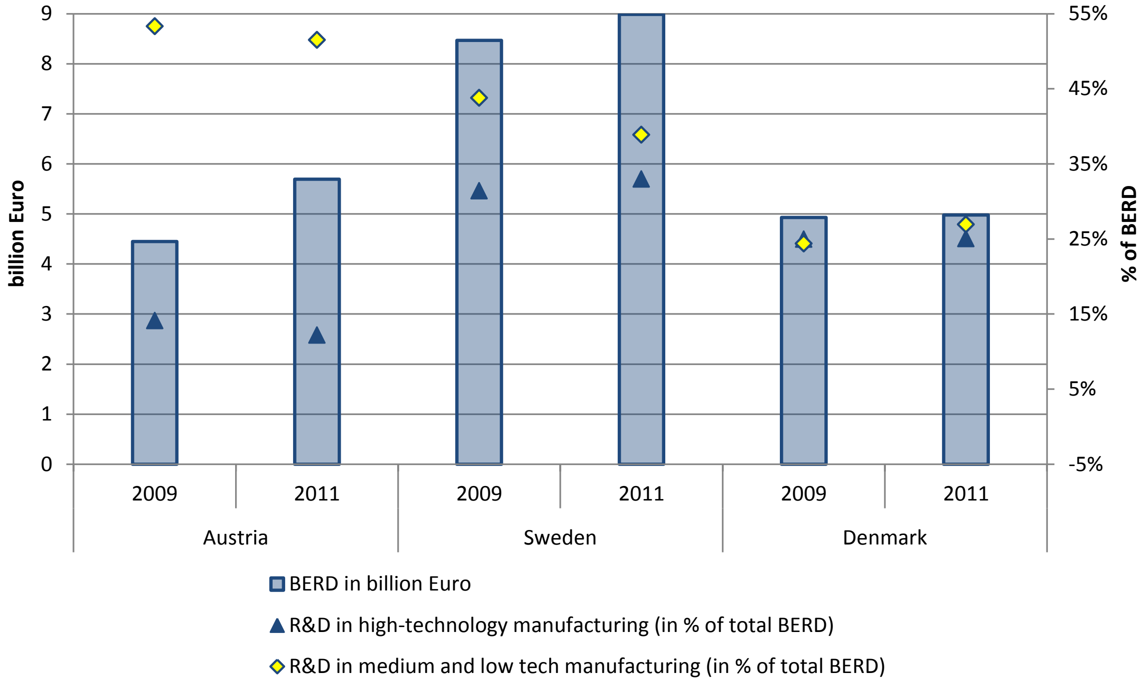
4.4.1 Structural differences

An examination of the structural composition of BERD and value added shows clear structural differences between Austria, Denmark and Sweden, which are very important in our context. Sectoral structures show strong elements of long-term path-dependency, while performance of firms within sectors might be influenced in the short- and mid-term. Thus, it is of particular interest to examine, if a lower BERD rate compared to Sweden and Denmark could be explained by a higher significance of sectors with lower R&D intensities (structural effect) or by a lower R&D intensity within different sectors (locational effect).

A high share of value added (32.3% in 2012 compared to 29.8% in Sweden and 22.8% in Denmark) and business sector R&D expenditures (51.5% in 2011 compared to 38.9% in Sweden and 26.9% in Denmark) in Austria is, for example, still performed in medium and low-tech manufacturing, with the share of value added (from 3.7% to 2.5% in 2012) and R&D-expenditures in high-tech sectors even decreasing since 2002. In comparison to the share of value added in high-tech sectors in Austria of 2.5% in 2012, Sweden (6%) and Denmark (6.4%) show significantly higher values.

Figure 40 also shows the differences in the structural composition of business R&D expenditures between Austria and the two Nordic countries Sweden and Denmark. While in Sweden and Denmark the shares of BERD in high technology manufacturing are at least slightly increasing over time, both the share of BERD in medium and low tech manufacturing as well as the share of business R&D expenditures in high-technology manufacturing sectors in Austria decreased from 2009 to 2011. The high shares of business R&D in high-tech sectors in Sweden and Denmark are driven by different sectors. While in Denmark 894.12 m € or 18.4% (Austria: 170.3 m €, 3% of the BERD) of the total BERD in 2011 was spent in manufacturing of basic pharmaceutical products and pharmaceutical preparations, Swedish firms spent 2,104.92 m € or 23.4% (Austria: 523.84 m €, 9.2%) of business R&D expenditures in the manufacturing of computer, electronic and optical products.

Figure 40: BERD and BERD by technological intensity in % of total BERD

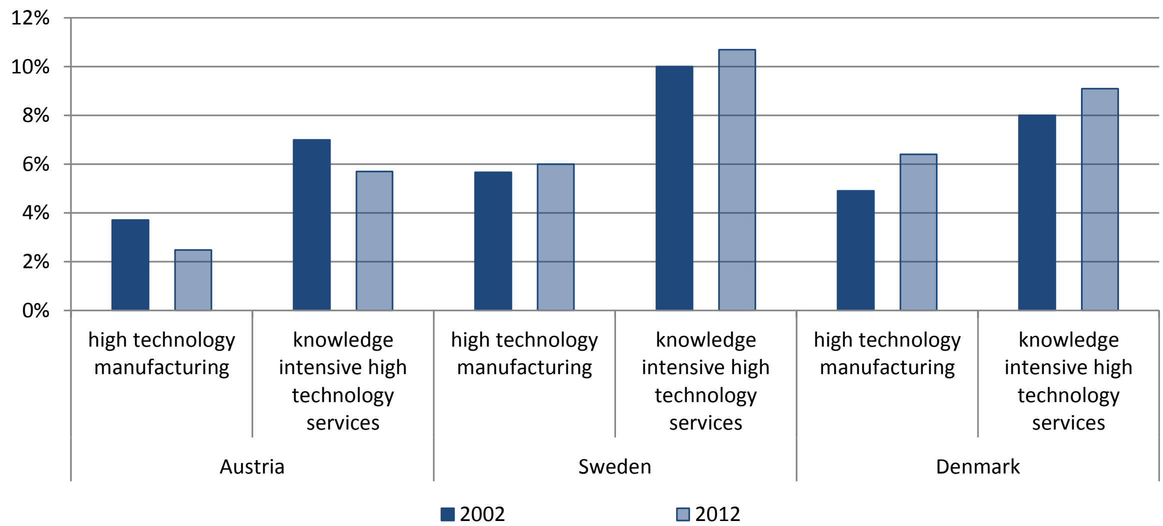


Source: EUROSTAT (2015).[207]

Similarly the share of value added of knowledge intensive high technology services to the total value added decreased since 2002 in Austria (from 7% to 5.7%) against the background of increasing overall business sector R&D expenditures. On the contrary, we observed the opposite development in Sweden and Denmark, where both the share of value added of high technology manufacturing and knowledge intensive high technology services increased in the last decade (see Figure 41).

Figure 41: Share of value added at factor costs (in % of total value added) in technology intensive sectors 2002 and 2012*

*share of high technology manufacturing for Denmark for 2003



Source: EUROSTAT (2015).

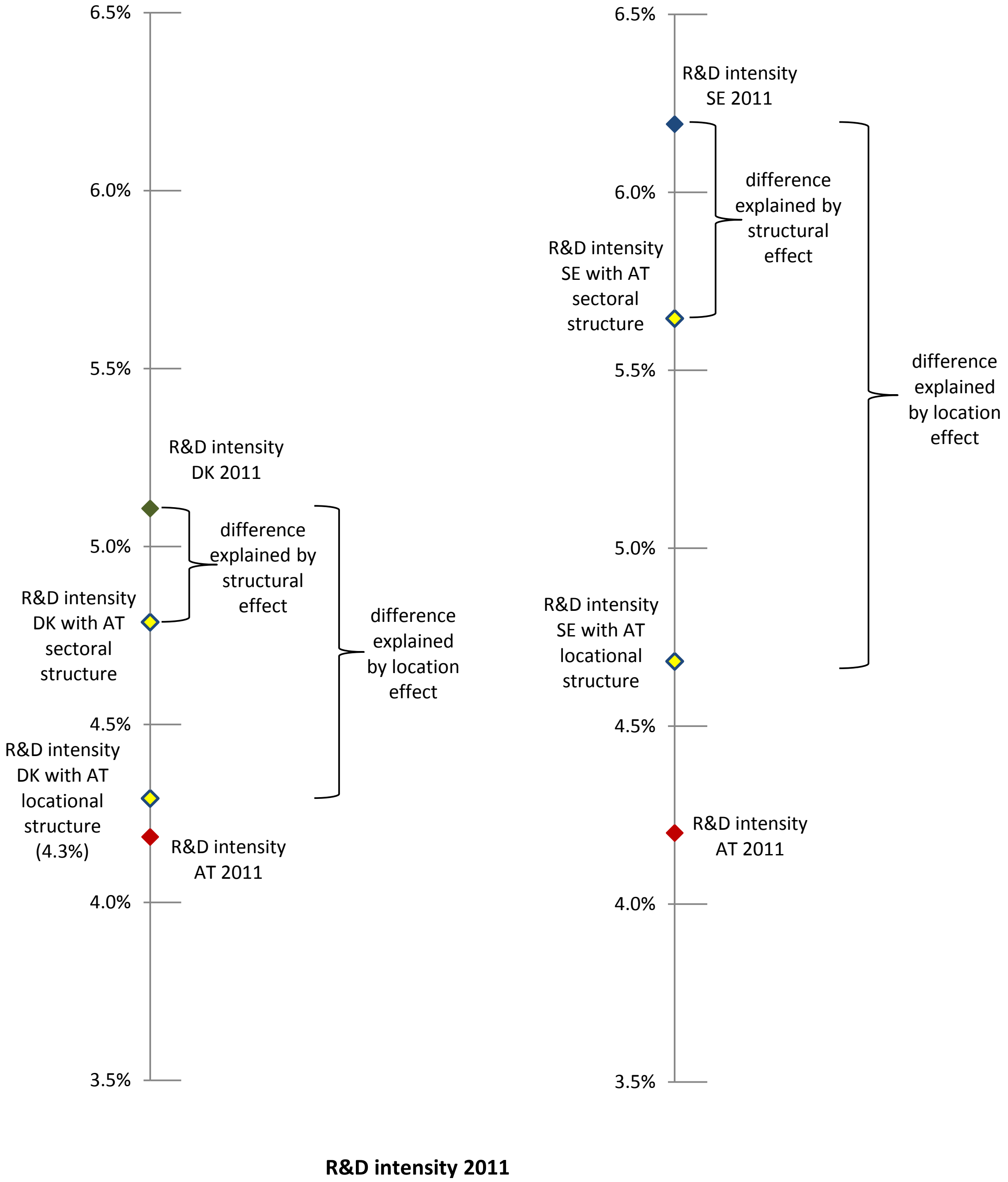
[207] EUROSTAT (2015): Business enterprise R&D expenditure (BERD) by economic activity (NACE Rev. 2).

The specialisation patterns of the Austrian industry in medium- and low technology sectors and services is, despite increasing levels of R&D, one of the most decisive factors for its weak performance in the IUS, since the IUS put emphasis on industry structure rather than on sectorial performance. This leads in general to an overrating of countries with high specialization in research intensive sectors, but low levels of own research and innovation within these sectors. Vice versa, Austria is underrated in the IUS because of its high specialization in medium and low technology fields, despite its high level of research in these sectors.[208] Especially the Austrian ICT sector is underrepresented compared to the innovation leader countries Sweden and Denmark. Calculation of the revealed technology advantage index measured by employed persons in 2012 showed that Austria has an RTA index of 0.89 (1 is the EU-28 average) and therefore is clearly behind Denmark (1.52) and Sweden (1.59).

In order to answer the question whether the differences in R&D intensities between Austria and the innovation leader countries Denmark and Sweden were solely or primarily caused by structural differences, a 'structural component analysis' was conducted to split differences in R&D intensities into a location and a structural effect. In this analysis, the R&D intensities of Sweden and Denmark were recalculated two times using on the one hand the Austrian sectoral structure (the shares of value added in high technology manufacturing, medium and low technology manufacturing as well as services) and on the other hand the Austrian locational structure (using the research intensities in the same sectors). The results show that Austria has disadvantages both in the sectoral structure and the locational performance compared to Denmark and Sweden (see Figure 42). Figure 42 depicts two scenarios for Denmark and Sweden, firstly with the Austrian sectoral structure and secondly with the R&D-performance of sectors in Austria. Both countries would not perform better, neither with the Austrian sectoral structure and their initial R&D intensities, nor with the BERD to value added ratio of Austrian industries and their initial sectoral structure. Approximately one third of the gap in research intensities can be explained by the sectoral structure, while about two third of the difference can be attributed to the research intensity used in the individual technology sectors.

[208] See e.g. BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014; AIT, JOANNEUM RESEARCH, IHS, WIFO, ZSI (2015): Stärkefelder im Innovationssystem: Wissenschaftliche Profilbildung und wirtschaftliche Synergien, im Auftrag des BMWFW,

Figure 42: R&D intensities and country differences 2011



Source: EUROSTAT (2015).[209, 210]

4.4.2 Start-ups and business demography

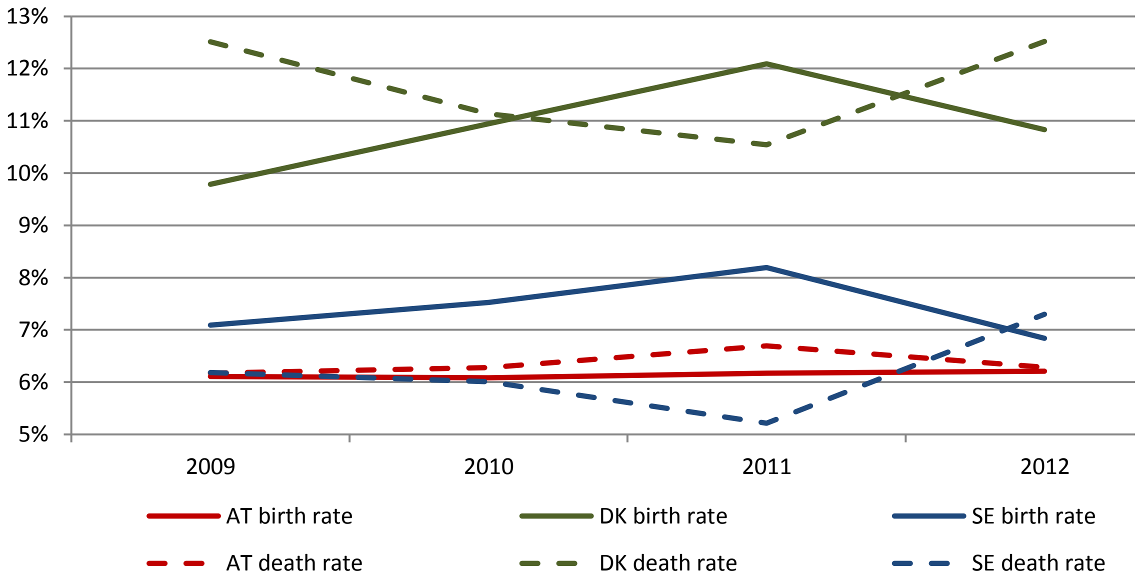
Austria shows a comparably low dynamic in business start-ups, especially compared with the great dynamics of (mostly one-person) companies in Denmark. The total number of enterprises (except holding companies) increased in Austria since 2009 (because of lack of data for Sweden and Denmark, a comparison for a longer period is not possible) by 0.1% from 338,617 to 339,071 in 2012. In Sweden the number of enterprises increased in the same period by 12.9%, while in Denmark an increase of 3.7% was observed. A look at one-person

[209] EUROSTAT (2015): Economic data in high-tech sectors by NACE Rev.2 activity.
[210] EUROSTAT (2015): Business enterprise R&D expenditure in high-tech sectors – NACE Rev.2.

companies shows an especially large discrepancy between Austria and Denmark. While in Austria, the number of one-person companies decreased by 10.5% between 2009 and 2012, a growth of 12.6% has been observed in Denmark (Sweden: 1%).

The following figure shows a comparison of enterprise birth and death rates between Austria, Denmark and Sweden. It is clearly evident that the Scandinavian countries have a more dynamic business demography with both higher birth and death rates (foundations respectively closures measured in relation to the number of active companies – see Figure 43). The differences are even more significant when only ICT companies are taken into account. While Austria has a slightly higher enterprise birth rate for ICT firms (6.5% in 2012) than for all companies, in both Denmark (16.5%) and Sweden (8.1%) the ICT birth rates clearly exceed the birth rates for all companies. This is also true for death rates of ICT companies in Austria (6.4%), Sweden (11%) and Denmark (16.1%).

Figure 43: Enterprise birth and death rates 2009-2012

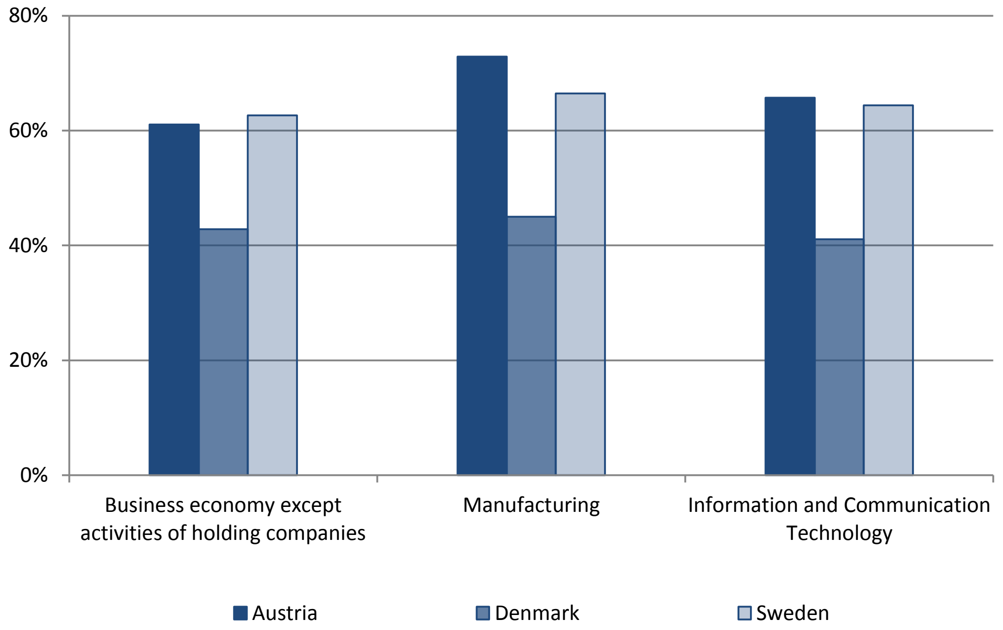


Source: EUROSTAT (2015).[211]

While Austrian enterprises have lower birth and death rates than Swedish and Danish firms, their survival rates are high. In 2012, 72.9% of all enterprises founded in manufacturing in the year 2007 were still active, which is true for only 66.5% of Swedish companies and even 45% of Danish firms in this sector. Also in the ICT sector, Austrian firms born in 2007 have quite high survival rates (65.7%) compared to Sweden (64.4%) and Denmark (41.1%) in 2012 (see Figure 44).

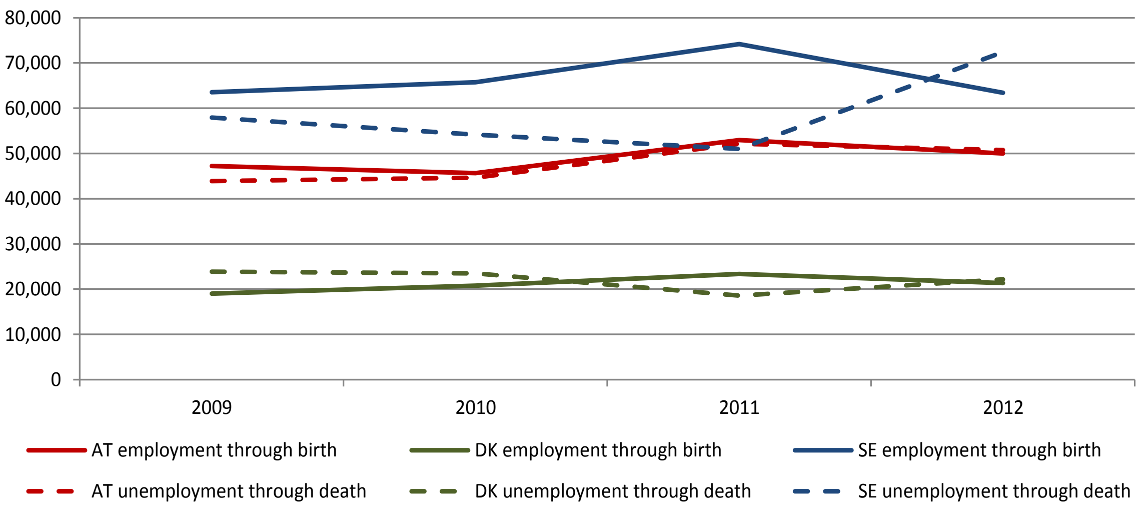
[211] EUROSTAT (2015): Business demography by size class (from 2004 onwards, NACE Rev. 2).

Figure 44: Share of enterprises newly born in 2007 still active in 2012 (5 years)



The importance of business start-ups is shown by the number of jobs created by foundations respectively lost by company closures (see Figure 45). While Austria has a smaller number of new founded companies than Denmark, the number of people employed through new founded enterprises is clearly larger (this is true vice versa for closures). This is caused mainly by the high number of one-person business start-ups in Denmark, which is nearly twice as high as in Austria. Measuring new employment through enterprise foundation in the ICT sector shows that in 2012, 1.4% of all employed persons in the ICT sector in Austria worked in new founded firms. In Sweden (2.2%) and Denmark (2%), a larger share of ICT employment comes along every year through new ICT companies.

Figure 45: Change in employment caused by foundation respectively closures of companies 2009-2012



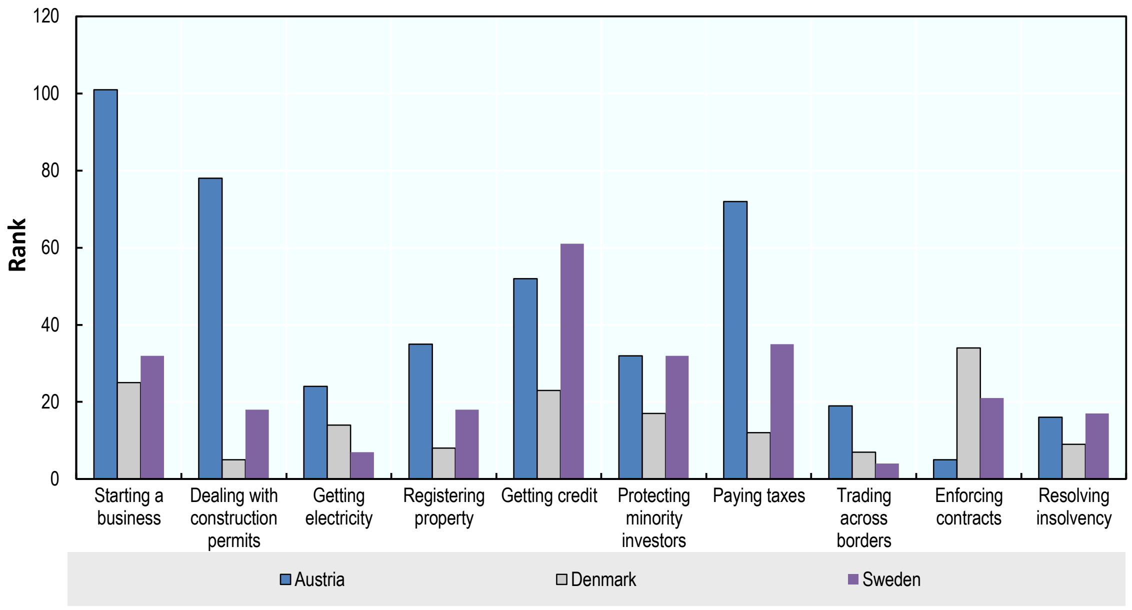
Source: EUROSTAT (2015).[212]

[212] EUROSTAT (2015): Business demography by size class (from 2004 onwards, NACE Rev. 2).

The large distance especially to the number of enterprise foundations in Denmark raises questions about the framework conditions of starting a business in Austria. An analysis of the World Bank about the ease of doing business in different countries supports the results above. Austria ranks significantly behind Sweden and Denmark in indicators as ease starting a business, ease of dealing with construction permits, ease of paying taxes, ease of getting credit and others (see Figure 46).

An important factor behind the Swedish success is the government reform from 2010 that created a social security system for self-employed and removed some of the risks associated with moving from wage-employment to self-employment. Sweden has also liberalized its rules for hiring and firing. For instance, firms with no more than 10 employees are allowed to exempt two employees from the "last-in-first-out" rule in case of redundancies. Other liberalizations in labor market rules have all in all made it less risky to hire and it is believed that this has been an important factor behind the high increase in employment. The time and cost to close a business is unfavorable in Sweden but relatively advantageous in Denmark. But when it comes to the bankruptcy recovering rate Sweden is outscoring Denmark. The number of procedures required to start a business is low in both Sweden and Denmark. The time it takes to register a firm is considerably longer in Sweden than in Denmark. The administrative burden is about the same in Sweden and Denmark.

Figure 46: Ease of doing business ranking



Source: World Bank (2014), Doing Business database

The regulatory and legal environments in place have to be considered as prerequisites or success factors for business start-ups. The Austrian Business Promotion Agency (AWS) is the main funding source for start-up funding, with several measures in place (funding in terms grants, loans or guarantees as well as support and coaching measures). In April 2015, the Austrian government announced to launch a start-up initiative with 40 targets and measures to develop around the main areas of innovation, financing, awareness, networking and infrastructure & regulations in order to place Austria within the European countries with the highest enterprise birth rates.[213]

4.4.2.1 Influence of Business eco-systems on firm foundations – Two hot-spot areas

Austria shows a broad spectrum of policy measures supporting highly innovative business start-ups in early phases (including awareness building, incubation and funding) but a strong business "eco-system" is still missing. Denmark and Sweden could be role-models in this respect, especially in two hot-spot areas in the capital regions of both countries, namely the Stockholm Region and the bi-national Swedish-Danish Oresund Region.

Both business eco-systems are characterized by their high knowledge intensity and innovation capacity. The Stockholm Region for example has strengths especially in industry niches and areas with relatively high knowledge intensity. Identified niches have been found primarily in ICT, Knowledge Intensive Business Services (KIBS), CleanTech as well as Professional services and research skills. The strengths of the region provide good conditions in order to specialize in fields where future challenges could addressed with high knowledge and competence levels.[214]

Also the Oresund Region has a profile of increasingly knowledge-based economies with strong universities and innovative companies. Regional strategies support economic development for high-tech areas as life sciences, ICT, material science and clean technology. This environment provides the basis for the dynamic business demography in the region, which is higher than their national contexts. In 2009, 26% of all new businesses in Denmark and Sweden were started in the Oresund Region.[215]

4.4.3 Finance structure and venture capital in the business sector

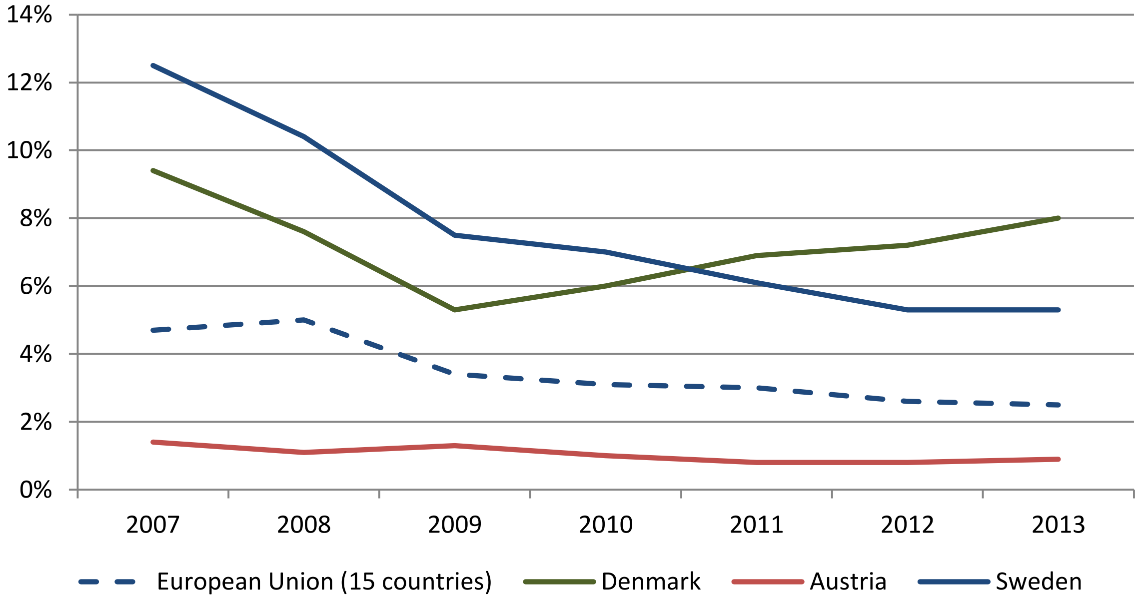
One major and persistent weakness of Austria in its performance in the IUS is the low share of equity and venture capital financing as percentage of GDP (see Figure 47) compared to the innovation leader countries, but also in comparison to EU averages (see Figure 47).

[213] http://www.bmwfw.gv.at/Presse/AktuellePresseMeldungen/Seiten/Mahrer-%C3%96sterreich-soll-Gr%C3%BCnderland-Nr.-1-in-Europa-werden.aspx.

[214] Länsstyrelsen Stockholm, DAMVAD (2015): Kartläggning av styrkeomraden i Stockholmsregionen. Rapport 2015:4.

[215] Nauwelaers, C., K. Maguire and G. Ajmone Marsan (2013): The case of Oresund (Denmark-Sweden) – Regions and Innovation: Collaborating Across Borders", OECD Regional Development Working Papers, 2013/21, OECD Publishing.

Figure 47: Total venture capital (seed, start-up and later stage venture) in % of GDP



Source: Eurostat (2015)[216]

Private equity and venture capital play an important role in the expansion and stabilisation process of a company or for whole new sectors. This is especially the case for young firms in high-technology sectors which show high capital needs even in early phases of firm development. These companies have limited access to traditional financiers, e.g. banks, because of associated high risks and uncertainty. The successful acquisition of venture capital shows a signal effect and provokes additional external financing under certain circumstances. Thus, for very young firms venture capital is an interesting and sometimes essential form of financing, since VC investors can help young firms to overcome risks and intransparencies. Venture capital becomes even more relevant with higher risk and intransparency of a company (i.e., the higher the degree of innovativeness, the lower the fraction of intangible assets, the lower the age, etc.). Additionally, young innovative firms often lack management experience, which can be compensated by an experienced investor, see the business-angel approach. Generally speaking (exemptions prove the rule) venture capital investments focus on a later stage of young companies, while business angels and incubators are more and more filling the gaps in the early stage. These early stage investors become more recognized and better understood as capital source and additionally command larger pools of capital than ever.[217]

The weak performance of Austria regarding the VC indicator in the IUS 2014 might at least partially be due to the domination of the banking sector in Austria's corporate financing. This seems to be the case since uncertainties in the financing of young innovative firms lead to a situation, where banks are unable to price the high risk.

---

[216] Eurostat (2015): Venture Capital Investment by detailed stage of development (from 2007, source: EVCA) [htec_vci_stage2]

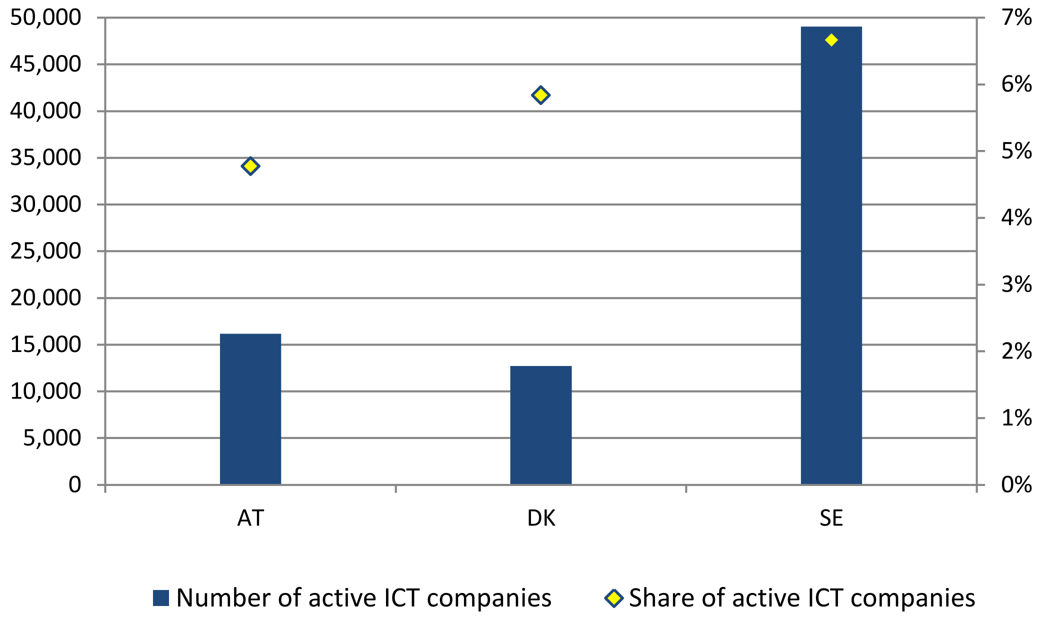
[217] Gassler, H., Sellner, R. (2015): Risikokapital in Österreich -Ein Flaschenhals im österreichischen Innovationssystem?, IHS-Policy Brief, Wien; Tykvova, T., Borell, M., Kroencke, T.-A. (2012): Potential of Venture Capital in the European Union. Brussels; EYGM Limited (2014): Adapting and evolving. Global venture capital insights and trends 2014.

While the number of (semi-)public players providing (publicly funded) risk capital increased over the last few years, Austria was not able to develop an appreciable private venture capital scene. On the contrary, Sweden, Finland, Switzerland and the UK have a more market based finance structure. One important reason of this might be the high number of small and medium-sized family-owned companies in Austria, which often do not want to raise external risk capital in order to prevent a possible loss of control. Because of this characteristic of the Austrian company structure in, the venture capital markets developed late and slow, and the dynamics in its development were stopped by the financial crisis in 2008, which led to a marked decrease in venture capital availability and a shift of risk capital provision from seed and start-up VC investments to later stage VC investments.

Also, there might be not only a shortage of venture capital supply, but also a lack of promising companies (shortage of demand for venture capital) in promising technology fields. In Germany for example, the number of VC firms and their VC volume increased significantly for digital start-ups over the last few years, where internet and technology firms were the most popular ones among investors. The main reason behind is the potential for profits, which lead investors to back these companies with large financial resources.[218] The Austrian ICT landscape (3.1% of the total value added in 2010) not only has significantly smaller shares of total value added and employment than the German counterpart (3.9%), Denmark (4.7%) and Sweden (6.4%), but is also shrinking. Between 2009 and 2012, the number of active ICT companies (manufacturing and services) decreased in Austria by 1.8%, while the numbers of ICT companies in Germany (8.2%), Denmark (17.9%) and Sweden (13.3%) were increasing. The number of new founded ICT companies in Austria 2012 was smaller than in 2009, while the number of births was growing in all other countries. While Austria has a larger number of ICT companies than Denmark (16,180 in 2012 compared to 12,733 in Denmark), the share of ICT companies measured at total companies is smaller in Austria (4.8% in 2012) than in Denmark (5.8%) and Sweden (6.7% - see also Figure 48).[219] The lower relevance of the ICT sector in Austria is also shown by the share of persons employed in the ICT sector. While in Austria, 2.4% (2012) of total employment has been assigned to the ICT sector, this is true for 4.2% of employed persons in Denmark (2011) and 4.1% of employment in Sweden (2010).

[218] See Tykvova et al. (2012); Gassler, H., Sellner, R. (2015); Greif et al. (2014).
[219] EUROSTAT (2015): Business demography by size class (from 2004 onwards, NACE Rev. 2).

Figure 48: Total number of ICT companies and their share of total companies 2012



Source: EUROSTAT (2015).[220]

In Austria, the provision of risk-capital for SMEs and the support of start-ups mainly come from public sources with an increasing amount of support mechanisms. With the aim to support structural change towards a greater share of high-tech industries and R&D-performing and innovative companies, Austrian innovation policies in the last few years focused on corporate venturing with a variety of measures in place.

In a European study Tykvova et al. (2012) showed that public-sector related VC investors (PVCs) clearly showed more intense patenting activity compared to non VC-backed companies, although they had a smaller patent stock with a lower patent quality than other types of venture capital investors. Also, PVCs seem in general to have a substantial impact on the financed firms only regarding employment and the impact seem to be larger in the companies at the early-stage and ineffectual for more mature firms. This is the case since firms in this stage have difficulties in raising financial resources and PVCs fill these financial gaps and reduce the resulting financing constraints.

The national government currently aims to improve financing conditions for innovation and support to newly founded businesses, in particular innovative SMEs and high-tech start-ups.

- The so called Business Angel Fund, administered by the Austrian Business Service (aws) in cooperation with the European investment bank on behalf of the Austrian Federal Ministry of Science, Research and Economy and the Austrian Federal Ministry for Finance, has a public budget of € 22.5 million in 2015, that will be doubled by private business angels to achieve a total funding volume of € 45 million. The AWS-Business Angel Fund is the Austrian equivalent of the European Business Angel Network.
- Another € 68.5 million of public funding is dedicated to early stage capital ("Gründerfonds") during the next 13 years, also administered by the AWS.

[220] EUROSTAT (2015): Business demography by size class (from 2004 onwards, NACE Rev. 2).

- To support young enterprises in the identification of potential partners and investors, the FFG organises venture-capital-fora in which young entrepreneurs are matched with potential investors. Since there are lot of public funding and support mechanisms already in place, further measures should attempt to increase the private share of funding for risk and venture capital, especially by reducing administrative and regulatory burdens or via tax incentives. This is necessary since public, respectively semi-public, initiatives are indeed necessary in early-stage financing, but their risk aversion lead the focus on viability of firms instead of high performance.

While in Denmark and Sweden business angels and innovation incubators carry the seed phase of young companies and VC investment is especially large in the start-up phase and later stage ventures, the early stage is one of the key targets in Austrian VC financing. The figure below also shows that investments in the start-up phase are considerably lower than for the seed phase and later stages and thus is clearly insufficiently considered in Austria.

Table 10: Venture Capital Investment by stage 2014

	Seed	Start-up	Later stage venture	Total VC
		million EUR		
Austria	10	4	10	25
Denmark	3	133	59	195
Sweden	5	93	103	202
		Number of companies		
Austria	64	14	10	88
Denmark	4	69	29	100
Sweden	42	245	110	396

Source: EUROSTAT (2015).[221]

4.4.3.1 Venture capital in Denmark and Sweden

Compared to Austria, Denmark performs well regarding the indicator for venture capital investments (share of VC to GDP) in the IUS 2014 (DK: 0.296; AT: 0.134). While in most countries the VC in % of GDP decreased or stagnated since 2009, it increased in Denmark. A large part of the Danish venture capital comes from the Danish Growth Fund (DGF), which is a public financed investment fund that manages more than 2 billion DKK (about € 268 million). The primary focus of investments is the co-financing of high risk and knowledge-based small and medium sized companies. According to the World Bank, this makes a significant contribution to innovation and growth in Denmark. The DGF mainly operates as a fund-of-funds, but also provides financial support as direct equity investments, mezzanine capital, loans and loan guarantees. The DGF ensured growth in the Danish economy after the financial crisis in 2008 by using several new and innovative instruments for funding of a broad range of Danish firms. The World Bank describes the actions of the DGF as highly successful in leveraging private investments into the risk capital market and thereby demonstrating the benefits of well-designed and well-managed initiatives to help grow a sustainable risk capital

[221] EUROSTAT (2015): Venture Capital Investment by detailed stage of development (from 2007, source: EVCA).

market. The main areas of DGF funding are fund investments, investments in start-ups as well as loans and guarantees.

Other very important sources for risk capital in Denmark are venture companies, which invested 1.984 billion DKK (about € 266 million) in 2013. They typically invest capital, competencies and network in new innovative, high-tech companies. The companies are often in their early stages when the VCs invest, but normally VC follows subsequent to innovation incubators and business angels. The main investment type of Danish VCs is follow-on investment, which is a subsequent investment after a previous investment in the company, generally at later stage. Only little importance is attached in Denmark to business angels as a possible source of financing for small and medium-sized enterprises (SMEs). The government is generally reluctant to take initiatives in this area. One important reason is the negative experience from two major policy initiatives: the PartnerKapital co-financing programme and the support for the Danish Business Angel Network.[222]

Also, there are additional sources as innovation incubators, business angels or the Danish Market Development Fund (DMDF), which are highly relevant even if their total amount of VC is significantly lower. The DMDF is an interesting example on how growth in Denmark is promoted. It is not a venture capital fund, but instead helps enterprises to bring their new products to market faster and makes it easier for public-sector institutions to obtain innovative solutions.[223]

The share of VC to GDP in the IUS 2014 for Sweden is similar to Denmark and significantly higher than the value for Austria (SE: 0.289; AT: 0.134). The total amount of venture capital invested in Sweden is considerably higher than in Denmark. Both, in Sweden and Denmark the prioritized sectors for government venture capital investment are ICT, Clean Tech and Life Science.[224]The amount auf VC invested by the private sector in Sweden is higher than public VC investments by a ratio of 1.5:1 for 2013[225], although private investments faced a sharp drop in the aftermath of the crisis in 2008.[226] The majority of the capital is spent in the expansion phase rather than the start-up and early commercialisation phases. The venture market in Sweden has, historically, been dominated by venture capital funds at least partly funded by the government. At the seed stage, many of the investments were made by venture firms with a clear connection to either university holding companies or incubators. However since the financial crisis the Swedish VC market has continued to shrink, also in the last five years when exciting new ICT and High-Tech-startups have been booming. For Sweden and especially the Stockholm region it makes more and more sense to make a distinction between formal and informal capital. The formal capital comprises investment companies, public funds and the private equity and venture capital funds backed by institutional investors and pension funds (Limited Partners).

[222] Swedish Agency for Growth Policy Analysis (2013): Affärsänglar, riskkapitalfonder och policyportföljer; Rapport 2013:08
[223] Danish Market and Development Fund (2015): http://markedsmodningsfonden.dk/in_english.
[224] Swedish Agency for Growth Policy Analysis (2013): Affärsänglar, riskkapitalfonder och policyportföljer; Rapport 2013:08
[225] Ibid.
[226] Ibid.

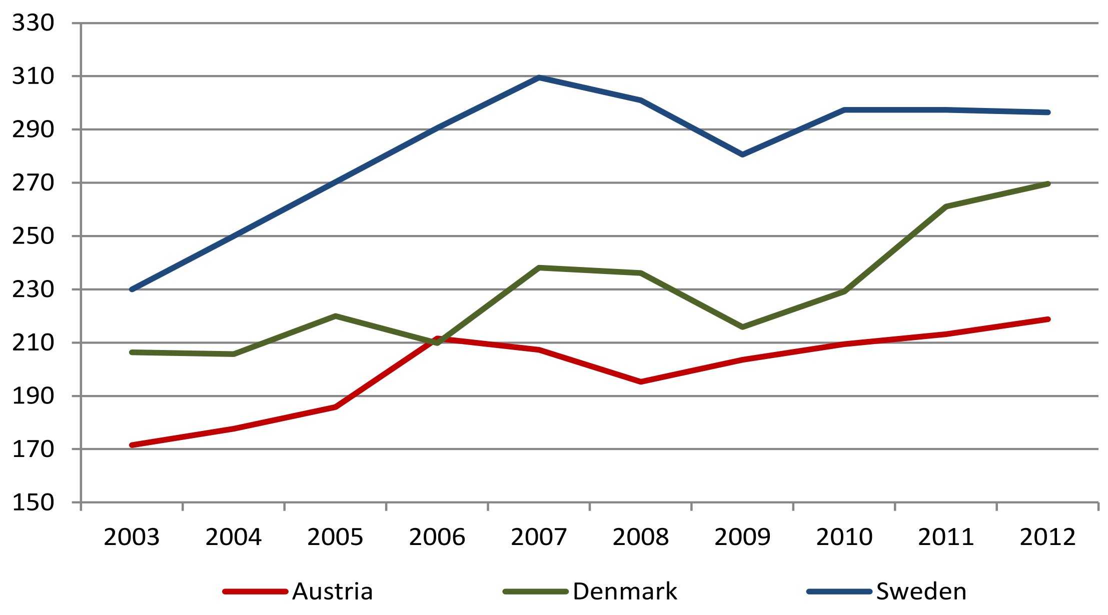
The informal capital comprises angels, 'superangels', family offices, crowdfunding, incubators, accelerators and corporate ventures. The trend is that this informal capital is growing, while the formal capital is shrinking. The informal capital usually acts faster, since the decision makers usually are private individuals investing their own money based on gut feeling. The "formal" venture capital investments in Sweden have decreased with an average of 20% per year since 2008, according to data from the Swedish Venture Capital Association.[227]

In Denmark and Sweden, public venture capital consists of both direct and indirect (fund of funds) investments. The difference between the countries is the prioritization of these forms. Evaluations have shown that there is a risk of crowding out private venture capital, especially when public agents invest directly in businesses. The understanding is therefore that it could be better for public funds to be invested through funds of funds and in prioritized areas.[228]

4.4.4 Patenting and innovation performance

Sweden and Denmark show comparatively strong performances in respect of patent applications per capita. With 296.48 patents per million inhabitants in 2012 (estimated value), Sweden lies only behind Liechtenstein (1,382.04) and Switzerland (426.11). 269.59 patents per million inhabitants have been observed for Denmark in 2012. Austria (218.81) performs well compared to most other countries, but has a relatively large gap to the two Scandinavian innovation leaders (see Figure 49).

Figure 49: EPO patent applications per million inhabitants 2003-2012 (2011 and 2012 estimated values)



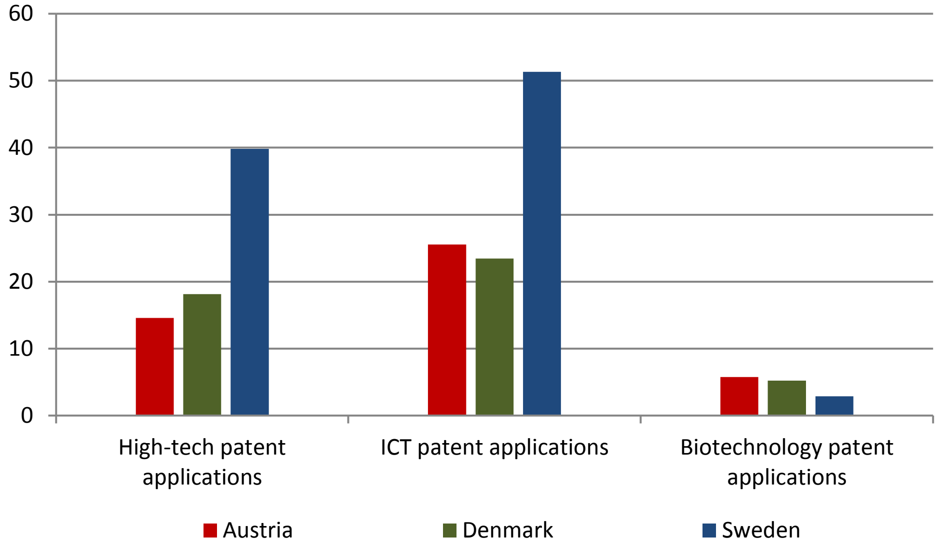
Source: EUROSTAT (2015).[229]

[227] http://www.standoutcapital.com/blog/stockholm-tech-startup-boom-new-face-venture-capital-part-3-4/
[228] Swedish Agency for Growth Policy Analysis (2013): Affärsänglar, riskkapitalfonder och policyportföljer; Rapport 2013:08
[229] EUROSTAT (2015): Patent applications to the EPO by priority year.

Even if the sectoral structure in Austria is dominated by medium and low tech sectors, the Austrian performance with respect to patent applications per million inhabitants in high tech sectors in 2012 was positive. Although Sweden seems to be out of reach and Denmark had a slightly higher number of EPO patent applications per million inhabitants in the high-tech sector, Austria performed better than Denmark in ICT patent applications per million inhabitants. Also, Austria shows a strong performance in the field of biotechnology (see

Figure 50).

Figure 50: High-tech patent applications to the EPO per million inhabitants

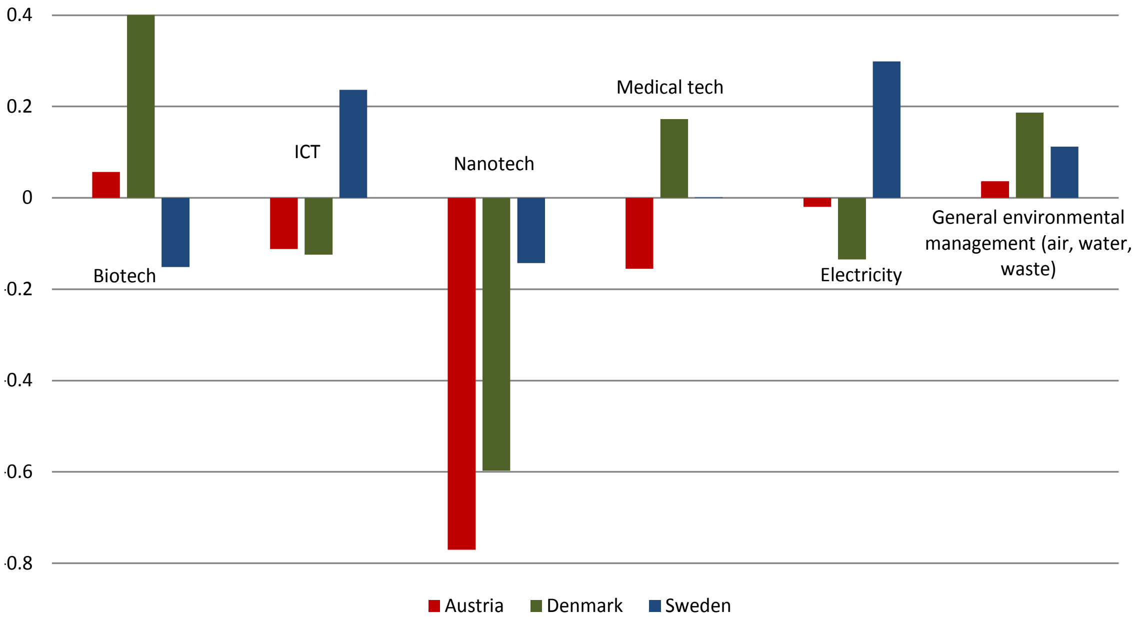


Source: EUROSTAT (2015).[230]

A closer look at the relative specialization patterns of Austrian companies with respect to patenting activities (based on PCT patent applications of national inventors by technology fields in 2011) shows that there is a slightly positive specialization in Biotech and General environmental management (0 is the average specialization in the EU-28), which is conform to the results above. In comparison, Denmark is specialized to a higher extend in Biotech, Medical tech and General environmental management, while Sweden show specialization patterns in ICT, Electricity and General environmental management (see Figure 51).

[230] Ibid.

Figure 51: Relative specialization index of patent applications filed under the PCT, inventors country residence, 2011



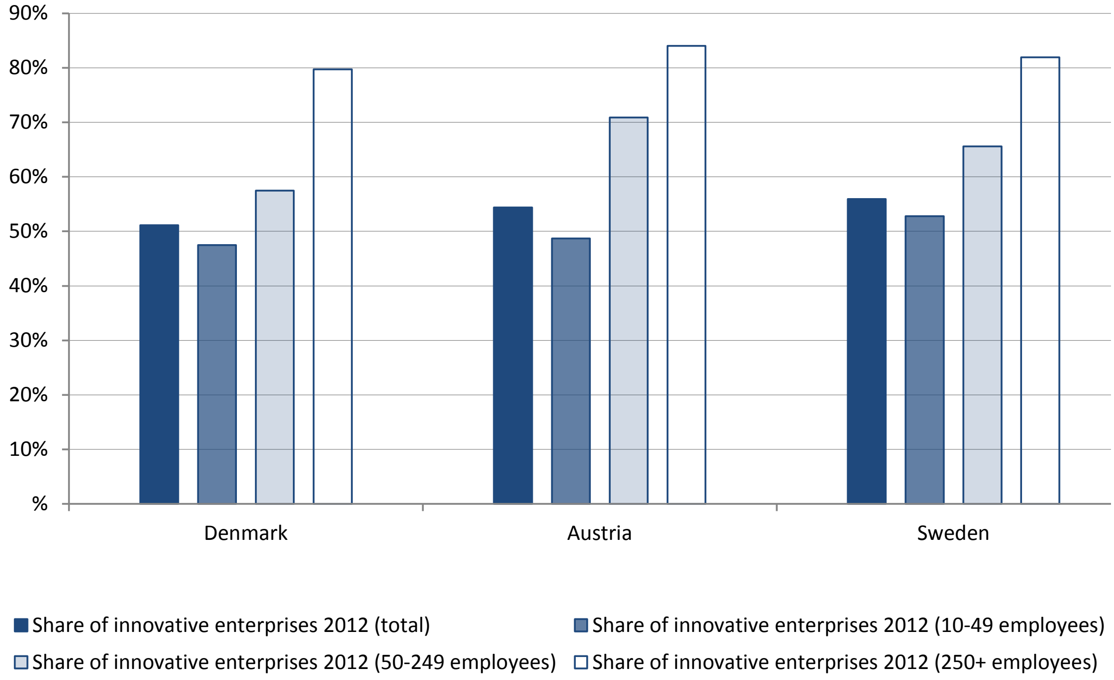
Source: OECD (2015), calculation DAMVAD Analytics[231]

Comparing the innovation activities of companies in Austria, Denmark and Sweden shows that Austrian enterprises perform at equally high levels as the Scandinavian benchmarks. Especially large (250 or more employees) and medium sized (50-249 employees) Austrian companies show higher shares of innovative firms relative to all companies. In total, Swedish companies (55.9% of all companies) are slightly more innovative than Austrian (54.4%) and Danish firms (51.1%).

Innovations can be separated in technological (product and/or process innovations) and non-technological innovations (organizational and/or marketing innovations). Austrian companies perform especially well in non-technological innovations (46.1% of all active firms) compared to Denmark (41.8%) and Sweden (39.1%). In contrast, Sweden shows a high level of innovative activities with respect to technological innovations (45.2% of all firms had innovations activities of this type in 2012) compared to Austria (39.3%) and Denmark (38.2%).

[231] OECD (2015): Patents by technology field

Figure 52: Share of innovative enterprises 2012



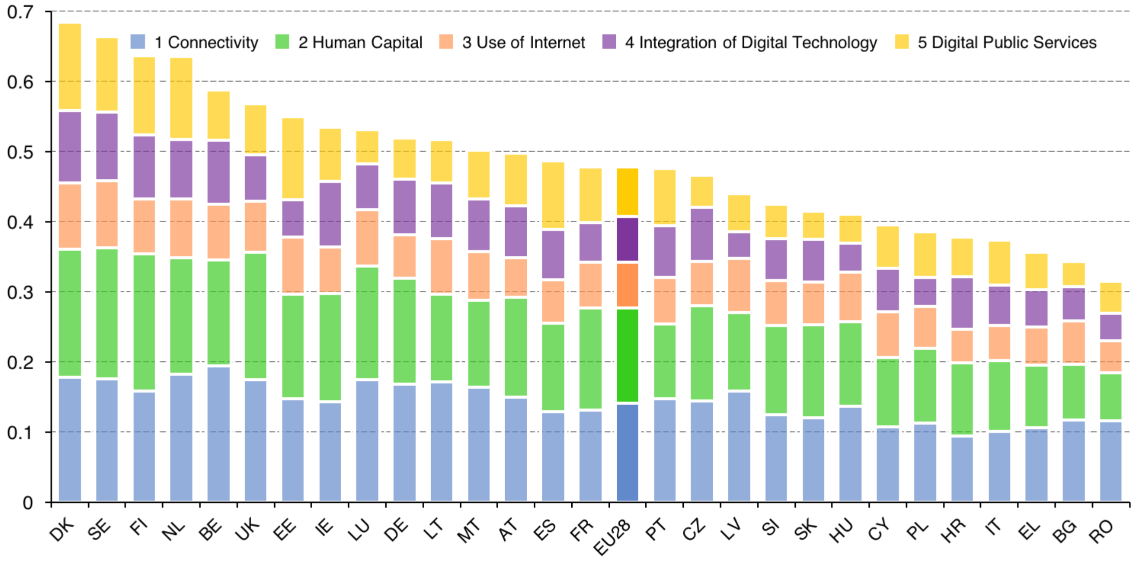
Source: EUROSTAT (2015).[232]

A noticeable fact in the CIS data is that considerably more enterprises with product and/or process innovations enterprises in Austria received any public funding (39.7%) than in Sweden (13%), which is conform with the high share of public R&D funding of BERD in Austria.

Examinations regarding ICT-readiness, as prerequisite for innovative industries and businesses, show that Denmark and Sweden are well ahead of Austria in all explored studies. Both Denmark and Sweden are top-performers in respective indicators in the EU-DESI-Index (rank one for Denmark and rank two for Sweden). In contrast, the Austrian performance lies slightly above the EU-28 average (see Figure 53). The index includes five main dimensions with respect to digital economy: connectivity, human capital, use of internet, integration of digital technology and digital public services, where Austria lies slightly below all values of Sweden and Denmark.

[232] EUROSTAT (2015): Enterprises by main types of innovation, NACE Rev. 2 activity and size class.

Figure 53: Digital Economy and Society Index (DESI) 2015



Source: European Commission (2015).[233]

Examinations of high-speed fixed and mobile networks in the OECD-STI-Outlook 2014 also show advantages for Sweden and Denmark with respect to ICT infrastructures, especially for mobile broadband subscriptions.[234] Additionally, two indicators in the Global Innovation Index 2015, namely ICT access and ICT use identify Sweden and Denmark as well ahead of Austria.[235] This tends to be a further small piece in order to explain the difference to the innovation leaders Sweden and Denmark. Hence, this points to the importance of strategic policies and funding towards ICT in order to support innovation activities.

4.4.5 Synthesis, conclusions and potential learnings and recommendations for Austria

Several aspects of structure, R&D and innovation intensity of the business sector have been covered in this chapter. In the following, main findings are summarized along these aspects. Specific recommendations were pointed out related to these topics.

The structure of funding of business R&D expenditures in Austria is quite different from the structure in Denmark and Sweden. While in Sweden and Denmark, a large part of BERD is funded by the national business sector itself, only a bit less than two third of the Austrian BERD is funded by intramural enterprises. This is explained by a comparatively high share being funded of enterprises from abroad was well as by the government sector.

Funding systems differ quite a lot between the countries in comparison: in Sweden, the share of public funded R&D in the business sector is much lower (also due to large R&D-intensive companies). Sweden also applies no tax incentives for corporate R&D compared to Austria or Denmark. R&D funding for companies in Sweden is mainly for collaborative R&D and R&D in

[233] European Commission (2015b): The Digital Economy and Society Index (DESI). http://ec.europa.eu/digital-agenda/en/desi#_ftn1.
[234] OECD (2014b): OECD Science, Technology and Industry Outlook 2014, OECD Publishing, http://dx.doi.org/10.1787/sti_outlook-2014-en.
[235] Cornell University, INSEAD, and WIPO (2015): The Global Innovation Index 2015: Effective Innovation Policies for Development, Fontainebleau, Ithaca, and Geneva.

large companies is not funded on a large scale. In Denmark, funding is provided mainly to SMEs in the form of start-up and market development support. The framework concerning public funding of business R&D is quite favourable in Austria for several reasons: Continuing policy to focus on public funding towards R&D and innovation instead of investment. Public RDI funding is also used as a 'locational argument' corresponding to a high significance of foreign affiliates.

- While individual measures of business R&D support have been assessed, impact assessments of the public support to business R&D remain scarce. All countries lack a 'portfolio evaluation' of their instruments. Austria has yet to evaluate its direct and indirect support measures for Business R&D and Innovation.

The industrial sectoral structure of Austria shows significant differences compared to Sweden and Denmark. While Sweden and Denmark have a comparatively high share of value added in high-tech sectors, Austria has a relatively high share in medium and low technology sectors (and vice versa). Austria has competitive advantages in these areas considering the strong supply linkages to European (especially the German) industry. However, the gap between Austria and the Nordic countries with respect to the share of value added in high-technology sectors increased since 2002. Since the IUS puts emphasis on industry structure rather than on sectorial performance, this leads to an underrating of Austria in the ranking. But a recalculation of R&D intensities shows that the structural differences only explain about one third of the difference in the overall research intensities.

- Austrian companies are outperformed by their Swedish and Danish counterparts with respect to their research efforts when structural disadvantages are taken into account. Hence innovation and R&D intensity and diffusion of Key Enabling Technologies in these areas can be improved significantly.

Austria shows relatively low dynamics in business start-ups compared to Denmark and Sweden, and also the total number of companies stagnated from 2009 to 2012. This is at least partially due to different regulatory frames and corresponds with comparatively high survival rates of Austrian firms. However, highly innovative business start-ups are a main driver of structural change and need to be fostered continuously.

- The differences in firm demography between Austria, Denmark and Sweden, (e.g. the large increase of one-person companies in Denmark), raise questions about the framework conditions and the ease of doing business in Austria. While recently some initiatives have been launched in Austria with the ambition to position the country among the European countries with the highest enterprise birth rates, this remains to be an area which should receive high policy attention and should be addressed from various angles (regulation, provision of VC, awareness and education, IPRs, encouragement of academic spin-offs etc.).

- Austria shows a broad spectrum of policy measures supporting highly innovative business start-ups in early phases (including awareness building, incubation and funding) but a strong business 'eco-system' is still lacking. Denmark and Sweden could be role-models in this vein, especially in some hot-spot areas (like the capital regions of both countries). Supporting schemes for later phases of business (e.g. accelerators in Denmark) exist but ought to be strengthened in Austria.

Austria performs at about the same level as companies in Sweden and Denmark when it comes to innovation activities in general. Especially Austrian large and medium sized companies show higher levels of innovation activities than enterprises in Sweden and Denmark. Also, Austrian firms perform very well in non-technological innovation and have larger shares of innovative firms compared to Sweden and Denmark. While Austria performs well regarding patent activities in Europe, there is a relatively large gap concerning the number of EPO patent applications per million inhabitants to the benchmark countries Sweden and Denmark. Although Sweden seems to be out of reach in high-tech EPO patent applications and Denmark had a slightly higher number of EPO patent applications per million inhabitants in the high-tech sector, Austria performed better than Denmark in ICT patent applications per million inhabitants. Also, Austria shows a strong performance in the field of biotechnology, where it surpasses the benchmark countries.

- Even if the propensity to innovate and patent is relatively high in Austria, not least due to a favourable framework concerning public funding of business R&D, there is room for improvement concerning the input-output relation and for commercialisation of these inventions (e.g. following the example of recently launched measures (like 'Marktstart') to support market development for SMEs. Overall though, scope for 'quick-fixes' are limited as changes in industrial structure and innovation behaviour of firms can only be changed in the mid- to long term. To do so, Austria is at no visible disadvantage concerning the funding instruments as compared to its peers in Denmark and Sweden given the size and scope of its innovation funding for the business sector.

A comparison of Austria, Denmark and Sweden regarding venture capital investments shows that the total volume of VC in Austria is significantly lower than in Sweden and Denmark, although this is not the case for the number of companies funded. Total VC for Austria in 2014 (seed, start-up and later stage venture) was 1/8 of Denmark and 1/9 of Sweden. This gap already existed before the financial crisis in 2007 and thus was no consequence of it. The number of VC firms and their VC volume increased significantly for digital start-ups over the last few years, where internet and technology firms were the most popular ones for investors. Since the ICT landscape is on the one hand smaller and on the other hand even decreasing in Austria compared to Germany, Sweden and Denmark, this might be an additional reason for the weak performance of Austria with respect to venture capital. Furthermore, the Austrian VC system shows marked differences with respect to the stage of investment, with emphasis of public VC funding being put on the early-stage other than in Denmark and Sweden. The dependence of Austrian companies on the banking sector is especially problematic in the early stage of young firms, which from 2007 onwards clearly shows that exactly this stage had to face the strongest decrease of risk capital provision in start-up VC investments in Austria.

- Denmark is especially remarkable, as it experienced a very different development, seeing its VC markets increase even in the years of the financial crisis. Notably the Danish Growth Fund (DGF) was able to attract private VC investors using a fund-of-funds model, and highly successful in leveraging private investments into the risk capital market thereby demonstrating the benefits of well-designed and well-managed initiatives to help grow a sustainable risk capital market. The chances to emulate this development in Austria might not be too high, as the DGF relied on the (pre)existence of other funds which are available to a much lesser extent in Austria, but deserves further examination.

- Overall, especially risk capital from the private sector has to be increased significantly in Austria. Innovation in high-tech branches involves high risks and large financial resources, which cannot be carried by the public sector alone. The main target of the public sector should be to provide a well-designed framework and a well-managed platform in order to attract venture capital investors.

Another marked difference between Denmark and Sweden and Austria is the role of ICT in the development of the respective research and innovation system. The role and weight of this sector is not only more pronounced in industrial structure, but also in the general 'ICT readiness' of the countries. ICT readiness is weak especially in Austrian peripheral regions and the coordination between federal levels could be improved. Denmark and Sweden societies are more IT oriented, better equipped with infrastructure and more prone to use IT both in households as well as in enterprises. While industrial structures cannot be changed easily, the uptake and diffusion of IT can. Measures in this vein include further advances in eGovernment initiatives, Smart Cities initiatives and the provision of sufficient broadband infrastructure.

- Like in Denmark and Sweden, Austria would benefit from a coordinated federal digitalization agenda.

4.5 The Role of ERA policies for national STI policy

International and European developments in research and innovation increasingly influence the development of national research and innovation systems and policies. For European countries, the European Research Area (ERA) is of special importance as it offers not only an additional source of R&D funding or international cooperation, but also a conceptual policy framework. This framework might orient both the activities of individual actors in the research an innovation system as well as STI policy as a whole.

In the following we will present findings on the importance of ERA as a reference point both for individual actors as well as for policy design. While the former is somewhat easier to describe as it manifests itself in the participation of researchers and organisations in the Framework Programs or the competition for ERC grants, the latter is much more difficult to operationalize.[236] For individual participation we can refer to internationally comparable statistics and studies.[237] For the influence on policy orientation, we have to resort mainly to the evidence from policy documents and interviews.

Because of the increasing importance of "mission-oriented " policies, addressing great societal challenges (which are also covered in the next chapter), we will focus here on this example to depict the degree of "alignment" of national and ERA policies.

4.5.1 Participations and Success in the Framework Programmes

In the following, comparative figures on participation and success of Austria, Denmark and Sweden in the European Framework Programmes (FP) are presented. The Netherlands are included, as they persistently show remarkable returns, high participations shares and outstanding performance in attracting ERC grants. Furthermore, the financial contributions to transnationally coordinated R&D are analysed as a proxy for the national importance of the engagement in bi- and multilateral R&D-projects, relative to national R&D-performance.

Table 11 and Table 12 depict participations and success rates for Austria, Denmark, Sweden and the Netherlands in FP6, FP7 and H2020. For Horizon 2020, these values are based on the number of approved submissions until April 2015, instead of actual contracts. Austria received funding from FP7 of € 1.2 billion, positioning itself in terms of absolute values between Denmark with € 1.1 billion and Sweden with € 1.7 billion. The Netherlands – as another interesting country to be compared - show a remarkably high amount of funding from FP with

[236] E.g. there is currently a project underway in Austria to assess the degree to which national and EU STI policies are articulated towards each other (*Erarbeitung einer österreichischen Position zu Alignment* im Auftrag des BMVIT). In the context of this project it became clear, that Austria is probably the first country to embark on such a systemic analysis.

[237] Arnold, E.; Boekholt, P.; Good, B.; Radauer, A.; Stroyan, J.; Tiefenthaler, B.; Vermeulen, N. (2010): Evaluation of the Austrian Support Structures for FP 7 & EUREKA and Impact Analysis of EU Research Initiatives on the Austrian Research & Innovation System, Technopolis Final Report; Arnold, E.; Mahieu, B.; Stroyan, J.; Campbell, D.; Carlberg, M.; Giaracca, F.; Horvath, A.; Jávork, Z.; Knee, P.; Meijer, I.; Sidiqi, S.; Wagner, C. (2011): Understanding the Long Term Impact of the Framework Programme; on behalf of European Commission DG Research; Danish Ministry of Higher Education and Science (2015): Effects of participation in EU framework programmes for research and technological development – for researchers, institutions and private companies in Denmark; Research and Innovation: Analysis and Evaluation 3/2015; Arnold, E.; Åström, T.; Boekholt, P.; Brown, N.; Good, B.; Holmberg, R.; Meijer, I.; Mostert B.; van der Veen G. (2008): Impacts of the Framework Programme in Sweden; VINNOVA Analysis VA 2008:11

€ 3.3 billion. This picture, regarding distribution and differences among countries compared, basically holds true also for FP6 and preliminary data of H 2020. In total, Austria accounts for 2.64% of total funding in FP7, compared to Denmark with 2.36%, Sweden with 3.80% and the Netherlands with 7.41%.

Table 11: Participations in FP6, FP7 and H2020 (numbers and national share of total funding in %)

	FP6			FP7			H2020*		
	Total	in % of total	share of funding in % of total	Total	in % of total	share of funding in % of total	Total	in % of total	share of funding in % of total
AT	1945	2,61%	2,54%	3516	2,63%	2,64%	493	2,88%	2,90%
DK	1641	2,21%	2,37%	2754	2,06%	2,36%	377	2,20%	2,32%
NL	4074	5,48%	6,64%	8151	6,10%	7,41%	1125	6,56%	8,20%
SE	2648	3,56%	4,06%	4506	3,37%	3,80%	525	3,06%	3,40%
Total FP	74400	100%	100%	133615	100%	100%	17146	100%	100%

* based on approved submissions until 03/2015
Source: FFG, eCorda

Table 12: Success Rates FP7 und H2020*

	Success Rate FP7	**Success Rate H2020****
AT	22.4%	18.4%
DK	24.2%	16.7%
NL	25.5%	18.8%
SE	23.6%	17.2%

* ratio of all participations evaluated and all approved participations, success rates for FP6 are not available in a comparative way, ** based on approved submissions until 03/2015
Source: FFG, eCorda

Regarding the share of nationally coordinated projects Austria performs above Denmark and below Sweden both in FP6 and FP7, which corresponds to the total number of projects participations. Once again, the high share of projects coordinated by Netherlandish institutions has to be highlighted.

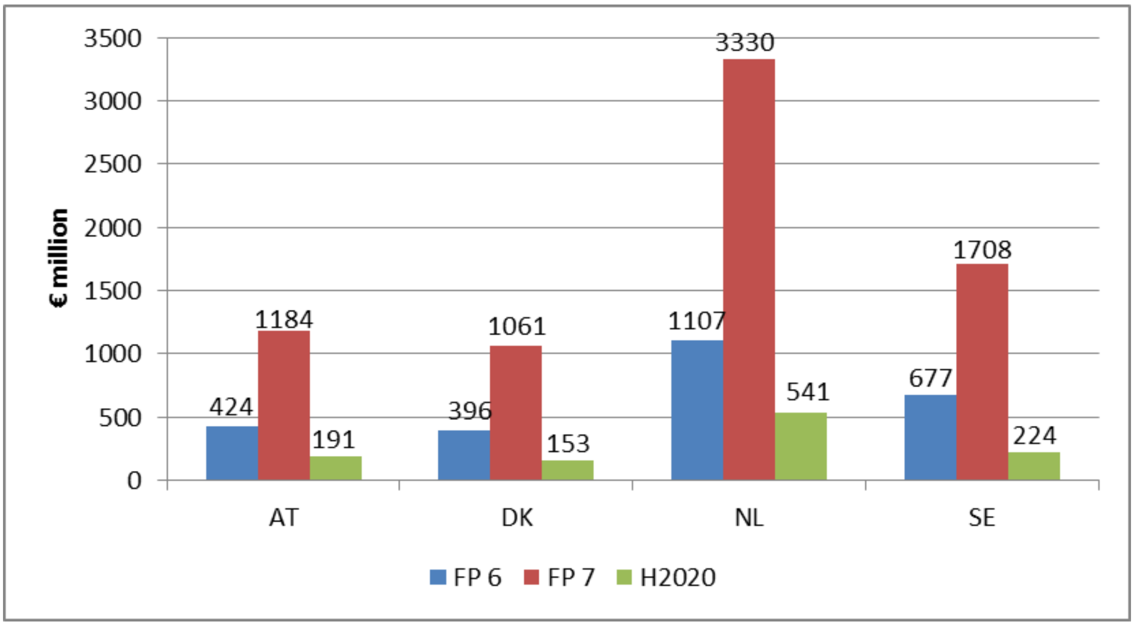
A remarkable difference of Austria's participation in the framework programmes is its distribution among types of participants, both in absolute numbers as well as in the retrieved share of funding. In Sweden and Denmark, higher education institutions (HEIs) account for a larger share of national participations in the framework programmes in FP6 and FP7 than in Austria, both in terms of volumes of participations. This reflects the strong position of Danish and Swedish universities.[238] Recent Analysis for Denmark shows for example the University of Copenhagen, Aarhus University and Technical University of Denmark (DTU) together retrieved about 1/3 in FP6 and almost 1/2 of total retrieved funds in Denmark.[239]

Looking at the participations on program level for FP6 and FP7 and at already approved submissions in H2020, Austria shows a comparatively high share of participations in ICT-topics

[238] Arnold, E.; Åström, T.; Boekholt, P.; Brown, N.; Good, B.; Holmberg, R.; Meijer, I.; Mostert B.; van der Veen G. (2008): Impacts of the Framework Programme in Sweden; VINNOVA Analysis VA 2008:11
[239] Danish Ministry of Higher Education and Science (2015): Effects of participation in EU framework programmes for research and technological development – for researchers, institutions and private companies in Denmark; Research and Innovation: Analysis and Evaluation 3/2015

(labels changed over time)[240], compared to Sweden, Denmark and the Netherlands as well as compared to the total distribution of participations in the FPs. In H2020 *Secure, clean and efficient energy* in the Societal Challenges pillar also appears to have attracted another comparatively high share of participations (see tables 21-22 in ANNEX). This is a reflection of consequent national attempts to promote research in these areas in Austria, connected with the participation in related multi-lateral activities (e.g. JTI-ECSEL, ERA-Net+ Smart Grids).

Figure 54: Funding Revenues from FP6, FP7 and H2020 in million €*



*based on approved submissions until 03/2015
Source: FFG eCorda

Hence, while partly reflecting the better endowed research systems in Denmark and Sweden in terms of higher participation and funding, Austria scores well in comparison with Denmark on aggregate level. Equally remarkable is the strong performance of ICT and *Secure, clean and efficient energy* technologies, both areas frequently being cited as strongholds of Denmark and Sweden. The even better performance of the Netherlands can be explained both by higher participation from comparatively stronger public research institutions (namely TNO) and universities.

Austria does not seem to have a comparative disadvantage in terms of the quality of participations, with success rates in H2020 higher than the immediate comparator countries and almost at level with the very successful Dutch. Apparently, Austria could at least compensate for the better endowment of the research systems by other factors. The Austrian support infrastructure (e.g. the EIP of FFG) and a pro-active stance of policy might be explanatory factors in this vein.[241]

[240] FP 6: *Information society technologies*; FP 7, H2020: *Information and Communication Technologies*
[241] Arnold, E.; Boekholt, P.; Good, B.; Radauer, A.; Stroyan, J.; Tiefenthaler, B.; Vermeulen, N. (2010): Evaluation of the Austrian Support Structures for FP 7 & EUREKA and Impact Analysis of EU Research Initiatives on the Austrian Research & Innovation System, Technopolis.

4.5.2 Participations and Success in ERC-Grants

Another important indicator, especially with respect to the quality of more basic research are participation and success in the grants of the European Research Council (ERC). Here, Austria surprisingly surpluses Denmark and Sweden.

Compared to Denmark and Sweden, Austria has a high success rate in terms of ERC-grants in FP7, with 18.93% compared to 14.12% of Denmark and 13.27% of Sweden. Once again the remarkable high success rate of the Netherlands stands out. Data on ERC-grants in H2020 is of preliminary nature for the moment, with adjustments in terms of nominations are currently taking place and should be therefore treated with caution. Success in ERC-grants is seen to reflect excellence in national scientific research in Austria, especially for young researchers. Corresponding to that, the highest share of ERC-grants that are dedicated to Austria are ERC-Starting Grants with 70 (Advanced Grants: 42, see Table 14) compared to Denmark and Sweden with a more even distribution between Starting and Advanced Grants.

Table 13: ERC Grants success rates

	FP7			H 2020*		
	submitted	approved	success rates	submitted	approved	success rates
AT	671	127	18.93%	136	16	11.76%
DK	673	95	14.12%	146	19	13.01%
NL	2166	470	21.70%	333	59	17.72%
SE	1387	184	13.27%	214	18	8.41%

*based on approved submissions until 03/2015
Source: FFG, eCorda

Table 14: Approved grants in FP7 by type of grant (numbers)

	ERC Advanced Grant	ERC Consolidator Grants	ERC Starting Grant	ERC-SyG	Supporting action	Supporting action (Proof of Concept)	Total National
AT	42	5	70	2	3	5	127
DK	38	7	45	2		3	95
NL	160	29	232	9	4	36	470
SE	75	12	87			10	184

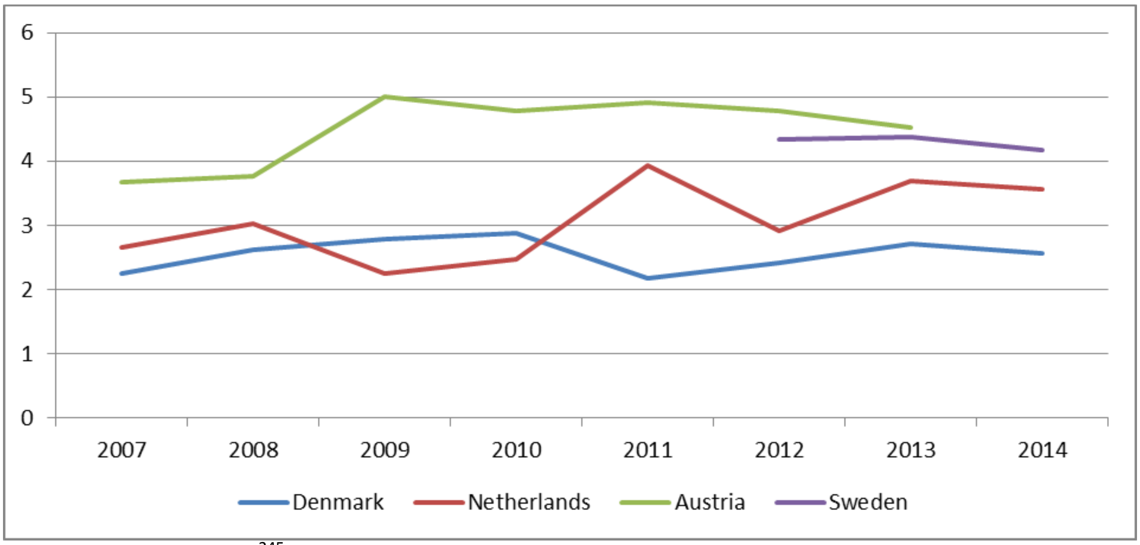
Source: FFG, eCorda

This observation warrants explanation, as both Denmark and Sweden can refer to research systems that perform considerably better in terms of high-impact output than Austria. From the qualitative evidence we gathered, it might be hypothesized that the much better endowed and diversified funding opportunities in both Denmark and Sweden at the national level are a major explanatory factor. Conversely it could be said that Austria partly compensates for smaller funding at the national level by a greater drive towards European programmes. How the participation in the FPs affects national systems is, however, also of interest for well-endowed systems like Denmark and Sweden. A recent analysis of the Danish Ministry of Higher Education and Science on the effects of the participation of Danish researchers, institutions and private companies in FP6 and FP7 showed a significant higher impact of publications resulting from ERC-grants but also from project participations in strategic areas of FP6 and FP7 compared to publications related to funding from DNRF or the Danish Council for Independent Research as well as the overall Danish performance.[242] This is true for universities and research organisations. An analysis of the FP's impact on Sweden, since its first participation in FP2 pointed out their complementary role to the very well-endowed national funding scheme. Added value of the FPs was especially identified by their stronger promotion of more applied and innovation oriented research to the very much basic research focused Swedish funding system.[243]

4.5.3 Transnationally coordinated R&D

One way to actually measure international (European) orientation of national policy is to look at the amount of public funding devoted to "transnationally oriented R&D".[244] The possibility to participate in by and multilateral R&D-activities is determined very much by the national structure of the R&D landscape and the national endowment with resources. Figure 55 shows national contributions of public funding for transnationally coordinated R&D in % of total GBOARD. According to these figures Austria distributes a relatively high share of its budgets for R&D to transnational R&D (2013: 4.53%), compared to Sweden with 4.38%, Denmark with 2.72% and the Netherlands with 3.7%. Figure 56 – Figure 58 show the different components of Austria's contributions to transnationally coordinated R&D.

Figure 55: National public funding to transnationally coordinated R&D in % of total GBOARD



Source: Eurostat (2015)[245]

[242] Danish Ministry of Higher Education and Science (2015): Effects of participation in EU framework programmes for research and technological development – for researchers, institutions and private companies in Denmark; Research and Innovation: Analysis and Evaluation 3/2015

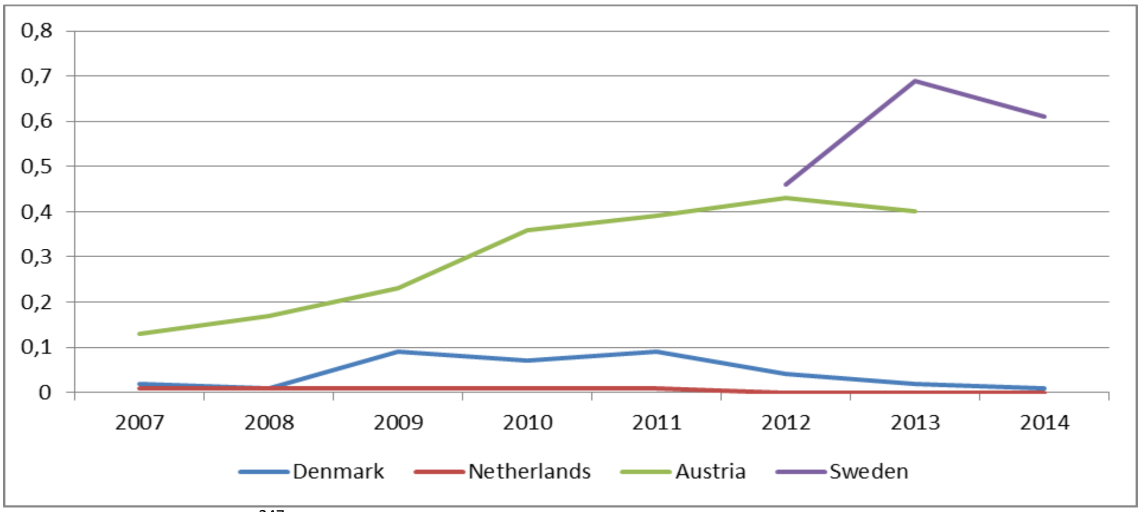
[243] Arnold, E.; Åström, T.; Boekholt, P.; Brown, N.; Good, B.; Holmberg, R.; Meijer, I.; Mostert B.; van der Veen G. (2008): Impacts of the Framework Programme in Sweden; VINNOVA Analysis VA 2008:11

[244] Total budget funded by the government (state, federal, provincial), as measured by GBAORD directed to transnational public R&D performers and transnational public R&D programmes. This indicator comprises three categories: national contributions to transnational public R&D performers (CERN, ILL, ESRF, EMBL, ESO, JRC); national contributions to Europe-wide transnational public R&D programmes (ERA-NETs; ERA-NET+; European Fusion Development Agreement (EFDA); EUREKA; COST; EUROCORES; European Space Agency (ESA); European Molecular Biology Organisation (EMBO); European Molecular Biology Conference (EMBC); Article 185 initiatives; Joint Technology Initiatives) and national contributions to bilateral or multilateral public R&D programmes established between MSs governments (e.g. D-A-CH)

[245] Eurostat (2015): National public funding to transnationally coordinated R&D [gba_tncoor]

0.4% of the Austrian GBOARD is budgeted for national contributions to bi- and multilateral public R&D-programmes in 2013. This comprises national contributions of the FWF to joint projects, especially the multilateral joint programming of D-A-CH between the FWF, the Swiss' SNF and the German DFG.[246] Only Sweden contributes more of its GBOARD to bi- and multilateral programmes with 0.69% of GBOARD in 2013. Figure 57 shows the development of national contributions to Europe-wide transnational public R&D-programmes, including Joint Programming Initiatives, ERA-Nets, ART-185 Initiatives, Joint Technology Initiatives, COST and Eureka, as well as other EU-Initiatives. For Austria this comprises national co-funding to these initiatives through FFG and FWF. Though decreasing since 2009, Austria still shows the largest share of R&D-budgets allocated to transnational EU-R&D programmes (2013: 3%). Between 2013 and 2014 the amount of funding to Europe-wide transnational cooperation increased from € 15.5 million to € 27.2 million, mainly due the increased financing needs for ERA-Net-Activities.

Figure 56: National contributions to bilateral or multilateral public R&D programmes in % of total GBOARD

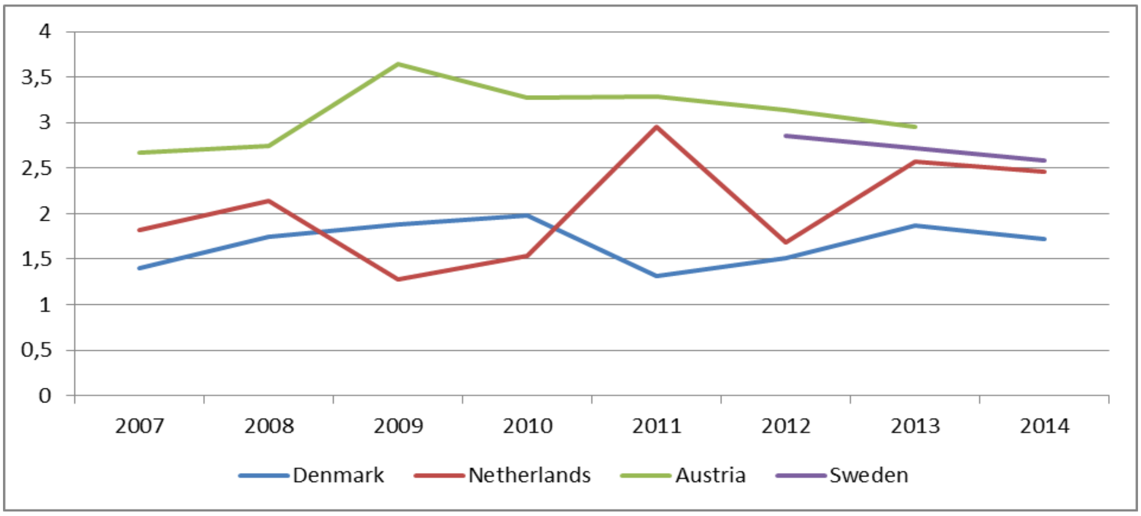


Source: Eurostat (2015)[247]

[246] http://www.fwf.ac.at/de/forschungsfoerderung/fwf-programme/internationale-programme/joint-projects/

[247] Eurostat (2015): National public funding to transnationally coordinated R&D [gba_tncoor]

Figure 57: National contributions to Europe-wide transnational public R&D programmes in % of total GBOARD



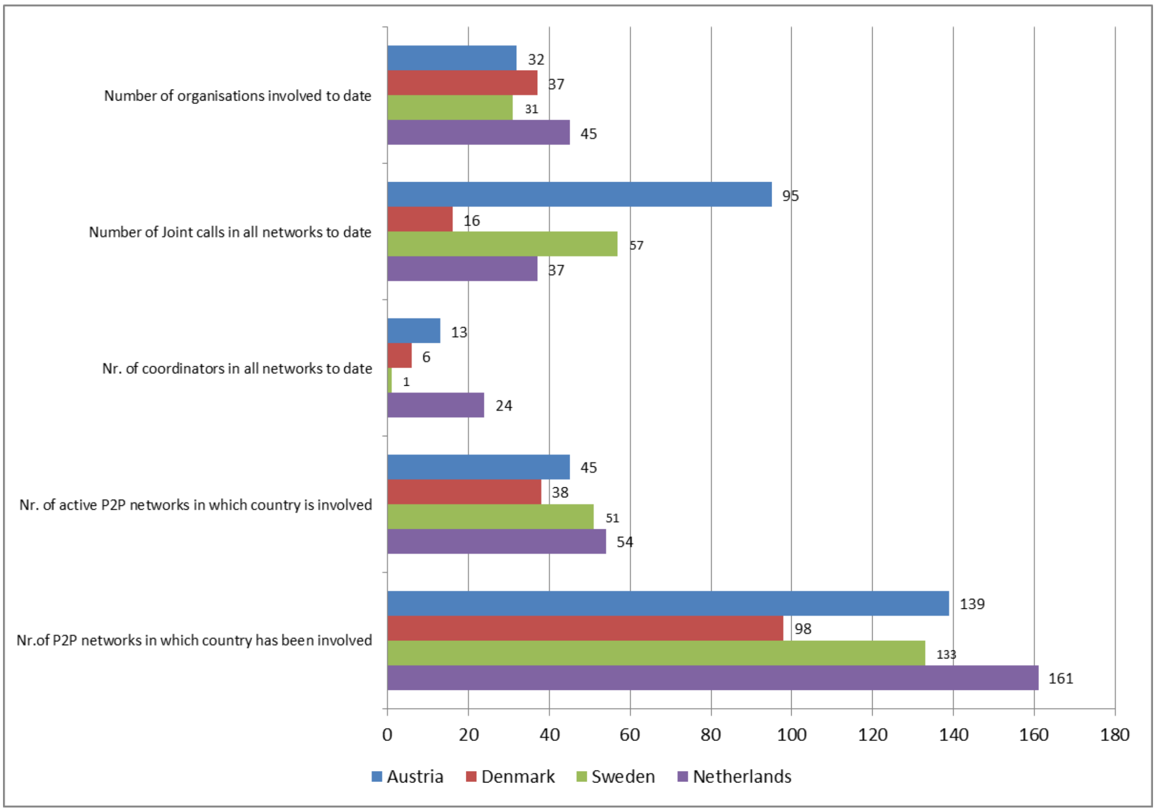
Source: Eurostat (2015)[248]

While Austria performs comparatively well with respect to these figures the overall level does point to the limited role that various instruments of bi- and multilateral R&D-funding still have. Hence, in terms of funding, European funding in the more R&D-intensive countries is more of an "add-on". In lesser R&D-intensive countries where EU funding might even be the single largest funding stream (e.g. Hungary, Greece) this is very different.

Beside the share of funding dedicated to bi- and multilateral R&D activities, the number of participations in respective networks is another indicator for the national orientation towards the transnational and European level, also regarding societal challenges, since these initiatives are often target related topics and might be also linked directly to certain areas of the FP.

[248] Eurostat (2015): National public funding to transnationally coordinated R&D [gba_tncoor]

*Figure 58: Involvement in European public-public partnerships (P2Ps)**



*Art. 185, ERA-Net Activities, Joint Programming Initiatives (JPI)

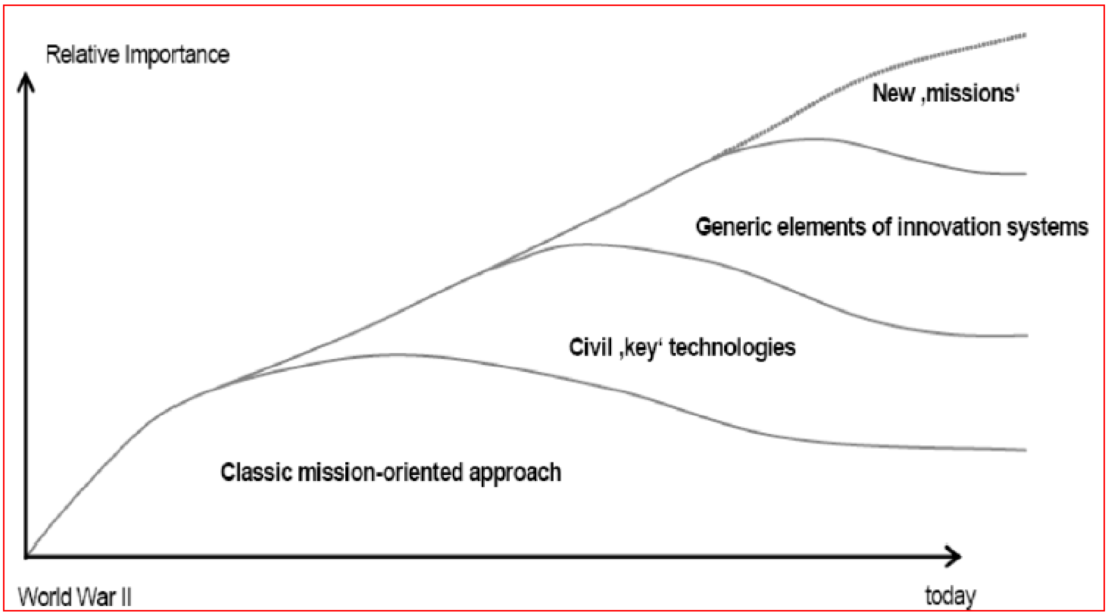
Source: ERALEARN portal: https://www.era-learn.eu/network-information/countries, 2015

Figure 58 indicates the strong engagement of Austrian organisations in public-public partnership activities. In terms of active networks involved, Austria (45) ranges only slightly behind Sweden and the Netherlands (54). Regarding the past involvement, Austria (139) is only outperformed by the Netherlands (161). This strong participation in bi- and multilateral networking activities might serve as another important explanation for the comparatively good performance of Austria in the FPs compared to Denmark and Sweden, as well as for the outstanding performance of the Netherlands.

4.5.4 ERA, Grand Challenges and mission-oriented policy

When trying to spot thematic alignment of European and national STI-policies, the so-called "mission-oriented programs" addressing grand societal challenges are a good reference point. This rationale for STI policy has gained ground (again) in recent years. While it was a predominant driver of public policy in the 1950ies and 1960ies (though with very different characteristics) from the 1990ies onwards more horizontal, generic approaches were applied in STI-policy.[249]

Figure 59: Historical development of main STI policy rationales



Source: Gassler/Rammer/Polt (2008)

Ever since, due to the rise of challenges which are perceived as global or at least international mission-oriented policies have staged a comeback as a major rationale for STI policy. They were established as a main pillar of ERA following a Green-paper on ERA rationales which - among other things – argued for a broadening of the concept of innovation and the policy instruments addressing it.[250] Namely it pointed to:

- the necessity to go beyond the funding of R&D and include the demand side as well,
- to see the economic potential of achieving social and environment goals and to couple the respective rationales,
- the potential to achieve scale and scope when addressing these challenges,
- the need to focus on a small number of (large) challenges,
- the need to involve a large number of actors beyond the confines of research institutions.

[249] Gassler, H.; Polt, W.; Rammer, W. (2008): Priority setting in technology: Historical development and recent trends. In: Nauwelaers C., Wintjes R. (eds.): Innovation Policy in Europe Measurement and strategy. Cheltenham, Edward Elgar.
[250] Georghiou, L. (2008): Europe's research system must change; Nature 452, 04/2008; EC (2008): Challenging Europe's Research: Rationales for the European Research Area (ERA) – Report of the expert group; European Commission DG Research.

One might add to these characteristics that the tackling of these challenges cannot be (sufficiently) dealt with at the national level alone and externalities (both positive as well as negative) are high.[251]

In 2009, under the Swedish presidency, this approach was endorsed in the so-called "Lund Declaration"[252] which pointed to the necessity to incorporate several of these challenges in the European Framework Programmes. This was duly enacted when the "societal challenges" became one of the three pillars of H2020 in 2014, accounting for almost 40% of the total envisaged budget.

As we shall describe in the next paragraphs, there has indeed been growing reference to the approach formulated on EU level also in national policy documents and programmes. Hence, one could hypothesize a growing influence (or alignment) of this main pillar of H2020 (and indeed ERA) on national policy making.

With the formulation of the Lund Declaration two strands in research funding where combined in a strategic vision for both, national as well bi- and multilateral coordinated R&D-funding and policy setting, emphasizing the idea of mission orientation to efficiently tackle areas of future challenges. The first strand is the promotion of research in prioritized target areas with the aim to develop new fields of strengths, sustain existing ones and create areas of international competitiveness by combining both academic and industrial prerequisites. This is accompanied by a second strand, the need for targeting areas of societal interest and future challenges, also by relying on users' needs in their formulation and implementation.

According to Dachs et al. (2015) modern approaches towards mission-oriented research and innovation policies comprise eight major features:[253]

1. Targeting and orientation the allocation of (scarce) public resources and alignment with private sources,
2. Knowledge diffusion as important target,
3. Multilevel governance in the coordination of policies,
4. Combination of technological and social innovation concepts,
5. Broad inclusion of stakeholders of policies,
6. Interdisciplinary collaboration,
7. No determination of technologies,
8. International orientation.

At European level Joint Programming Initiatives (JPI) serve as an instrument to transnationally strategically coordinate and promote research and innovation activities in areas of societal interest. This is fostered by the structure of the current European Framework Programme HORIZON 2020, with funding being allocated among specific work programmes addressing

[251] OECD (2012): Meeting Global Challenges through Better Governance: International Co-operation in Science, Technology and Innovation, OECD Publishing.
[252] http://era.gv.at/object/document/130
[253] Dachs, B., Dinges, M., Weber, M., Zahradnik, G., Wanke, P., Teufel, B. (2015): Herausforderungen und Perspektiven missionsorientierter Forschungs- und Innovationspolitik, AIT, Fraunhofer ISI im Auftrag der dt. Expertenkommission Forschung und Innovation (EFI).

areas of societal challenges.[254] In the aftermath of the Lund Declaration also several countries (e.g. Germany, Finland, Denmark Sweden, Netherlands) emphasized the idea of prioritizing funding along areas of strategic national interest in national programs or strategies.

There are several ways to adopt mission-oriented R&D and innovation policies and funding at national level, from setting up targeted funding schemes (e.g. in Sweden) to anchor mainly existing policies and funding to explicitly formulated priority areas (e.g. NL Top Sectors). Sweden applies a variety of initiatives to promote research in priority areas and the societal challenges. In the following related initiatives in Sweden will be discussed. These will be compared with schemes and policies in Denmark, Germany and the Netherlands. Since these programs have only recently been established, findings on their functioning and impact may be tentative but can provide some lessons for the implementation of such a program.

4.5.5 The Swedish CDI initiative

The so-called Challenge Driven Innovation Initiative (CDI, Swedish acronym *UDI*) was implemented as direct reaction to the Lund Declaration in 2009. The programme was launched in 2011. VINNOVA is in charge of the management of programme. So far, four areas of societal challenges were identified by VINNOVA with good prospects to create international compatible breeding ground for innovations. These comprise:[255]

1. Future Health Care
2. Sustainable Attractive Cities
3. Information Society 3.0
4. Competitive Production

Besides providing solutions for challenges in the fields defined above and increasing Sweden's competitiveness and international attractiveness as location for research and innovation, the provision of prerequisites for a more successful participation in Horizon 2020 is a core objective of the CDI-programme. Furthermore, in the CDI initiative user-demand and cross-sectional cooperation should be strengthened and play a key role for the selection of projects. As the emphasis is being put on collaborative research between universities, public research institutes and the business sectors, it complements existing cooperation oriented programmes as VINNOVA's VINNVÄXT-Programme, implemented in 2001 as a dedicated funding scheme for innovation-driven regional development.[256]

The set-up of the CDI-program comprises three stages. Funding in stage 1 is dedicated to the implementation of a network and the development and refinement of a research proposal within one of the challenges, with a budget of up to SEK 500,000 (€ 53000). Successful

[254] These are: Health, demographic change and wellbeing; Food security, sustainable agriculture; marine and maritime research and the bio-economy; Secure, clean and efficient energy; Smart, green and integrated transport; Climate action, resource efficiency and raw materials; Inclusive, innovative and secure societies; COM(2011)808, Horizon 2020 – The Framework Programme for Research and Innovation

[255] VINNOVA (2013): Challenge Driven Innovation – Societal challenges as a driving force for increased growth

[256] In the VINNVÄXT Programme, regions compete for a long term funding of up to SEK 10 million annually for 10 years by applying with strategic programmes for innovation and competitiveness developed by national stakeholders enforcing the triple-helix approach of academia, business and policy makers. Regional strengths according to the VINNVÄXT-Programme in many cases are defined in the challenge areas also targeted by the CDI-programme (e.g. New Tools for Health, ProcessIT in the 2004-Call period); VINNOVA (2011): Innovative Growth through Systems Integration and Globalisation – International Evaluation of the 2004 VINNVÄXT Programme Initiatives

completion of stage 1 is the prerequisite for being eligible for stage 2, which is the actual development of the project proposed in stage 1. Total funding is limited to SEK 10 million (€ 1.1 million) for up to 30 months at maximum. The last stage comprises a follow-up investment for the implementation and utilization of the developed approach, with funding of up to SEK 20 million (€ 2.1 million).[257] Since the implementation of the CDI in 2011 257 projects have been funded in state 1, 68 in stage 2 and 18 have reached stage 3. Whereas companies, especially SMEs, represent the largest share of participating organisations in the projects awarded in all stages, they only account for a comparatively small number of coordinators. Coordinators mainly come from the public sector, with a, compared to their overall little role in the Swedish research system, large amount of projects being coordinated by public research institutes (RISE). Around 10% of coordinators in all stages comprise municipalities and counties as well as hospitals. The participation of universities and their involvement as coordinators decreases over the stages of the CDI-cycle. One explanation for this is said to be the increased amount of basic funding for research allocated to universities with the government bill 2008/09 and 2012/13 that does not incentivize universities to participate in collaborative R&D and innovation projects.

In terms of funding, up till 2015 cumulated funds of SEK 949 million (€ 101.1 million) have been allocated to participants, which accounts for around 46% of total VINNOVAs annual budget. The highest share of funding was dedicated to universities and public research institutes, only a small amount was financing for the participants from the business sector, especially large companies. This represents a specific feature of the Swedish public funding system that is the traditional little role of government R&D-funding for large companies.

Though it is too early to really assess the impact of the CDI in terms of their contribution to societal challenges, some observations could be made already. The high participation of public actors, especially of the research institutes, signals their capability to engage in collaborative in cross-cutting projects with the industry sector. The most important effect of the CDI is therefore said to be the establishment of sustainable networks of different actors, even for the proposals not receiving funding. Projects eligible to stage 3 so far at least were able to demonstrate the potential for the creation of spin-offs or the attraction of further funding.

Potential inconsistencies have been pointed out, especially concerning the definition of the priority areas, with both “ICT 3.0” and “Competitive Production” are said not to really cover “societal” needs and challenges but rather certain technology fields. Generally, the proper definition of priority fields is a specific challenge of the mission-oriented approach, when it comes to their concrete and evidence-based formulation. Policy makers are often said not to be knowledgeable and informed enough to properly choose priority areas, whereas on the other hand stakeholder-based selection processes are in danger of “capture” by vested interests and require a sound coordination mechanism to balance between specific interests. Another potential flow of the CDI-programme (as more generally of mission-oriented programmes in which targets are defined bottom up) is said to be its strong focus on networking activities and collaboration in projects, rather than the actual development of new technologies. In some of the interviews it was argued that especially large companies might be

[257] http://www.vinnova.se/sv/Var-verksamhet/Gransoverskridande-samverkan/Utmaningsdriven-innovation/Utmaningsdriven-innovation/Dokument-och-mallar/

more in favour of directly targeting technological development as is the main thrust in the so-called Strategic Innovation Area Initiative (SIO) and therefore opt for other programmes. This points to the fact that whereas in other countries mission and priority oriented approaches consequently aim to align with other existing strategies in programs, in Sweden the opposite seems to be true. With the CDI-, the SRA and SIO-programmes, three targeted funding schemes have been developed in recent years in parallel, leading to an increased complexity, rather than to a more streamlining of the system.

4.5.6 Institutional Prioritization and collaboration: the Swedish Strategic Research Areas (SRA) and Strategic Innovation Areas (SIO)

Sweden and Austria have roughly the same share of generic public research funding (SE: 75% of civil GBOARD, AT: 71 of civil GBOARD). With the Government of Bill 2008/09 the Swedish government called for the implementation of so-called strategic research areas (SRA) at universities to contribute to the development of fields of scientific excellence with societal relevance. Furthermore, universities' cooperation with the business sector should be enforced. 20 strategic research areas have been defined by the government, with input from the Swedish Research Council, the Swedish Energy Agency, the Swedish Research Council of for Environment Agricultural Sciences and Spatial Planning (FORMAS) and VINNOVA, comprising research in the topics Medicine, Technology and Climate. For the period 2010-2014 43 co-called "research environments" (research groups) at 11 universities where established with a budget of around € 563 million (SEK 5.3 billion) and 9500 affiliated researchers.

Evidence about the success of the initiative is mixed.[258] According to the evaluation of the strategic research area initiative on behalf of the Swedish Research Council published in 2015, the strategic implementation and success of those areas at the host universities' varied widely. In general the largest amount of funding was used for the intake of young faculty, with strong emphasis being put on internationalisation. Furthermore, the SRAs appeared to be supportive for the intake of doctoral students as well as build-up of research infrastructures. On the other hand the impact of the SRAs on scientific output and excellence is judged to be mixed, as a direct contribution could hardly be identified especially in universities with an already excellent performance. Due to their longer-term focus of funding however, there is some evidence on their contribution to incentivize universities to tackle more risky research. SRAs also seem to have a positive impact on inter- and intra-university collaboration. Only little evidence could be provided regarding the contribution of the SRAs to systemic innovation activities at universities. The mixed picture of the success of the SRA-initiative is also confirmed by the interviews with various stakeholders (see Annex). A major bottleneck seems to be that they have been chosen primarily by government without any strategic involvement of the universities. The narrowing down of the SRAs on just three fields of sciences gave also rise to some criticism. Given the high autonomy of university research, their implementation and impact at universities' strategic positioning was very different, depending on how universities were able to align their resources, recruitment and management capacity with the SRA. Overall the perception seems to be that the SRAs do not have changed much in the portfolio of activities, but were used at least by some for the establishment of new fields of excellence.

[258] Swedish Research Council (2015): Evaluation of the strategic research area initiative 2010-14

The SRA initiative (at least not for the time being) did not show the expected effects in terms of universities' increasing their participation in collaborative innovation activities and the improvement of links with the business sector. The Government Bill 2012/13 therefore stated the need for the implementation of the so-called Strategic Innovation Area Initiative, with targeted funding of SEK 225 million (€ 24 million) for the period 2013 – 2016, which is rather small compared to the total budget of the SRA (let alone the research budget of universities). The implementation of the program is managed by VINNOVA. Other than in the SRA-approach, areas of strategic importance should be defined in a bottom-approach by a broad range of innovation stakeholders, including the public sector, higher education institutions and the industry. The collaborative development of so-called Strategic Innovation Agendas (SIAs) is eligible for funding by VINNOVA. In second step, VINNOVA decides on whether these SIAs might be suitable for the development of so-called Strategic Implementation Programmes (SIPs). In that respect, the process has top-down-features again. In total the process is very much aligned with the steps of establishing an ERA-NET, with many of the stakeholders reported to be familiar with this kind of scheme. The SIPs lay out the implementation process for the respective SIA, i.e. the development of calls for project proposals and the monitoring process for projects results. The set-up of the SIP is a again a collaborative process, normally designating a project coordinator and a supervising board of directors. The first SPIs have been implemented in August 2015, which therefore allows no assessment so far on the impact and functioning of this initiative. Regarding the thematic orientation, the current SIPs could be found in fields of mining, metallic and lightweight materials, process industries, automation and production technology and aerospace. In a first assessment stakeholders of the process reported, that the SIO was first of all supportive in expanding their existing networks.

4.5.7 Thematic prioritisation in Denmark: RESEARCH 2020 and Inno+

Other than in Sweden, the strategic enforcement of prioritized areas tackling grand challenges in Denmark is not directly tied to the implementation of a dedicated funding scheme or resources. The Globalisation Strategy of 2006 was a push towards a more thematic oriented approach in public funding, whereas in the 90ies generic research was emphasized to be an important of Danish competitiveness. In 2012 the Danish government announced to RESEARCH 2020 (Forsk 2020) as strategic umbrella and orientation point for the alignment of public, resources, agencies' and private funding and promotion of research. In total the public sectors spends about DKK 1 billion (€ 130 million) on societal challenge related areas.[259] RESEARCH 2020 is part of the governments' innovation strategy of 2012. Five visions including 14 themes (see Table 15) of promising strategic research areas in Denmark that may be driving forces in the knowledge based tackling of societal challenges were defined in a broad stakeholder process between 2011 and 2012.[260] Each of the areas is based on an analysis of Danish prerequisites and strengths in research and industry. In that respect, the program follows the 2008 implemented RESEARCH 2020, which was based on a much broader range of fields.

[259] Danish Ministry of Science, Innovation and Higher Education (2012): RESEARCH 2020, Strategic Research Horizons.
[260] Ibid.

Table 15: RESEARCH 2020, visions and strategic research areas

Green Economy	Health and Quality of Life	High tech society with innovation capacity	Efficient and competitive society	Competent and cohesive societies
Future energy technologies and systems Environment and water resources Climate/Climate adaption Bio-resources/Food	Prevention and diagnostic of diseases Healthcare and care of the future	Digital solutions Future production systems Strategic growth technologies (Nano, Biotech, Materials, ICT)	Policies encouraging competitiveness and growth Effective and innovative welfare and prevention (knowledge based public sector) Transport, logistics and living space	Education, learning and competence development Cultural understanding and cross-cultural competences

Source: RESEARCH 2020, Strategic Research Horizons, Ministry of Science, Innovation and Higher Education

Most of these strategic areas in those addressing specific technologies and research fields are oriented towards the societal challenges as promoted in Horizon 2020. On the other hand, one might note, that especially the last two areas "Efficient and competitive society" and "Competent and cohesive societies" cover functional characteristic of societies as such, rather than strategic areas of research.

As complement to RESEARCH 2020, the Danish innovation strategy[261] formulates the implementation of the INNO+ programme to establish so-called innovation partnerships in areas of societal challenges were Denmark might have the potential to contribute with innovative solutions in the medium-term. In a broad and stakeholder-inclusive approach around 90 organisations and institutions submitted a total of almost 500 proposals for areas that should be prioritized in innovation.[262] As a result of that in 2013 a catalogue was presented, including now six large priority areas and 21 sub topics of strategic importance for innovation.[263]

- Innovative transport, environment and urban development
- Innovative food production and bio-economy
- Innovative health solutions
- Innovative production
- Innovative digital solutions
- Innovative energy solutions

The implementation of innovation activities along these 21 sub topics should take place in so-called innovation partnerships, including higher education institutions, GTS-institutes and the business sector. It is too early to state any conclusions about these two initiatives, RESEARCH 2020 and Inno+. Nevertheless, stakeholder already expressed their concern that the priorities

[261] Danish Ministry of Science, Innovation and Higher Education (2012): RESEARCH 2020, Strategic Research Horizons.

[262] http://ufm.dk/en/publications/2013/inno-catalogue/inno/process-and-participation

[263] Danish Ministry of Science, Innovation and Higher Education (2013): Inno+ – the innovative Denmark; http://ufm.dk/en/publications/2013/files-2013/pixi_uk_web_pdfa1.pdf

and topics chosen concentrate on existing fields of Danish strongholds, rather the developing new fields of strength. Another special feature that was pointed out in that context is the little role of regions in R&D and innovation processes. This is said to be stronghold of Danish STI-policy making, as the concentration of responsibilities for STI-policy on national level increases the flexibility and streamlining in funding and the adoption of mission-oriented policies.

4.5.8 The Netherlands' Top Sector Approach

In 2011 the Dutch government launched the policy initiative to strategically align public resources for R&D and innovation along nine so-called top sectors. This approach aims to target future challenges and optimise Netherlands' competitiveness and prosperity based on the enforcement of knowledge and innovation. This marks a significant change in Dutch R&D and innovation policy towards a more demand driven approach. Stakeholders along the knowledge triangle of the business sector and tertiary education and research should join forces, exploring new markets, inventions and products. The nine strategic priorities comprise agri&food, horticulture and propagation materials, high-tech systems and materials, energy, logistics, creative industry, life sciences, chemicals and water. They were identified as the most promising and competitive areas of the Netherland's economy, together accounting for over 80% of business sector R&D expenditures, 55% of total exports but only up to 30% of value added and employment.[264] Science-industry collaborative research should be encouraged in these areas, especially targeting the participation of SMEs. The sectoral-approach is chosen for two major reasons 1) to overcome existing barriers between several government departments and ministries involved and 2) to leverage private investments through a close cooperation of public and private actors in the respective fields. The total estimated budget is about € 1 – 1.1. billion each year between 2013-2016, mostly including existing finance instruments (ministries, NWO, PRIs and HEI, entrepreneurs) that will be streamlined along the priorities (excl. EU and regional funding).

The definition of the top-sectors was very much in the hands of the so-called top teams including high level representatives from industry, public research and the government. The top teams formulated strategic agendas for each of the top sectors. Responsible for the implementation of the strategic agenda are the so called top consortia for knowledge and innovation (TKI), comprising public-private partnerships, including businesses and higher education and research institutions. The implementation of the TKIs is supported by the government in the form of allowances to reimburse private partners for their engagement, comprising € 83 in 2013. The public-private partnerships for the implementation of the strategic agendas by the TKIs are formalized in the so-called be annual innovation contracts between die business community and the government. The innovation contract signed in 2013, foresees a total investment of € 2 billion for the top sectors in a two years period, of which € 970 million are contributed by the industry. Especially € 36 million are dedicated to align the top sector activities with the societal challenges formulated in Horizon 2020 and to support respective applications.[265]

[264] OECD (2014): Reviews of Innovation Policy: Netherlands; OECD Publishing.
[265] Ibid.

Beside of strategic funding for collaborative research and innovation activities, the top-sector initiative also comprises with the so-called *Technology Pact*, targeted measures and funding along all stages of the education cycle, to increase skills and human resources in areas related to the Top Sectors.

A specific feature or the top sector approach is the implementation of an accompanying monitoring and evaluation scheme. Statistics Netherlands developed on indicator based monitoring to assess the progress of the approach on 2-years basis, taking 2010 as baseline scenario. Table 16 shows the indicators applied.

Table 16: Top Sector monitoring indicators

Themes	Indicators
Macro-economy	Production, Added value, Active workers (in FTEs), Investments in tangible fixed assets and in computers, Export value of goods, Throughput of goods, Number of exporters
Enterprises	Number of companies, SMEs, Company survival rates, Number of new and ceasing companies
Employment	Employees, Self-employed employees, Researcher, foreign researcher working in the Netherlands, Vacancies,
Innovation	R&D expenditures of companies; by the company and outsourced, Total innovation expenditure, total and SME, Technological and non-technological innovators, Innovators SMEs, Turnover of innovative products, Innovation in partnership by type / organisation, Innovation in partnership SMEs
Education	Obtained diplomas and Subscriptions in the secondary, higher and university education

Sources: CBS 2014, Monitor Topsectoren

Furthermore the Dutch Advisory Council for Science, Technology and Innovation (Adviesraad voor het Wetenschaps en Technologiebeleid AWT) is commissioned to evaluate the top sector approach. First assessments of the top sector approach[266] indicated an overall broad acceptance of this initiative that is dedicated to the holistic inclusion of stakeholder. As potential limitation, the risk of inflexibility to adapt to new challenges was addressed since thematic areas defined in the top sectors are based on a more backward looking approach of Dutch existing strongholds. However the overall assessment is that the approach is flexible enough, to cope with further adjustments, due to the large number of sectors and the little amount of alignment regarding funding for basic research. Specific issues were mentioned especially regarding the inclusion of SMEs that reported problems in affording the resources required for the participation in a top sector's strategic agenda and process. Another crucial point is the alignment between the national and regional level (though the overall role of regions is little in STI-policies and funding), since the regions in the Netherlands receive considerable funding for development and innovation from the EU structural funds.

4.5.9 Germany: the High-Tech Strategy

Germany shows – and this also holds true for Austria – main strengths in the medium-high technology sectors which turned out to be an advantage during recent years of financial and economic crisis.

[266] AWTI. (2014). Balans van de Topsectoren. The Hague: Adviesraad voor Wetenschap, Technologie en Innovatie; OECD (2014): Reviews of Innovation Policy: Netherlands; OECD Publishing.

To initiate structural change towards more high-tech sectors, in 2006 the government developed a new strategy with the aim of securing long-term international competitiveness. This strategy has been extended in 2009 and updated recently in order to accompany programme planning at the European level until 2020. The current version of the High-Tech Strategy set the target to become a worldwide innovation leader.

The remarkable thing here is that the High-Tech Strategy has been developed as a comprehensive, interdepartmental innovation strategy of the German government. Another relevant point is, that the High-Tech Strategy has not merely been developed in order to coordinate existing policy instruments but that new instruments for funding research and innovation have been introduced under the umbrella of the strategy (e.g. Spitzencluster Wettbewerb, Exzellenzinitiative, Forschungscampus, Unternehmen Region, Innovation zwanzig20). Beyond the funding and systemic intervention of the new instruments an important component should be mentioned: the building of local regional structures or hubs and international visibility. Thus, when comparing with the "FTI-Strategie der Bundesregierung" in Austria, the High Tech Strategy has been more directed and successful in committing and ensuring financial resources for targeted measures, implementation and branding at an international level.

Five pillars of innovative strength have been defined: (1) prioritising future challenges relative to prosperity and quality of life, (2) consolidating resources and promoting transfer, (3) strengthening the dynamism of innovation in industry, (4) creating favourable conditions for innovation, (5) strengthening dialogue and participation. The six priority areas relative to future prosperity defined are: (a) digital economy and society, (b) sustainable economy and energy (c) innovative workplace (d) healthy living, (e) intelligent mobility, (f) civil security.

In March 2012 the federal government agreed on an action plan for the High Tech Strategy 2020 and formulated 10 future-oriented projects (*Zukunftsprojekte*) focussing on grand societal challenges (climate/energy, health/healthy food, mobility, communication, and security). Thus the High Tech Strategy at the national level provides a clearer link to European and multi-lateral activities.

4.5.10 The mission-oriented approach - a summative assessment

Since the 90ties a new mission led approach, i.e. the complementation of the traditional thematic oriented and technology based approach of mission-oriented funding by a demand and user-driven perspective to address societal needs and challenges, is gaining in importance for R&D and innovation policies and funding.[267]

Drawbacks and potentials of this type of policy are heavily discussed.[268] From the perspective of competitiveness of countries they might be supportive for the creation of critical masses by the promotion of strategically important sectors and push towards structural change towards a more knowledge based economy. From a governance perspective they might be seen as

[267] Gassler, H.; Polt, W.; Rammer, C. (2008): Priority setting in technology: Historical development and recent trends. In Nauwelaers C., Wintjes R. (eds.): Innovation Policy in Europe Measurement and strategy. Cheltenham, Edward Elgar.

[268] E.g. Boekholt, P., Arnold, E., & De Heide, M. (2007): The use and effectiveness of programmatic policies – Some examples and evidence from around the world. Amsterdam: Technopolis Group; OECD (2014): Reviews of Innovation Policy: Netherlands, OECD Publishing.

efficient bundling of scare public resources also in the alignment of international trends in research and funding (European Framework Programmes, attracting research). On the other hand, prioritization processes are said to be in danger of "picking winners", i.e. applying a more backward looking approach that might lead to a lock-in in existing strongholds rather than promoting an efficient and flexible adoption of industry towards a changing environment and making economies more prone to external shocks. Furthermore, prioritisation of funding is in danger to limit resources in less promoted sectors. This might especially affect the balance between applied and basic research. Another concern is that oriented funding might encourage less-risky research projects, since the fitting to the agenda might be stronger promoted than cutting edge research. This includes the danger of promoting deadweight activities of stakeholders. Furthermore, the definition of promising areas for targeted investments and strategic activities require a complex process of stakeholder involvement, since governments might not be the right level to prioritize.

As the examples show, countries are adopting to this strand of mission-oriented funding and policy making in variety of different approaches, tackling the issues raised above in some way or another. Motivation for these processes in Europe are twofold: One the one hand, mission-oriented funding is promoted at European level by the structure of the current 8 Framework Program Horizon 2020 as well as related initiatives like Joint Programming, calling for multilateral collaboration in fields of societal challenges. On the other hand, countries especially in Europa are facing an increased need to sustain or establish fields of competiveness in a globalized world, and position themselves in global value chains. Knowledge and innovation oriented specializations are seen to be key in that regard.

Sweden developed a variety of mission-oriented programmes with different strategic targets (university specialisation, collaborative research, science-industry linkages) in focus, but without an overarching strategic and coordinative framework between these different schemes. Therefore it was stated by stakeholders, that these initiative are in danger to increase fragmentation in Swedish R&D and innovation programming rather than to actually prioritize. One important target especially of the SRA and SIO initiatives is, to incentivise universities by additional funding to stronger engage in strategic processes and collaborative research, which points to the necessity of targeted funding to stimulate universities activities.

Denmark's interpretation of mission-oriented policy making and programming as applied with the RESEARCH 2020 and Inno+ initiative is in favour of a more holistic approach providing an overall strategic frame for the alignment of activities and funds of stakeholders, policy makers and agencies involved in the R&D and innovation system. Whereas one the one hand, the broad inclusion of stakeholders and the commitment to respective targets is seen as success the actual impact and progress of these initiatives might be hard to assess.

A closer look reveals though, that the influence of this policy approach, while discernible, is rather limited. Speaking to a number of relevant stakeholders in this realm, we gathered the impression, that both in Denmark and Sweden this type of approach (i) receives comparatively little funding compared to more traditional types of research funding, (ii) has not been a very prominent point of reference for the formulation of national priorities. Where it was taken up, some re-packaging of already existing programmes seems to have occurred.

Both Sweden and Denmark have in common to differentiate between strategic programmes for research and innovation. Netherlands and Germany apply a more inclusive approach in that respect. The examples both from the Netherlands as well as from Germany also point the importance of dedicated funding for strategic prioritizations and initiatives, both by the streamlining of existing programmes as well as by the allocation of new monies. The Netherlands furthermore show as example for how to incorporate monitoring and evaluation mechanisms from the very beginning of the process.

4.5.11 Potential learnings and recommendations for Austria

While other leading countries (notably Sweden and the Netherlands) outperform Austria in some dimensions of FP participation, this does not seem to indicate lower quality of Austrian research. Rather, it could be attributed to different inputs and financing conditions. The comparatively better endowed national research systems of Denmark and Sweden seem to be less oriented towards ERA and ERA-related policy approaches than Austria.

In terms of potential lessons for Austrian policy setting related to ERA, policy debates in Denmark and Sweden were characterized by predominantly national concerns and do not give European STI policy a large weight. Both the Danish and the Swedish research and innovation systems are well anchored internationally, though there are some debates about the attractiveness for students and researchers from abroad. Discussions about necessary steps to foster internationalization are going beyond Europe, though, and address questions of positioning the HEI and the enterprises in global competition and value chains. This again might be a reflection of well-endowed national research systems. Nevertheless, ERA priorities seem to have had at least some influence on priority setting, especially in the up-take of ‘grand societal challenge’ topics (following the Lund declaration). When it comes to support infrastructures, again there might not much to learn from the Danish and Swedish examples (scope for policy learning is quite often seen the other way round). ERA initiatives, targets and instruments seem to play a greater role in Austria’s strategic R&D-policy setting than in Denmark or Sweden.

- Austria performs significantly behind Sweden in terms of FP and H2020 indicators, regarding the share of retrieved funds to total funding as well as participation numbers and the share of project coordinators in FP6 and 7 and up till now in H2020. Regarding ERC grants (up till now 16 approved in H2020) Austria is in absolute terms behind Denmark (19) and Sweden (18) but compares well if the respective sizes of the research base are taken into account. The expansion and further quality improvement of the research base might also be the best way to approach the self-set Austrian target with respect to participation and coverage rate in H2020.
- ERA-related funding, policies and initiatives (FPs, ERA-Nets, JPIs etc.) are an important supplement to existing strongholds rather for the creation of new fields of excellence. Working on the efficient streamlining of public funds and positioning Austria according to the European requirements for tackling societal challenges and European priorities efficiently and at the same time exploit national strengths for future competitiveness have to be continuous challenges for national R&D and innovation policy.

There are a variety of strategic targets, policies and documents in Austria but depending on where they are anchored institutionally they increase, rather than decrease the complexity in terms of instruments and measures in place. In general, ministries tend to introduce new programmes or funding schemes instead of enforcing harmonization and targeting along broader targets or strategic dimensions and priorities. Furthermore, regional governments and municipalities play a non-negligible role R&D-policy making and funding. Currently seven out of nine Austrian states promote their own R&D- and innovation strategies and agendas, with only little coordination among each other's or towards an orientation to common national targets.[269] Additionally, most of the Austrian states run their own funding agencies and programs.

Furthermore, the role of thematic funding on national level compared to generic and structural programmes is little in Austria. The most important source for thematic funding in Austria are the so-called topical programmes, administered by the Austrian Research Promotion Agency FFG, accounting for around ¼ of total agency's funding. The topical (thematic) programmes represent the third-largest programme sector in the funding portfolio of the Austrian Research Promotion Agency (FFG) in 2014, with a cash value of € 139.63 million (2013: € 125.14 million).[270] These programmes aim to support national and international priority topics, including energy, ICT, production, and security research, which are all themes that are competitive at the European level, regarding the most successful topics of Austrian participation in the Framework Programmes.

Working on the efficiently streamlining public funds and positioning Austria according to the European requirements for a strategic thinking of tackling societal challenges and efficiently and sustainable exploit national strengths for future competitiveness are therefore pending demands for national R&D and innovation policy. The trend shows mission-oriented funding to shift from a technological driven approach towards a user- and demand driven orientation. Taking into account the learnings from the examples of other countries, recommendations are formulated in the following:

- Austria needs to start process towards aligning and disentangling of its structures for R&D-policy making and funding on several levels of policy making (national and regional governments and municipalities). A national effort towards mission and challenge oriented prioritization process, using the current spirit of policy designs at the European level, might be a useful anchor for such a project.
- Especially small-countries might benefit from a challenge driven but bottom up-oriented approach in mission-oriented funding other than by funding certain technologies as this allows for a greater flexibility as the state might not be right on to pick winning technologies.
- Mission-oriented approaches require both, a strategic agenda, based on broad inclusion of stakeholders, as well as a dedicated amount of funding at least by putting a bracket around existing funds.

[269] BMWFW, BMVIT (2015): Austrian Research and Technology Report 2015, Report under Section 8(1) of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria, Vienna
[270] Ibid.

- Strategic and competitive funding programmes might be an incentive for universities to encourage specializations in certain areas.
- The formulation of measurable targets, both qualitative and quantitative, as well as monitoring and evaluation process are key to increase the accountability of any strategic program.

4.6 Science-industry linkages and commercialisation of research

Sound linkages between public research institutions and the business sector, either comprising commercialisation activities of public institutions themselves (e.g. patents, licensing, spin-offs) or several other channels of knowledge transfer play an important role in any national innovation systems. In fact these linkages – or rather their perceived absence or weaknesses – were at the heart of debates stressing gaps between the level of scientific and research outputs and their lack of the translation of these into innovation. Hence, the past two decades have seen numerous attempts to bridge this gap through various policy measures. In many countries, these measures have been among the most important ones in the STI policy portfolio. E.g. the various “competence center programs”[271] have been among the largest measures in terms of funding in some countries (e.g. COMET and its predecessors in Austria[272], or the SHOKs in Finland[273]).

The importance of various channels varies with the structure of the difference research and innovation systems: Following a mapping of the OECD (2013a) Austria, Denmark and Sweden all fall into the same category, characterised by a comparatively high share of business in total R&D spending (“firm-centered innovation system”) and a high share of higher education institutions in the total of publicly performed R&D (“university-centered public research”)(see Figure 60).[274]

This positioning is inter-alia a reflection of the relatively small share of public research institutions (PROs) as compared to the higher education institutions. As this sector is in most countries predominantly oriented towards more applied research (both for public missions as well as for private business needs), the need to bridge the gap between scientific research and innovation seems even more pronounced in countries with a high share of HEIs. Another characteristic differentiating research and innovation systems with respect to industry-science relations, is of course the structure of the industry and the size of companies: Countries specialized to a greater extent in more science-based industries (as both Sweden and Denmark are), where basic research is more directly linked to industrial application such as ICT and pharma sectors, often show a clearer relationship between industry and science. In the same vein, larger companies find it easier to establish links to HEI for several reasons. Again, this structural characteristic “disfavours” Austria as compared to Denmark and Sweden, which have a larger number of large firms, some with very long-lasting relations to respective university partners (see 4.4.1 on structural differences of business R&D). There are several ways to address this challenge and they have been used somewhat different in Austria, Denmark and Sweden, which offers some scope for policy learning.

---

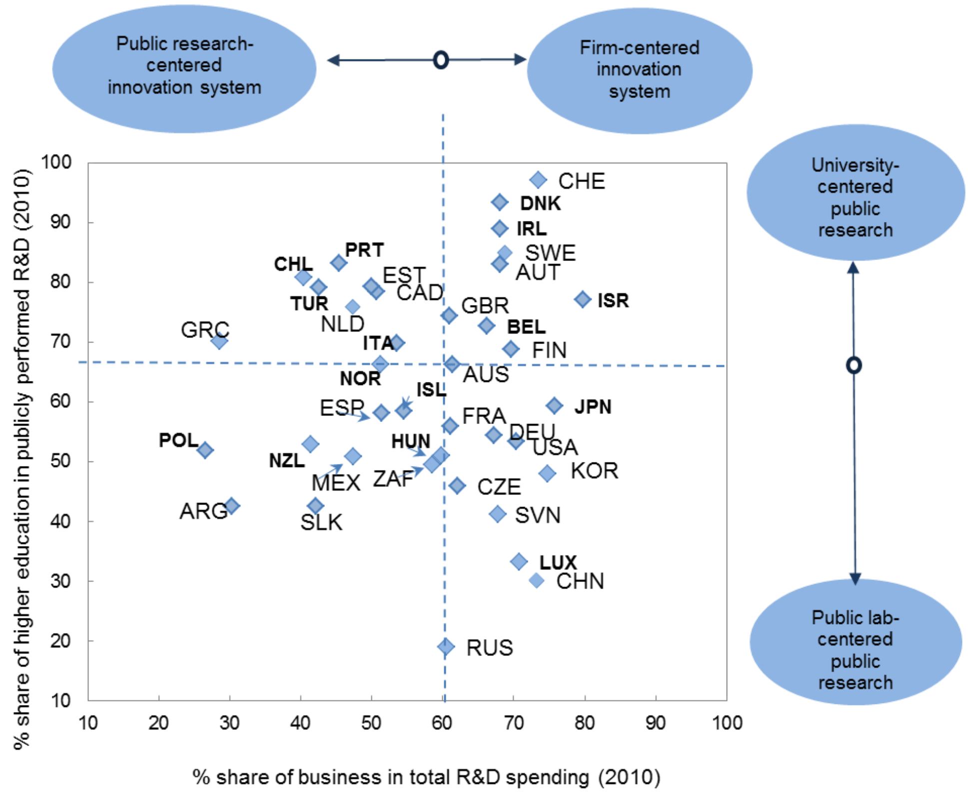
[271] The Swedish program in this vein was among the earliest and a role-model also for the Austria programme.

[272] Dinges, M.; Zahradnik, G.; Wepner, B; Ploder, M.; Streicher, J.; Linshalm, E. (2015): Wirkungsanalyse 2015 des österreichischen Kompetenzzentrenprogramms COMET, im Auftrag der Österreichischen Forschungsförderungsgesellschaft (FFG)

[273] Lähteenmäki-Smith, K.; Halme, K.; Lemola, T.; Piirainen, K.; Viljamaa, K.; Haila, K.; Kotiranta, A.; Hjelt, M.; Raivio, T.; Polt, W.; Dinges, M.; Ploder, M.; Meyer, S.; Luukkonnen, T.; Geoghiou, L. (2013): “Licence to SHOK?” External evaluation of the strategic centres for science, technology and innovation. Publications of the Ministry of Employment and the Economy.

[274] See Fig. 2.2. Archetypes of innovation systems; OECD (2013a): Commercialising Public Research: New Trends and Strategies; OECD Publishing

Figure 60: The Weight of Industry and Public Research in OECD countries



Source: OECD (2013), Commercialising Public Research: New Trends and Strategies, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264193321-en.

A comparative assessment of the industry-science relations in Austria reveals a mixed picture: Austria is on par above the comparator countries Denmark and Sweden in a number of important related indicators, e.g. the share of HERD financed by business. All three countries are below EU28 and OECD averages, though an assessment of whether a country is a “leading” country with respect to industry-science relations is hard to provide at the level of comparisons of international averages. Rather, the background for policy learning would be the adequacy of the level and type of interactions for the specifities of a research and innovation system. Here, as elsewhere, “more” is not necessarily “better”. In any case, the quantitative part of our study indicated that industry-science relations, despite the fact that both in terms of comparatively high levels of university patenting or research output jointly produced between HEI and enterprises, continue to be an issue also in the discussions of the “innovation leaders”. While the general (and generally justified) perception seems to be that the large firms (either directly or through their foundations) have great influence on the strategy research portfolios (research) universities[275] and have no apparent difficulties for cooperation, the matter is different for SMEs and in the regions. There, industry-science relations are mostly confined to knowledge transfer via graduates (especially from university colleges and the “newly established universities” in Sweden) and direct contracts (mostly service rather than research). Both are a highly appreciated, but limited focus of industry-science linkages in these regions for these actors.

[275] E.g. KTH had developed its strategic research agenda with the involvement of long-standing industrial partners and University of Copenhagen is currently significantly expanding its campus with the support of Novo Nordisk Foundation.

Empirical studies describe several channels of knowledge-transfer, comprising collaborative research e.g. in public-private partnerships, contract research and consulting activities of PROs and the mobility of researchers and students between institutions and sectors as the main identified channels.[276] One commonly used measure for the intensity of collaborative or contract research of higher education institutions is the share of business funding of R&D in total R&D-expenditures of HEIs. Strong linkages between the business sectors and HEIs are also represented by the higher share of HERD being financed by the business sector, which is higher in Austria than in Denmark and Sweden amounting to 5.15% of total HERD in 2011 (see Table 17). HERD financed by the business sector doubled from 2002 to 2011, from 0.02% to 0.04% of GDP. Regarding the distribution of business funded HERD by scientific discipline, 13.4% of total funding for Engineering comes from the business sector; 6% of expenditures in Human Medicine and 2.9% Natural Sciences are funded by the business sector. [277]

Table 17: Share of HERD financed by the Business Sector

	2005	2008	2009	2010	2011	2012	2013
Austria	..	..	5.20	..	5.15	..	..
China	36.70	34.57	36.67	33.23	35.26	33.37	33.77
Denmark	2.36	..	3.56	3.11	3.41	2.72	2.71
Finland	6.51	7.21	6.39	5.71	5.47	5.12	5.01
Germany	14.14	15.14	14.23	13.94	13.95	14.03	..
Netherlands	7.76	..	8.23	..	8.17	8.33	7.41
Norway	4.74	..	3.81	..	4.01	..	..
Russian Federation	29.32	28.56	22.43	24.53	23.99	27.22	27.63
Sweden	5.08	..	4.51	..	4.02	..	3.75
Switzerland	..	6.85	..	9.14	..	10.94	..
United Kingdom	4.59	4.60	3.86	4.11	3.99	4.05	4.10
United States	5.04	5.69	5.60	4.64	4.53	4.59	..
Total OECD	**6.08**	**6.54**	**6.29**	**5.82**	**5.87**	**5.86**	**..**
EU28	6.44	6.84	6.44	6.41	6.56	6.44	..

Source: OECD MSTI Database, Eurostat

In terms of university patenting, another indicator for science-industry linkages, Austrian universities faced a significant catching-up process from the beginning of 2000 until 2013, increasing the share of university patent applications to total national patent applications from 0.5% to 3%[278]. This was mainly due to the measures introduced with Universities Act of 2002 (UG 2002), that all inventions by university researchers have to be reported to universities management and the “uni:invent” program, introduced in 2004. Uni:invent, run by the Austrian Business Agency AWS and financed by the Federal Ministry for Science and Research, was a funding mechanism run from 2004 to 2009 to enforce universities patenting, first by providing coaching for universities and researchers in the patenting process and second, by providing financing for university patents. The highest share of university patents are applied

[276] For an overview see OECD (2013a): Commercialising Public Research: New Trends and Strategies; OECD Publishing

[277] BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014. Status report in accordance with Section 8(1): of the Research Organisation Act on federally subsidised research, technology and innovation in Austria; page 25

[278] BMWFW (2014): Universitätsbericht 2014 Dem Nationalrat vom Bundesminister für Wissenschaft, Forschung und Wirtschaft gemäß § 11 Universitätsgesetz 2002, BGBl. I Nr. 120/2002, vorgelegt; based National Science Foundation Science and Engineering Indicators with publication data from Thomson-Reuters.

by technical universities with 47% of university patenting in 2013. During the period of uni:invent on third of university patents were applied in Biotechnology, 16% in Process and 13% in Mechanical Engineering. Despite this positive development, with 0.2 patents per million GDP, Austria still ranges in the bottom half of OECD countries, compared to Denmark, Netherlands and Switzerland with 0.4 according to the OECD-STI Outlook 2014. Due to the so-called “professors’ privilege” in Sweden patenting of universities is underrepresented, as IPRs are owned by the individual inventor. As patenting activities are highly skewed towards specific sectors, this difference also reflects different country specialisations.

Based on data reported in the *community innovation survey* (CIS), Austria performs above the average in European comparisons regarding the cooperation between innovation active firms and higher education institutions. 22% of total innovative firms report cooperation with HEIs in Austria (3rd position in EU behind Finland with 26.1% and Slovenia with 25.4%), compared to Denmark with 15% and Sweden with 18% (EU28: 13%; EU15: 13%). Furthermore the share of firms cooperating in technological innovations (product and process) with HEIs in Austria is 50.6%, compared to Denmark with 36.9% and Sweden with 58.8% (EU average: 41.6%) in percentage of all technological innovative enterprises (see Table 18).

Table 18: Science-industry cooperations in innovation

	Enterprises co-operating with universities or other higher education institutions	**Technological innovative enterprises co-operating with universities or other higher education institutions**
	in % of all innovative firms	in % of all technological innovative firms
Austria	21.8	50.6
Denmark	14.9	36.9
Sweden	17.6	58.8
EU28	13.01	41.6

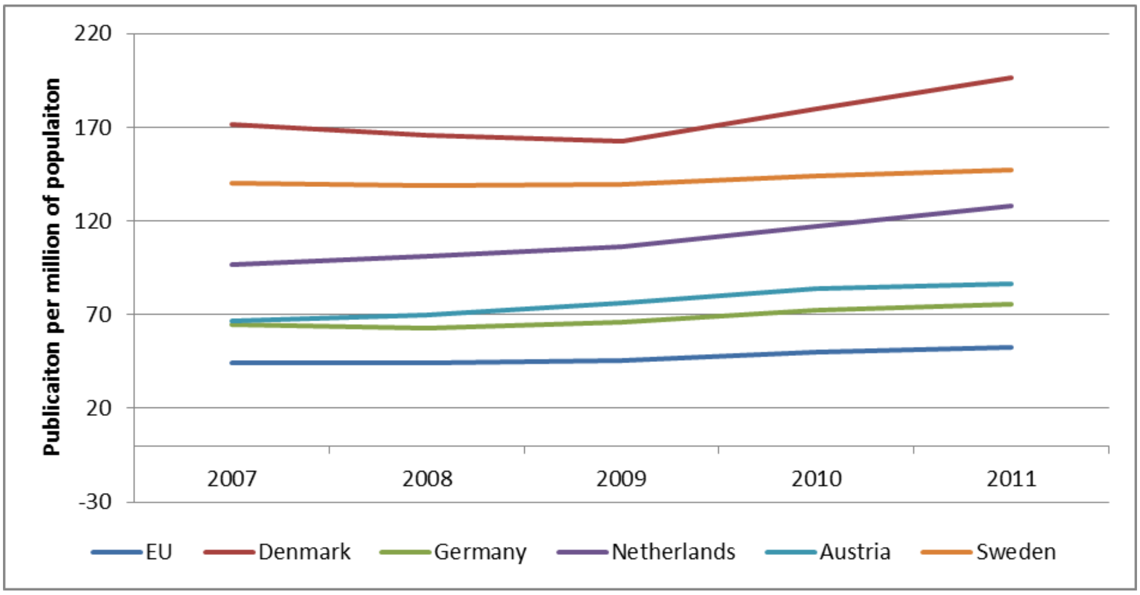
Source: Eurostat CIS 2012, Schiefer, A. (2015)[279]

In terms of research output based on science-industry collaborations, measured by the amount of public private co-publications per million of population, both Denmark and Sweden are persistently performing above Austria. One the one hand, this might point to a higher productivity in terms of scientific outcome of collaborative research. On the other hand, as with the other indicators, a straightforward interpretation of this result is not easy, as it only partially reflects the actual intensity of public-private cooperation. First, this indicator is very much depending on the industrial structure of country, with pharmaceuticals, bio-technology, chemicals, ICT and electronics are showing a larger propensity for co-publications (e.g. based on clinical trials, test series or discoveries) than other areas of research. As it is typically large companies that have a higher tendency to participate academic co-publications, countries with large companies in these areas might be in favour. When looking at the Danish and Swedish industry structure, as displayed in the respective chapter on business R&D (chapter 4.4), the argument is in favour, that it is only partly the intensity of institutionalizing the third mission at universities but the economic structure that explains the intensity of public private co-

[279] Schiefer, A. (2015): Innovationsaktivitäten der Unternehmen im internationalen Vergleich 2010-2012; Wissenschaft und Technologie, Statistische Nachrichten 2/2015, Statistik Austria.

publications.[280] Second, the indicator depends very much on the prevailing incentives for publications both for academic and business sector researchers. [281] This includes also the type of interrelation between these two sectors. For Denmark e.g. the Industrial PhD program is an important for public-private co-publications, with academics being employed both at universities and enterprise, though these publications might not be the result of actual collaborative research between the university and the firm but of the institutional hosting of the researchers in both institutions.

Figure 61: Public-private co-publications per million of population



Source: IUS Indicator 2.2.3 based on CWTS Thomson Reuters

All in all, Austria's industry science-relations have seen remarkable progress in the recent past. While some output figures (university patenting, co-publishing) point towards higher levels (esp. in Denmark) a substantial part of this difference might be explain by the different industrial structure of the countries.

In terms of science-industry activities (as measured e.g. through the share of firms cooperating with HEIs or the share of HERD coming from industry) Austria is on a level with or even above Denmark and Sweden.

In the following sections, we will look into the possibilities to learn from policies that try to address industry-science relations.

[280] Lundquist, M. (2015): Chalmers: an entrepreneurial university institutionalizing the entrepreneurial, in Foss, L.; Gibson, D.V. eds. (2015): The entrepreneurial university – context and institutional change, Routledge.
[281] Tijssen, R. J.W. (2012): Co-authored research publications and strategic analysis of public private cooperation; Research Evaluation, Oxford University Press

4.6.1 Policies, funding structure and support mechanisms for science – industry linkages in Austria

Already in the 1990ies science - industry linkages have been identified as a main bottleneck for the development of the Austrian research and innovation system. Hence a variety of funding and support programs and instruments for the implementation and strengthening of partnerships between universities and business have been established. A main thrust of these initiatives was to focus on institutional and long-term programs, bringing together partners from academia and business in formal settings and/or independent legal entities such laboratories or research centres, These institutions were main vehicles for project related funding, which in turn was very much geared towards fostering collaboration between science and industry - even for projects not carried out in the newly formed (temporal) institutions.

The *Comepetence Center Programme* COMET, administered by the Austrian Research Promotion Agency FFG and the Christian-Doppler-Research labs Josef-Ressel Centers, administered by the Christian Doppler Research Association serve as international visible examples for this type research funding.[282] In terms of annual budgets the COMET-Programme is the largest funding scheme for knowledge and technology transfer, being established in its current structure in 2008, bundling several successful funding schemes. The strategic focus of the COMET Programme is the collaborative development of new competences and the initiation and support of common medium and long term strategic research agendas of science and industry. The COMET Programme includes three different schemes:

K1- centres: focus on strategic science-industry research agendas, max. € 1.7 million national funding per year, duration of max 8 years),

K2 centres: equal to K1, however, higher risk and international visibility; max. € 5 million national funding per year, duration of 10 years

K-projects: development of new science –industry initiatives or collaboration between K-centres, max. € 0.675 million national funding per year, duration of three to four years.

The focus of both, K2 and K1 centres was rather more on the implementation and execution of previously coordinated research agendas than on the initiation of new high risk strands of research. The COMET-impact assessment showed that the programme has been successful concerning the creation of new competence and enhancement of predefined topics. Programme shows high impacts on publications, innovation outcome, qualification of young researchers and the establishment of long term (international) partnerships and mutual trust.

Another mayor instrument for fostering in science-industry relations in Austria came about through the establishment and growth of the Laboratories of the Christian-Doppler Society (CDG), which aim at linking individual firms with basic research at HEI. This model of exclusive access to research results seems to be highly appreciated by industry, as their number has been growing from 18 in 2000 to more than 70 in 2014[283].

[282] Universitätsbericht (2014); Project of OECD CSTP working group TIP on Strategic Public/Private Partnerships (PPP), 2014.

[283] See OECD: Public Research Institutions: Mapping Sector Trends (2011) http://www.oecd.org/sti/sci-tech/publicresearchinstitutionsmappingsectortrends.htm, pp 89 for a case study on the CDG

Other public funding mechanisms focusing on knowledge transfer and the commercialisation of academic research include the so-called AplusB-centres (academia plus business programm), a network of business incubators to support academic spin-offs, and the recently established *program for knowledge transfer centres and IPR-utilization* (WTZ) of the BMWFW. The latter should help to improve the still weak commercialisation performance of Austrian universities[284] by funding for the further development of patents to market maturity and prototypes. The establishment of knowledge-transfer centres should further help to support knowledge and technology transfer by strategically bundling research outputs by universities, universities of applied sciences and public research institutions. The total public budget comprises € 20 million provided by the BMWFW. It is the succession of the upper describe uni:invent program. Currently four WTZ have been established, with one especially in the field of Life Sciences.

The aim of the AplusB-Program, established in 2002, is to support the utilization of academic research results via academic spin-offs and start-ups. The program is funded by the BMVIT and administered by the FFG. So called AplusB-centres, being established under the participation of all public universities, selected universities of applied sciences, research organisations, funding agencies and private firms, support the foundation of academic start-ups and spin-off by coaching and awareness measures from the pree-seed phase to market. Currently there are 8 AplusB-centres established.[285]

Direct funding for knowledge transfer from scientific research towards enterprises is provided by the BRIDGE program, run and financed by the FFG. Within the program research results from basic research should be further developed in a cooperative way of scientific and business partners, to make them utilizable for firms.

Another cooperative program to enforce the utilization of scientific knowledge for technological development and innovation especially in SMEs is the so called COIN program (Cooperation & Innovation). It consists of two parts, of which one comprises the establishment of material and immaterial knowledge transfer structures and the other funding for networking and cooperation of SMEs with research institutions and universities on project basis.[286]

A new technology transfer centre program "PRIZE" was launched by the former Ministry of Economy, Family and Youth (BMWFJ, now BMWFW) in mid-2013, addressing the commercialization of university (basic) research results, with a particular focus on transfer to SMEs. It also allows for funding of cooperative projects of HEIs and public research organizations (PROs) for the development of prototypes. The program is run by the aws.

To sum up, Austria’s collaboration culture between the private sector and universities phased a consistent catching-up in the last 15 years. This was to a large part driven of funding for science-industry linkages that was very much based on the establishment of medium- and long term institutionalized collaborations in terms of centres or labs between the academic and the business sector, with a large variety of instruments in place.

[284] Compare: Austrian Council for Research and Technology Development (2014): Report on Austria’s Scientific and Technological Capability 2014, Vienna, p. 44
[285] Universitätsbericht (2014), p. 320
[286] COIN Programme Document (2014)

Evaluations of the various schemes have persisted to an overall positive impact the initiatives had on the level and the quality of industry-science relations. E.g. the evaluation of the current competence centre program indicated that the relations have become much more systemic and long-term oriented.[287]

4.6.2 Science-industry linkages in Denmark

Since the beginning of 2000, the role of universities for innovation is highly emphasized by Danish R&D and innovation policy makers. Also universities stated an increased awareness of their role in the innovation process, encouraged by the government's 2003 strategy to *"New ways of interaction between research and industry – turning science into business"*[288]. The strategy builds on an analysis of the Danish government that in Denmark, though performing high in the provision of high quality research, public support structures for encouraging science-industry collaborations where assessed to be inflexible and confusing. Furthermore, more emphasis should be given on encouraging SMEs to participate in scientific research and innovation projects, since R&D in the business sector is concentrated in a few large and old companies. The strategy of 2003 therefore builds on four major pillars, along which existing instruments should be developed:

- Collaboration in knowledge networks
- Collaborative research projects
- Collaborative innovations
- Collaboration in developing competences

Support instruments for industry-science relations could be broadly summarized in three main strands: -) support for network activities, -) funding for collaborative research, -) funding for intersectoral mobility and human resources for innovation, - encourage university patenting and commercialization activities. [289]

An important instrument for increasing the access especially of SMEs to results from scientific research to enhance their innovation capacity are the so-called Innovation Network, being promoted by the former Danish ministry for Science, Technology and Innovation in 2002. Innovation networks are partnerships of companies, research and knowledge institutions forming a framework for cooperation on a professional or technological focus area. Networking activities comprise the exchange of knowledge and competencies of scientists and companies in a certain area, room for the creation of ideas and support for the identification of partners for specific collaborative projects. Furthermore, they should be a support the internationalisation of Danish companies by increasing their competencies through exchange

[287] Schibany, A.; Dinges, M.; Reiner, C.; Reidl, S.; Hofer, R.; Marbler, F.; Leitner, K.-H.; Dachs, B.; Zahradnik, G.; Weber, M.; Schartinger, D. (2013): Ex-post Evaluierung der Kompetenzzentrenprogramme Kplus und K_ind/K_net; im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie (BMVIT) und des Bundesministeriums für Wirtschaft, Familie und Jugend (BMWFJ).

[288] Danish Government (2003): New ways of interaction between research and industry – turning science into business; http://ufm.dk/en/publications/2003/files-2003/new-ways-of-interaction-between-research-and-industry.pdf

[289] Mini Country Report/Denmark under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012). Pro Inno Europe (2011).

in the network.[290] The establishment of the network is financed by private (min. 40%) and public (max. 50%) co-funding. Currently 22 networks have been established. An analysis of the impacts of these instrument on behalf of the Danish Agency for Science, Technology and Innovation showed, that the participation of companies in such a network increases their probability to innovate after one year by more than 4.5 times, compared to non-participating companies. Also the probability to engage in collaborative research projects is significantly increased by participating in the network.[291]

Another SME related instrument is so-called innovation vouchers, implemented in 2008 aiming to increase SMEs collaboration with public research institutes. The voucher covers up to 50% of costs for the purchase of knowledge from public research institutes for development projects.[292] Similar to that, the Austrian Innovation Voucher instrument has already been implemented in 2007.

Public sector instruments that directly fund collaborative research projects have recently been bundled in the already described Innovation Fund Denmark (former being run by its predecessors, see chapter 4.2.4), comprising measures for large scale projects, societal partnerships, innovation, entrepreneurship grants as well as industry-researcher and international cooperation programs. Funding for so-called large-scale projects is provided up to 75% (max. 30 million DKK, € 4 million) of total cost for public-private collaborative research, development or commercialisation projects for a period of two to five years. Whereas this instruments puts emphasis on the originality and quality of projects, the instruments Societal partnerships adds to that by promoting research that provides solutions with an impact on both society at large and the members of the partnership in pre-defined areas. In the call period for 2016, e.g. the following technological areas will be covered by this scheme: -) advanced materials, -) Big Data and -) energy-efficient building renovations. Other schemes emphasise researcher's, start-ups' or SME's innovativeness. The InnoBooster funds high risk innovative ideas of researcher's, start-ups' or SME's innovativeness up to DKK 5 million (€ 400,000). The so-called Entrepreneurial Pilots provide start-up funding for new graduates, both by an initial lump sum for the purchase of material (up to DKK 35,000, € 4,700) as well as by a monthly grant of DKK 14,437 (€1,900) up to one year.[293]

A specific feature that is emphasized in Denmark is the importance of inter-sectoral exchange of individuals for the knowledge transfer. The Industrial PhD program (see chapter 4.1.5 for description) is often referred to be a successful example, both for increasing the scientific capabilities of firms as well as a measure to increase the employability of researchers in the private sector. Funding for individuals provided by private foundations that are linked to companies is another important factor for inter-sectoral mobility and knowledge transfers. E.g. about ¼ of PhD graduates of the University of Copenhagen get employed at Novo Nordisk when having been supported by respective funding programs.

[290] Danish Ministry for Higher Education and Science (2015): Innovation Network Denmark; http://ufm.dk/en/research-and-innovation/cooperation-between-research-and-innovation/collaboration-between-research-and-industry/innovation-networks-denmark
[291] DASTI (2011): The impacts of cluster policy in Denmark – An impact study on the behaviour and economical effects of Innovation Network Denmark.
[292] Mini Country Report/Denmark under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012). Pro Inno Europe (2011).
[293] Innovation Fund Denmark (2015): http://innovationsfonden.dk/en

Scientific evidence on the impact public-private research is an important anchor of public support mechanism and STI-policy planning in Denmark.[294] E.g. Frosch and Christensen (2011)[295] pointed to the positive effects of collaborative R&D, analysing companies engaging in several types of collaborative activities between 1999 and 2008. The analysis shows a significant of positive effect of collaborative research activities on firms productivity (other than for purchased research with no significant effect), especially for large companies but also for SMEs, in the first five after collaborating compared to non-collaborating firms. Firms' benefits from collaboration increase with the share of tertiary graduates, intramural performed R&D and the number of research personnel. Fosse et al. (2014) point to the positive effect of the innovation voucher and the Innovation Network on SMEs productivity growth.[296]

As already pointed out, Danish universities perform well in terms commercialization activities. Since the year 2000 according to the act on inventions Danish university researchers are obliged to report their inventions to the university, giving the university the right to overtake the invention for commercialisation. According technology transfers offices (TTO) have been established at Danish universities. The national TT network Techtrans was established to encourage network activities and the sharing of competences, knowledge and methods involved in technology transfer between universities.[297] Furthermore, commercialisation activities of public sector research are monitored in an annual survey.[298] As shown above, Denmark is among the Top-OECD countries in terms of university patenting. Nevertheless, an analysis of the Danish Think Tank DEA (2013)[299] raised some critical issues, regarding the meeting of targets stated in the Act on Innovation. First of all, governments unrealistic expectations regarding the potential of profit-making for universities' were pointed out, comparing revenues from IPRs with expenditures for commercialising inventions of universities. Furthermore, it was stated that with the required formalisation of knowledge exchange according to the Act on innovation, negotiations and agreements on the usage of IPRs between universities and the industry became more complicated.

How to optimally encourage relations between public sector research and business sector and how to make more use of public funded research is an ongoing discussion in Denmark. Analysis for the period 1999-2008, in which most of the aforementioned instruments have been established, pointed to the overall weak productivity growth of Danish companies. Putting emphasis on increasing productivity by further emphasizing collaborative research and innovation activities is therefore still high on government's agenda. Regarding the finance structure of universities it was pointed out in the interviews, that the current basic funding scheme still emphasizes academic research and teaching, putting little attention on the requirements for universities to perform also knowledge transfer and innovation activities.

[294] Mini Country Report/Denmark under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012). Pro Inno Europe (2011).

[295] Frosch, H.; T. Alslev Christensen, Eds. (2011): Økonomiske effekter af erhvervslivets forskningssamarbejde med offentlige videninstitutioner. Innovation: Analyse og evaluering København, Forsknings- og Innovationsstyrelsen.

[296] Fosse, H. B.; Jacobsen, J.; Jacobsen, R. H. (2014): The Short-run Impact on Total Factor Productivity Growth of the Danish Innovation and Research System; Center for Economic and Business Researcher (CEBR) at Copenhagen Business School.

[297] http://techtrans.dk/en/techtransdk/

[298] http://ufm.dk/en/publications/2014/public-research-commercialisation-survey-denmark-2013-summary

[299] DEA (2013): Tech Transfer in Danish Universities – what have we learned from ten years of trying to make money on research?.

4.6.3 Supporting science-industry linkages in Sweden

Sweden has a long tradition in terms of raising the awareness for universities participation in “third mission” activities officially becoming part of universities mandate in 1975 but dating back already in the 1940ies.[300] The uptake and implementation of third mission activities by the universities is differentiating among different types of higher education institutions.[301]

It have been mainly the so-called “new universities” or university colleges, established since the 1970ies that engaged into formal research collaborations with their surrounding business environment at an early time, mainly because of their limited access to public funds for R&D. This led to an early institutional build-up of competences in the establishment of collaborations, compared to the old and broad universities. Since the mid of the nineties, several competitive public funding programs and schemes especially targeting research and collaborations at the new universities have been established, like the already mentioned Knowledge Foundation or the VINNOVA-run VINNVÄXT program.

Technical universities, by their nature of research and development of technologies they perform have an easier access towards the establishment of linkages with the business sector. As already their establishment has been driven by requirements from the industry, this is another natural reason for their close connection to the industry sector.

The tradition of institutionalized collaboration at old and broad universities is much weaker established. One the one hand this is due to their broadness in terms of fields they cover. On the other hand this has to do with the weak governance structures within these types of institutions, in terms of implementing strategic targets and measures.[302] Furthermore, a specific feature in Sweden is the maintaining of the so-called professor’s privilege, allowing researchers to keep the ownership of their invention. The usefulness of this approach is heavily discussed in Sweden. One the one hand it is argued to be a mechanism: “…*to provide university employees the necessary incentives to commercialise their inventions*.”[303] Arguments against the professor’s privilege point to an unfavourable privatization of research revenues that have actually become possible with taxpayer funded R&D. Furthermore, the individual management of IPs rather than the enforcement of a professional TTO structure provides only little incentives for the creation of spin-off companies that might, in case of growing provide higher economic benefits than individual patents.[304]

In total excellent research and high reputation of universities on the one hand, as well as an industry structure dominated by national owned large and research intensive companies have for a long time been the driving force of sound but more informal and researchers led science-industry collaborations in Sweden for a long time. For example for the case of Chalmers

[300] OECD (2014): Reviews of Innovation Policy – Sweden; OECD Publishing, p. 185 ff.
[301] Åström, T.; Melin, G.;, Fridholm, G.,T.; Terrell, M.; Stålfors, S.; Ärenman, E.; Henningsson, K.; Jondell, M.; Arnold, A.; Arnold, E.; Danell, R. (2015): Långsiktig utveckling av svenska lärosätens samverkan med det omgivande samhället – Effekter av forsknings- och innovationsfinansiärers insatser; Technoloplis Group on bhealnf
[302] Ibid.
[303] E.g. Damsgaard, E. F.; Thursby, M.C. (2013): University entrepreneurship and professor privilege; Industrial and Corporate Change, Volume 22, Number 1, pp. 183–218
[304] OECD (2014): Reviews of Innovation Policy – Sweden; OECD Publishing, p. 185 ff.

university for example, Lundquist (2015)[305] argued, that it was actually the main driver for their development of becoming known as the prototype of an "entrepreneurial university", rather than the several, though important, institutionalized mechanism for collaboration like the Innovation Center, CIT-incubator or the Scholl of Entrepreneurship.

The erosion of those informal connections of researchers, due to the increasing internalization of the Swedish business R&D following global value chains in the early 1990ies called for a reorientation of public policies towards science-industry collaboration, e.g. with the implementation of the Competence Center (CC) Program by VINNOVAs predecessors NUTEK in 1993. The Swedish Competence Centers of institutionalized research collaborations became a role model for other countries, like the Austrian COMET program. Basic rationale for the implementation of the CC program was the idea that not only innovation activities, but also the way they were performed need to affected, fostering formal collaboration between universities and companies. Besides fostering inter-sectoral networking and multidisciplinary research, the CCs should directly contribute to the development and adoption of new technologies and industrial competences.[306] From the very beginning the program also involved the education of PhDs as important target.

The program was designed to provide funding for a period of ten years. In 1995 the first call was launched. In total 28 CCs were established between 1995 and 2007 at eight universities (Chalmers University of Technology, Karolinska Institute, Linköping University, Lulea University of Technology, Lund University, Royal Institute of Technology, SLU, Uppsala University), with a total budget of SEK 4.9 billion (€ 657 million). Funding was split almost equally between participants from the industry, the universities and VINNOVA with around 1/3 each. The largest industrial contributors comprised with Ericsson, ABB, AB Volvo AkkzoNobel, SAAB or Sandvik on top 6, some of the largest national Swedish companies. Though also SME were participating in the centres large companies accounted for 80% of total industrial funding. The highest share of funding was contributed by partners form the industrial field of microelectronics and telecommunications, followed by pharma and medical devices, automotive and engineering, together comprising 1/5 of total contributions (in cash and in kind).

Consequently, after a ten years period of funding, the program was suspended. An impact analysis on behalf of VINNOVA (2013)[307] pointed out the significant effect the CC program had not only on the participating companies and universities but also on consumers by the provision of new and high qualitative products. A variety of technological developments, products and services result directly from the research conducted in the CCs (e.g. Bluetooth as prominent example). In total the participation in the CC programme was found to have positive impact on the economic development of participating companies, both SMEs and large companies. Impacts of the program on universities comprise the effect on the orientation of research and education programs towards newly identified fields. The provision of human capital in areas related to the CCs are a further indirect spill-over of the program on the

[305] Lundquist, M. (2015): Chalmers: an entrepreneurial university institutionalizing the entrepreneurial, in Foss, L.; Gibson, D.V. eds. (2015): The entrepreneurial university – context and institutional change, Routledge.
[306] Stern, P.; Arnold, E.; Carlberg, M.; Fridholm, T.; Rosemberg, C.; Terrrell, M. (2013): Long term industrial impacts of the Swedish competence centres; Technolopolis, VINNOVA Analysis 11/2013.
[307] Ibid.

business sector, not only by the training of PhDs within the centres but also by linking already master thesis to CC themes. PhDs educated in the CC tend to be recruited by the related companies (similar to the Danish Industrial PhD program). Based on the success of the CC program a re-launch is planned for 2017.

Another reason for researcher and universities to establish capabilities for formalised collaborations with the business sector was the possibility to participate in the EU Framework Programmes with Sweden becoming a member of the EU in 1995, which were focusing collaborative research from the very beginning. In 1997 "third mission" activities became formalised by law as another duty of universities beside research and teaching.[308] Since that a variety of measures and programs have been implemented, including joint project funding esp. by NUTEK/VINNOVA and the Knowledge Foundation as well as by the establishment of science parks, technopoles and technology transfer offices.

In general, while enterprises do not complain about barriers to cooperate with HEIs, two concerns were voiced either by industry or by policy makers: one was that with the growing internationalisation of research and innovation activities, national bounded HEIs might not be much help (there are some discussion of whether PROs might serve this purpose, but this is very much a discussion about potentiality not about real trends).

Another strand of discussion was that in some of the new challenge-driven and mission-oriented programs the influence of academia on defining the strategic research agenda and running and coordinating the respective projects was seen as over proportional and industry not having had much of a say. This is in context with other countries (e.g. Finland), where industry was in the driving seat of the SHOK programme. Having said that, it should be mentioned that in the SIO initiative (see 4.5.6) a broad range of stakeholders was involved in the development of the programme and also into the implementation. As will be outlined in chapter on mission-oriented funding schemes for the example of the Strategic Innovation Areas (SIO), challenge driven and demand oriented programmes gain of importance in Sweden too, being based on public private collaborations in fields of societal interest.

Despite all efforts, as in Denmark, the necessity to overcome the so-called "Swedish Paradox", i.e. the question of high public funding for research is sufficiently transformed into research is still under discussion.[309] Furthermore, as it in general the case in Sweden, the high complexity and parallelism of funding schemes as well as the still weak possibilities of universities to set strategic targets as an organisation due to the not abolished bottom-up orientation of individual researcher's collaborations are under ongoing discussion.

[308] Vestergaard, J. (2003): Promoting university interaction with business and community – a comparative study of Finland, Sweden and UK; Institute of Management, Politics and Philosophy at Copenhagen Business School on behalf of Danish Ministry of Science &Technology

[309] E.g. Bitarre, P.; Edquist, C.; Hommen, L.; Ricke, A. (2008): The paradox of high R&D input and low innovation output: Sweden; WP Lund Universitiy Paper no. 2008/14; Edquist, C., Zabala-Iturriagagoitia, J.M (2015): The Innovation Union Scoreboard is Flawed: The case of Sweden –not being the innovation leader of the EU. Lund Papers in Innovation StudiesPaper no. 2015/16

4.6.4 Synthesis and Conclusions

Science-Industry relations have been high on the STI policy agenda in many countries. Austria is among those which have experienced considerable improvements in terms of number and strength of interactions, though not yet to the same extent in some output measures, where Denmark and Sweden score higher. Yet, it is not easy to tell whether Sweden or Denmark could serve as role models for Austria with respect to science-industry linkages, with both countries having different characteristics of industrial and institutional structures which cannot simply be copied or easily emulated. One might argue both countries have been early birds in certain specific areas, Denmark in terms of encouraging university patenting, Sweden with its implementation of the Competence Center Program. Both examples - as well as a number of other policy initiatives – have already been the subject of international policy learning which is frequently carried out in the realms of OECD or the EU (not least through respective ERA-Nets or TAFTIE).

Other specific features like the existence of large and research intensive companies in Denmark and Sweden could not be emulated in the short term. Whereas Sweden is focusing on funding mechanism concerning industry-science relations for all HEIs, in Denmark it is more of a competitive effort by the leading universities to show that that they have established most relation and that it has a positive impact on research and businesses productivity. It is seen important (and still a challenge in both countries) that universities are developing more research and innovation cooperation linkages especially with small innovative national but also foreign companies in HT/Knowledge-intensive /fast growing sectors.

- All in all, it can be said that the remarkable catch-up in terms of implementing programs and measures to encourage industry-science relation since the beginning of the 2000s in Austria was already very much inspired by policy learning through international comparisons. Such learning and monitoring should be continued.
- At this stage of development of science-industry relations in Austria, emphasis has to be put on evaluating the success of existing measures and adopting the recommendations that has already been provided on programs like COMET or other recent evaluations. A focus should be on the optimization of the programmes with respect to their output (including ‘behavioural additionality’) and impact.
- Besides funding for establishing industry-science relations, Austrian universities should be incentivized to measure their industry cooperation and set up ambitious targets (reflected also in the performance contracts). In this respect, Austria should look towards Denmark and focus on implementation of reforms and to make quantitative impact assessments of industry-science relations.
- An approach worth being considered is the promotion of the inter-sectoral exchange of individuals with specific programs. Austria could think about the implementation of programs similar to e.g. the Danish Industrial PhD.

5 Summary and Recommendations

Background

In the following, main conclusions from the comparison with Denmark and Sweden and tentative lessons for Austria are summarized. These lessons are meant to provide input to the Austrian discussion about what to learn from innovation leaders by identifying and qualifying the most important gaps between Austria and Denmark and Sweden respectively. These gaps are addressed against the background of examples, good practice and experiences from the comparator countries. In this vein, also examples of individual instruments and policy initiatives will be provided which could be emulated also in Austria, though the recommendations will not be a ‘menu of choice’ of a list of individual measures but rather *pointers* to areas of action and related *types* of measures.

Austria lags in several international comparisons of research and innovation performance (most notably the IUS) against the innovation leaders and there have been signs in recent years of a loss of dynamism in the performance of the Austrian research and innovation system – a performance which has been characterized by rapid catching-up until recently. The self-set targets of the Austrian STI strategy from 2011, namely to advance among the ranks of the innovation leaders, inter alia by raising R&D intensity to 3.76% of GDP, seem to be in danger if current trends continue. Against this background, this study was commissioned with the intentions to explore what can be learned from Denmark and Sweden as leading countries which come out on top of a considerable number of respective international comparisons.

Assessment on the System Level

- Denmark and Sweden are undoubtedly innovation leaders by more than one measure. Both score high with respect to the level of development of their research and innovation system, Denmark (and to a lesser degree also Sweden) also with respect to the dynamics of some important dimensions of the research and innovation system (e.g. scientific output, venture capital). As comparability also with a number of other dimensions is high, both countries lend themselves well to comparison and offer fertile ground for potential policy learning.
- International comparative policy learning though is not possible in a simplistic way, in which one tries to identify ‘best practice examples’ and attempts to transfer these to Austria. Rather, it would have to (i) identify which characteristics can and should be emulated, (ii) those which are potential role-models but would be difficult to transfer and (iii) take also into account the challenges and inherent tensions within the systems of the comparator countries, from which also a lot of lessons can be drawn. In this vein, we also noticed quite some debate in Denmark and Sweden alike about the appropriateness of some measures - notably a perceived imbalance of the input and output side with a cautionary note on potential overinvestment.
- A starting point was the identification and qualification of the mayor gaps between Austria and Denmark and Sweden in the IUS, but – given the well-founded methodological critique

towards the IUS - a number of other sources of comparison were also taken into account to get a more nuanced picture. In particular, we looked more closely into the structure and governance of R&D funding, the structure and performance of higher education institutions, the industrial structure and the role of VC funding for industry, Industry-Science Relations, the role of ERA for the research and innovation system and STI policies as well as at the trend towards the implementation of large scale mission-oriented funding programs in Denmark and Sweden.

- As a general observation on the aggregate level, it has to be maintained that Austria continues to have lower inputs than the innovation leaders. While R&D intensity has been rising in Austria in the past decades, Denmark and Sweden have invested more (in some areas like HEI substantially more) in this period. This holds true by and large for public as well as private investments, for the HEIs as well as for the business sector. The differences in past performance that make up for the different positions in the rankings thus can be attributed to a good deal also to this difference in inputs.
- While this is not depicted in the IUS, we were often hinted towards marked differences in societal attitudes between Austria, Denmark and Sweden. There are signs of marked differences in attitudes e.g. towards entrepreneurship and female participation in research. In both respects Denmark and Sweden outperform Austria (in some measures by far), which hints to the need for changes in general societal attitudes and approaches like fostering the ease of doing business or sharing of family duties.

Governance and Funding Structure

- In terms of quality of the policy processes, some lessons could be drawn e.g. from the rich evidence-based policy process on which the Swedish Government Bills for research to the parliament are formulated and the emphasis on impact assessment in the case of Danish assessments of individual measures as well as from the streamlined policy and funding structures in Denmark: the majority of all innovation and research policy support measures is concentrated in one Danish ministry and delivered through two main councils. Furthermore, a streamlining and clear division of labour between public funding schemes for both innovation and research was established in recent years. Austria might learn from these policy processes, e.g. by taking it as a starting point for a discussion about a more optimal division of labour between ministries and an adjustment of its funding portfolios.
- In terms of funding structure, with a view on broadening the financial base in Austria, public competitive funding should be increased significantly following the examples of Denmark and Sweden. Likewise, Denmark and Sweden also compare favorably with respect to the diversified landscape of private funding, mostly through foundations. Steps in these directions have recently been made in Austria, the effects of which should be revisited and assessed in some years. Some caveats do apply here as well in terms of portability of approaches: Given the amount of the gap between Austria and Denmark and Sweden, and the time it took to develop the landscape of private foundations in these countries, a quick closing of this gap seems unrealistic. In the meantime, other sources for

private funding and an increase in public funding are needed to narrow the gap. But as both Denmark and Sweden provide generous tax exemptions (up to a rate of 125% of research expenditures on capital income of private foundations), a further raise of tax exemptions on private philanthropic foundations also could be an option for Austria.

- On the other hand, there are also some less warranted side-effects of the multiplicity of different funding sources: in Denmark and Sweden the increase in mostly competitively awarded funding has raised questions about the necessity of co-funding which reduces degrees of freedom in the research institutions (e.g. with respect to the scientific specialization through the impact of large thematically dedicated foundations). Emphasis has to be put on developing monitoring mechanisms and alignment strategies of private funding with public interest, as these often introduce different incentives, different formal requirements and can add to the complexity of handling third party funding.

Tertiary Education System

- Both Sweden and Denmark have tried to substantially improve their HEI systems, both through marked increases of funding and institutional reforms, which were very substantial in the Danish case, involving concentration of research in a comparatively smaller number of organizations. Both have succeeded in producing high numbers of students, graduates and scientific output (especially in the case of Denmark), though the developments and dynamics differ somewhat between Sweden and Denmark. Despite the high level, there are concerns in Sweden about the impact and quality of research and concerns about the quality of teaching and graduates in both countries. We believe that the main thrust of these reforms and improvements of the HEI sector can be a good orientation for Austrian reforms as well. In order to emulate the positive development of the HEI sector, Austria would have to increase its spending for HEI considerably to reach the level of Denmark and Sweden. While such an increase in public funding is necessary, it is not a sufficient condition for improvement. As we have seen from the examples of Denmark and Sweden, institutional changes have to accompany increased funding.
- Both Denmark and Sweden are characterized by a pronounced concentration of research in a smaller number of institutions. This concentration has grown ‘organically’ in Sweden, with a small number of ‘old’ universities accounting for the bulk of R&D among HEI, while it was recently established through mayor institutional reforms in Denmark. These reforms – significantly reducing the number and increasing the size of research institutions and establishing a quite clear division of roles between research institutions with the aim of pooling resources and gaining international visibility – ought to be guidance for Austrian STI policy as well.
- Austria should follow the example of the innovation leaders and should aim for a continuous and substantial increase in the number of tertiary graduates. In Austria by far the highest share of tertiary education is performed at universities which might be a less efficient and more costly way to raise the number of graduates when employability is in focus. This balance in the distribution of students among several types of higher education

institutions is different in Denmark and Sweden with university colleges playing a more prominent role, especial in professional tertiary education. If Austria were to follow the expansionary course of Sweden in its HEI-system, more emphasis needs to be put on the role of universities of applied sciences and other type of post-secondary education. Solely focusing on increasing the number of tertiary graduates might lead to an “inflation of graduations”, that might not necessarily lead to an increased employability or provision of required skills in the business sector.

- At the same time, Austria shows a lower share of doctoral graduates, which are an important input for R&D activities. Following the Danish and Swedish examples, to increase the quality and structure of doctoral education should be a cornerstone of a HEI reform in Austria. Means to do so would include increasing regular employment of doctoral students as well as the connectivity with industry/private sector (e.g. the Industrial PhD program). A standardization of PhD-courses between universities also concerning the permeability between universities and universities of applied science are a key pr-erequisite. Collaborative graduate and PhD/ doctoral schools/colleges directly linked to high level research (cross-institutional) infrastructure (at least two HEIs, if possible cross border) are recommended, both to improve the interfaces between institutions as well as between sectors.
- In terms of increasing the international attractiveness for talents and skills – an important issue in all countries in comparison -, Austria should put emphasis on retaining skilled and trained people from abroad after finishing their degrees in Austria. In this vein, Austria needs to reduce entrance barriers to the labour market for graduates at Austrian HEIs from abroad. This requires an overhaul of the red-white-red card especially regarding minimum wage requirements and the limited time-frame allowed for becoming employed.
- Both Denmark and Sweden do not apply tuition fees or structurally different entry barriers to universities (like numerus clausus), but student intake is directly linked to financing for HEIs, i.e. allowing therefore to directly compensate increased student numbers by an increase financing. Austria should follow this example and to this end speed up its efforts to implement a student-place-based finance mechanism (“Studienplatzfinanzierung”).

Higher Education Funding

- Austria provides a nearly equal amount of funding for R&D, compared to Denmark, to 22 universities, whereas Denmark does for eight. Furthermore, competition between institutions, both about public basic funding as well as about a variety of public and private sources from agencies and foundations is higher developed both in Denmark and Sweden. The establishment of international competitive and visible research requires an overhaul of the Austrian university landscape, including strategic alliances or merger of universities, faculties or departments. A required increase of the share of competitive funding needs further to be complemented by measures implementing full cost calculation in public areas.

- Both Denmark and Sweden have a tradition of providing funds separately for research and teaching, with the latter being dedicated on the basis of student-place and student-success financing mechanisms. Furthermore, as emphasized both by the empirical findings in Denmark and Sweden as well by the assessment of stakeholders, strategic concentration and the establishment of a critical mass are key for the performance of international competitive research. In Denmark universities were financially incentivised to merge, in Sweden research funding and performance is traditionally concentrated at a few, 'old' institutions. New universities in Sweden are mainly incentivised to finance their research from competitive sources and in collaboration with the industry.
- The level of autonomy of institutions is high in both countries, but also governance mechanisms within universities are relatively weak. However, both HEI systems in Sweden and Denmark are characterized by a much greater steering capacity of public funding through the application of key performance indicators attached to public funding. Performance-based funding has a much greater weight in the Danish and Swedish system than in Austria. The assessments on the newly established funding modes for research at higher education institutions in both countries are both ambiguous and limited due to the inherent time lags in the impact of such measures on the performance and outcome of research. Furthermore, since they have been implemented quite recently, they have no explanatory power for the performance of the Danish and Swedish universities in the past two decades. This performance may be better explained by the sustained long-term funding and the institutional setting favouring concentration. Nevertheless, these practices offer substantial scope for policy learning and should be applied to greater extent also in Austria.
- The Austrian system of performance contracts as administrative justification of block grants has no feature of actual performance-based budgeting as long as milestones in the performance contracts are not directly contingent to public funding. A solution might be a more pronounced increase of the "Hochschulraumstrukturmittel" to become the major pillar of financing. Separate accounting for teaching and research is required. The establishment of a performance-based measure for the financing of student places ("Studienplatzfinanzierung") according to the Austrian "Hochschulplan" of 2011 has to be speeded up.

Business R&D and Innovation

- The structure of funding of business R&D expenditures in Austria is quite different from the structure in Denmark and Sweden. While in Sweden and Denmark a large part of BERD is funded by the national business sector itself, only a bit less than two third of the Austrian BERD is funded by intramural enterprises. This is explained by a comparatively high share being funded of enterprises from abroad was well as by the government sector.
- Funding systems differ quite a lot between the countries in comparison: in Sweden, the share of public funded R&D in the business sector is much lower (also due to large R&D-intensive companies). Sweden also applies no tax incentives for corporate R&D compared

to Austria or Denmark. R&D funding for companies in Sweden is mainly for collaborative R&D and R&D in large companies is not funded on a large scale. In Denmark, funding is provided mainly to SMEs in the form of start-up and market development support. The framework concerning public funding of business R&D is quite favourable in Austria for several reasons: Continuing policy to focus on public funding towards R&D and innovation instead of investment. Public RDI funding is also used as a 'locational argument' corresponding to a high significance of foreign affiliates.

While individual measures of business R&D support have been assessed, impact assessments of the public support to business R&D remain scarce. All countries lack a 'portfolio evaluation' of their instruments. Austria has yet to evaluate its direct and indirect support measures for Business R&D and Innovation.

- The industrial sectoral structure of Austria shows significant differences compared to Sweden and Denmark. While Sweden and Denmark have a comparatively high share of value added in high-tech sectors, Austria has a relatively high share in medium and low technology sectors (and vice versa). Austria has competitive advantages in these areas considering the strong supply linkages to European (especially the German) industry. However, the gap between Austria and the Nordic countries with respect to the share of value added in high-technology sectors increased since 2002. Since the IUS puts emphasis on industry structure rather than on sectorial performance, this leads to an underrating of Austria in the ranking. But a recalculation of R&D intensities shows that the structural differences only explain about one third of the difference in the overall research intensities. Thus, Austrian companies are also outperformed by their Swedish and Danish counterparts with respect to their research efforts when structural disadvantages are taken into account. Hence innovation and R&D intensity and diffusion of Key Enabling Technologies in these areas can be improved significantly.
- Austria shows relatively low dynamics in business start-ups compared to Denmark and Sweden, and also the total number of companies stagnated from 2009 to 2012. This is at least partially due to different regulatory frames and corresponds with comparatively high survival rates of Austrian firms. However, highly innovative business start-ups are a main driver of structural change and need to be fostered continuously.
- The differences in firm demography between Austria, Denmark and Sweden, (e.g. the large increase of one-person companies in Denmark), raise questions about the framework conditions and the ease of doing business in Austria. While recently some initiatives have been launched in Austria with the ambition to position the country among the European countries with the highest enterprise birth rates, this remains to be an area which should receive high policy attention and should be addressed from various angles (regulation, provision of VC, awareness and education, IPRs, encouragement of academic spin-offs etc.). Austria shows a broad spectrum of policy measures supporting highly innovative business start-ups in early phases (including awareness building, incubation and funding) but a strong business 'eco-system' is still lacking. Denmark and Sweden could be role-models in this vein, especially in some hot-spot areas (like the capital regions of both

countries). Supporting schemes for later phases of business (e.g. accelerators in Denmark) exist but ought to be strengthened in Austria.

- Austria performs at about the same level as companies in Sweden and Denmark when it comes to innovation activities in general. Especially Austrian large and medium sized companies show higher levels of innovation activities than enterprises in Sweden and Denmark. Also, Austrian firms perform very well in non-technological innovation and have larger shares of innovative firms compared to Sweden and Denmark. While Austria performs well regarding patent activities in Europe, there is a relatively large gap concerning the number of EPO patent applications per million inhabitants to the benchmark countries Sweden and Denmark. Even though Sweden seems to be out of reach in high-tech EPO patent applications and Denmark had a slightly higher number of EPO patent applications per million inhabitants in the high-tech sector, Austria performed better than Denmark in ICT patent applications per million inhabitants. Also, Austria shows a strong performance in the field of biotechnology, where it surpasses the benchmark countries.

- Even if the propensity to innovate and patent is relatively high in Austria, not least due to a favourable framework concerning public funding of business R&D, there is room for improvement concerning the input-output relation and for commercialisation of these inventions (e.g. following the example of recently launched measures (like 'Marktstart') to support market development for SMEs. Overall though, scope for 'quick-fixes' are limited as changes in industrial structure and innovation behaviour of firms can only be changed in the mid- to long term. To do so, Austria is certainly not at a disadvantage concerning the (public) funding instruments as compared to its peers in Denmark and Sweden given the size and scope of its innovation funding for the business sector.

- A comparison of Austria, Denmark and Sweden regarding venture capital investments shows that the total volume of VC in Austria is significantly lower than in Sweden and Denmark, although this is not the case for the number of companies funded. Total VC for Austria in 2014 (seed, start-up and later stage venture) was 1/8 of Denmark and 1/9 of Sweden. This gap already existed before the financial crisis in 2007 and thus was no consequence of it. The number of VC firms and their VC volume increased significantly for digital start-ups over the last few years, where internet and technology firms were the most popular ones for investors. Since the ICT landscape is on the one hand smaller and on the other hand even decreasing in Austria compared to Germany, Sweden and Denmark, this might be an additional reason for the weak performance of Austria with respect to venture capital. Furthermore, the Austrian VC system shows marked differences with respect to the stage of investment, with emphasis of public VC funding being put on the early-stage other than in Denmark and Sweden. This is very much due to thedependence of Austrian companies on the banking sector that is especially problematic in the early stage of young firms..

- Denmark is especially remarkable, as it experienced a very different development, seeing its VC markets increase even in the years of the financial crisis. Notably the Danish Growth Fund (DGF) was able to attract private VC investors using a fund-of-funds model, and highly successful in leveraging private investments into the risk capital market thereby demonstrating the benefits of well-designed and well-managed initiatives to help grow a sustainable risk capital market. The chances to emulate this development in Austria might not be too high, as the DGF relied on the (pre)existence of other funds which are available to a much lesser extent in Austria, but deserves further examination.

- Overall, especially risk capital from the private sector has to be increased significantly in Austria. Innovation in high-tech branches involves high risks and large financial resources, which cannot be carried by the public sector alone. The main target of the public sector should be to provide a well-designed framework and a well-managed platform in order to attract venture capital investors.
- Another marked difference between Denmark and Sweden and Austria is the role of ICT in the development of the respective research and innovation system. The role and weight of this sector is not only more pronounced in industrial structure, but also in the general 'ICT readiness' of the countries. ICT readiness is weak especially in Austrian peripheral regions and the coordination between federal levels could be improved. Denmark and Sweden societies are more IT oriented, better equipped with infrastructure and more prone to use IT both in households as well as in enterprises. While industrial structures cannot be changed easily, the uptake and diffusion of IT can. Measures in this vein include further advances in eGovernment initiatives, Smart Cities initiatives and the provision of sufficient broadband infrastructure. Like in Denmark and Sweden, Austria would benefit from a coordinated federal digitalization agenda.

Industry-Science Relations

- With respect to the different channels of industry-science relations, it is hard to assess whether Sweden or Denmark could serve as role models: Austria seems to be on a comparatively good level, with (negative) differences mainly due to structural characteristics of industry and the greater propensity to collaborate of larger enterprises and in ICT and life sciences, where both Denmark and Sweden have a more pronounced specialization.
- One might argue that both countries have been early birds in certain specific areas, Denmark in terms of encouraging university patenting, Sweden with its implementation of the Competence Center Program, that became role models for other countries like Austria. Other specific features like the existence of large and research intensive companies in Denmark and Sweden cannot be emulated. Whereas Sweden is focusing on funding mechanism concerning industry-science relations for all HEIs, in Denmark it is more of a competitive effort by the leading universities to show that that they areconnected with the business sector and have a positive impact on research, innovation and businesses productivity. It is important that universities are developing more research and innovation cooperation linkages especially with small innovative and foreign companies in HT/Knowledge-intensive /fast growing sectors.

- With respect to policies supporting industry-science relations, Austria faced a remarkable catch-up in terms of implementing programs and measures to encourage industry-science relation since the beginning of the 2000s, at this stage already learning from other countries’ experiences and approaches At the current stage of development of science-industry relations in Austria, emphasis has to be put on evaluating the success of existing measures and adopting the recommendations that has already been provided on programs like COMET or other recent evaluations. A focus should be on the optimization of the programmes with respect to their output (including ‘behavioural additionality’) and impact. Besides funding for establishing industry-science relations, Austrian universities should be incentivized to measure their industry cooperation and set up ambitious targets (reflected also in the performance contracts). In this respect, Austria should look towards Denmark and focus on implementation of reforms and to make quantitative impact assessments of industry-science relations. An approach worth being considered is the promotion of the inter-sectoral exchange of individuals with specific programs. Austria could think about the implementation of programs similar to e.g. the Danish Industrial PhD.

The Role of ERA policies for national STI policy

- Both the Danish and the Swedish research and innovation systems are well anchored internationally, though there are some debates about the attractiveness for students and researchers from abroad. Discussions about necessary steps to foster internationalization are going beyond Europe though, and address questions of positioning the HEI and the enterprises in global competition and value chains. Policy debates are characterized by predominantly national concerns and do not give European STI policy a large weight. This might be a reflection of well-endowed national research systems. Nevertheless, ERA priorities seem to have had at least some influence on priority setting, especially in the up-take of ‘grand societal challenge’ topics (following the Lund declaration). When it comes to support infrastructures, again there might not much to learn from the Danish and Swedish examples (scope for policy learning is quite often seen the other way round!). ERA initiatives, targets and instruments seem to play a greater role in Austria’s strategic R&D-policy setting than in Denmark or Sweden. In the adoption of ERA-policy instruments in Austria (e.g. ERA-Observatory, FFG-EIP, ERA-Roadmap), Austria serves as a role model for Denmark and Sweden rather than the other way round.
- Even though, Austria performs significantly behind Sweden in terms of FP and H2020 indicators, regarding the share of retrieved funds to total funding as well as participation numbers and the share of project coordinators in FP6 and 7 and up till now in H2020. Regarding ERC grants (up till now 16 approved in H2020) Austria is in absolute terms behind Denmark (19) and Sweden (18) but compares well, if the respective sizes of the research base are taken into account. The expansion of these might also be the best way to approach the self-set Austrian target with respect to participation and coverage rate in H2020.

- ERA-related funding, policies and initiatives (FPs, ERA-Nets, JPIs etc.) are seen as an important supplement to existing strongholds rather than for the creation of new fields of excellence. Working on the efficient streamlining of public funds and positioning Austria according to the European requirements for tackling societal challenges and European priorities efficiently and at the same time exploit national strengths for future competitiveness have to be continuous challenges for national R&D and innovation policy.
- Mission-oriented funding seems to be gaining importance in a number of countries, among them the countries in comparison. This is triggered both by national debates on societal challenges as well as by the respective priorities set on the European level. The exact weight of this strand of policies is hard to assess, though. Overall, the role of thematic funding on national level compared to generic and structural funding is comparatively small in Austria. The most important source for thematic funding in Austria are the so-called topical programmes, mostly administered by the Austrian Research Promotion Agency FFG, accounting for around ¼ of total agency's funding. These programmes aim to support national and international priority areas, including energy, ICT, production, and security research, representing the most successful topics of Austrian participation in the Framework Programmes.
- The international trends show mission-oriented funding to shift from a technologically driven approach towards a user- and demand-driven orientation. Taking into account the learnings from the examples of other countries, Austria needs to start process towards aligning and disentangling of its structures for R&D-policy making and funding on several levels of policy making (national and regional governments and municipalities). A national effort towards mission- and challenge-oriented prioritization process, aligned with respective policies at the European level, might be a useful anchor for such a project.
- Experiences show that especially small countries might benefit from such a challenge-driven approach in mission-oriented funding based on bottom up-principles. Compared to the priorization of certain technology fields, this allows for a greater flexibility, since the government might not be right one to "pick winners".
- Mission-oriented approaches require both, a strategic agenda, based on broad inclusion of stakeholders, as well as a dedicated amount of funding at least by ear-marking existing funds. Strategic and competitive funding programmes might be an incentive for universities to encourage specializations in certain areas. The formulation of measurable targets, both qualitative and quantitative, as well as monitoring and evaluation process is key to increase the accountability of any strategic program.

6 Zusammenfassung und Empfehlungen

Hintergrund der Studie

- Im Folgenden werden wesentlichen Schlussfolgerungen sowie tentative Lehren für Österreich auf Basis des Vergleiches mit Dänemark und Schweden dargestellt. Diese Lehren, auf Basis identifizierter und Bewertung von Lücken zu Dänemark und Schweden, sollen die Grundlage für eine österreichische Diskussion über Wege zum Ziel, Innovation Leader zu werden, darstellen. Die identifizierten Lücken werden im Kontext nationaler Best Practice und Erfahrungen aus Dänemark und Schweden qualifiziert. In diesem Zusammenhang werden Beispiele auf Ebene individueller Instrumente und Politikmaßnahmen dargestellt, die auf Österreich umgelegt werden könnten. Empfehlungen sind dabei jedoch nicht als Auswahlmenü einzelner zu übernehmender Instrumente zu verstehen, sondern als Hinweise auf wichtige Bereiche und Arten von Maßnahmen.
- Österreich liegt in verschiedenen internationalen Vergleichen in Bezug auf sein Forschungs- und Innovationsperformance (insb. im Innovation Union Scoreboard) hinter den Innovation Leader Staaten Dänemark und Schweden. Im Gegensatz zum stetigen Aufholprozess vergangener Perioden mehren sich in den letzten Jahren die Hinweise auf eine stagnierende bzw. rückläufige Dynamik in der Performance des österreichischen Forschungs- und Innovationssystems. Das im Zuge der österreichischen FTI-Strategie selbst gesetzte Ziel, zur Gruppe der Innovation Leader Staaten aufzustoßen, u.a. durch eine Erhöhung der F&E-Quote auf 3.76% des BIP, scheint im Lichte aktueller Trends gefährdet. Vor diesem Hintergrund wurde die vorliegende Studie mit dem Ziel beauftragt, herauszuarbeiten, welche Lehren von den Dänemark und Schweden als führende Länder diverser internationaler Vergleiche gezogen werden können.

Systemischer Vergleich

- Dänemark und Schweden sind in mehr als einer Hinsicht Innovation Leader sowohl. was den Entwicklungsstand ihrer Forschungs- und Innovationssysteme betrifft, als auch (Schweden in geringerem Ausmaß als Dänemark) im Hinblick auf die Dynamik in einigen wichtigen Dimensionen des Forschungs- und Innovationssystems (bspw. wissenschaftliche Publikationen, Risikokapital). Damit bilden beide Staaten einen fruchtbaren Boden für das Ableiten potentieller Handlungsempfehlungen.
- Das Ableiten von Handlungsempfehlungen auf Basis eines Vergleiches mit anderen Staaten sowie die Identifikation potentiell transferierbarer "Best-Practices" nach Österreich sind komplexe Unterfangen. Der Prozess umfasst mehrere Stufen: i) die Identifikation potentiell nachzuahmender Charakteristika, ii) die Identifikation potentieller Schwierigkeiten in Bezug auf die Nachahmung einzelner Praktiken, iii) die Antizipation von Herausforderungen und sowie auch die Berücksichtigung von laufenden Diskussionen in den Vergleichsländern, die ebenfalls wichtige Schlussfolgerungen und Lehren beinhalten können. In diesem Zusammenhang wird sowohl in Dänemark als auch in Schweden die

Effektivität einzelner Maßnahmen sowie ein beobachtetes zunehmendes Ungleichgewicht zw. Inputs und Outputs in Bezug zu einem potentiellen Overinvestment in Dänemark und Schweden diskutiert.

- Die Grundlage für die Identifikation von Unterschieden zwischen Österreich, Dänemark und Schweden bildet der IUS (Innovation Union Scoreboard). Vor dem Hintergrund der diversen fundierten methodologischen Kritikpunkte an dessen Indikatorik ist es jedoch notwendig, die Analyse um eine Reihe weiterer Quellen und Vergleiche zu ergänzen, um zu einem nuancierten Bild zu kommen. Die Betrachtungsdimensionen umfassen dabei Struktur und Governance der F&E-Finanzierung, Struktur und Performance des Hochschulsystems, die Industriestruktur und die Rolle der Risikokapitalfinanzierung, der Wissenstransfer zw. Wissenschaft und Unternehmen, die Rolle von ERA für das nationale Forschungs- und Innovationssystem sowie diesbezügliche Politikmaßnahmen, sowie der Trend in Bezug die Implementierung umfassender missionsorientierter Forschungsprogramme in Dänemark und Schweden.
- Eine generelle Erkenntnis, die sich aus dem Vergleich auf aggregierter Ebene ziehen lässt ist, dass Österreich nach wie vor ein Input-Problem aufweist. Wohingegen die österreichische F&E-Quote in vergangenen Jahrzehnten kontinuierlich gestiegen ist, wiesen Dänemark und Schweden bereits in der Vergangenheit beständig höherer Investitionen in F&E auf. Dies gilt sowohl für öffentliche als auch private Ausgaben. Diese Unterschiede in Bezug auf die Inputs in der Vergangenheit determinieren daher zu einem großen Teil die unterschiedliche Position in den Rankings.
- Obwohl sich diese im IUS nicht abbilden, wurde im Zuge der Studie von Seiten der Interviewpartner des Öfteren auf Unterschiede in der gesellschaftlichen Einstellung zu gewissen Themen in Dänemark und Schweden im Vergleich zu Österreich hingewiesen bspw. in Bezug auf Unternehmertum oder weibliche Partizipation. In beiden Bereichen liegen Dänemark und Schweden vor Österreich, was auf die Notwendigkeit der Änderung der in der Gesellschaft verbreiteten Einstellung bspw. zu Unternehmertum oder zur gemeinsamen Haushaltsführung von Mann und Frau hindeutet.

Governance und Finanzierungsstruktur

- In Bezug auf die Qualität der Prozesse zur Implementierung von Politikmaßnahmen können Lehren sowohl aus der hohen Evidenz-Basierung der schwedischen Research Bills sowie dem hohen Stellenwert von Wirkungsanalysen und Erhebungsmethoden in Dänemark. Ein weiteres dänisches Spezifikum sind die schlankeren und einheitlicheren Strukturen in Bezug auf politische Zuständigkeiten für Forschung und Innovation: diese sind im Wesentlichen in einem Ministerium und zwei angeschlossen Fördervergabestellen konzentriert. Weiters verfügt Dänemark über eine klarere Aufgabenteilung in Bezug auf die öffentliche Finanzierung von Forschung und Innovation. Österreich könnte diese Beispiele zum Anlass für eine Diskussion über die optimale Aufteilung von Zuständigkeiten zwischen den Ministerien und die Notwendigkeit der Anpassung der diesbezüglichen Förderportfolios nehmen (bspw. die Aufgabenteilung für Innovation und Start-Up-Finanzierung zw. FFG und aws).

- In Bezug auf die Finanzierungsstruktur für Forschung und Innovation sollte die wettbewerbliche öffentliche Finanzierung für Forschung, vor dem Hintergrund der Beispiele aus Dänemark und Schweden deutlich an Bedeutung gewinnen. Darüber hinaus verfügen sowohl Dänemark aus Schweden über eine ausgeprägte Kultur der privaten F&E-Finanzierung, insbesondere durch Stiftungen. Schritte in Richtung der Begünstigung der Ausweitung der privaten Finanzierung wurden in Österreich jüngst unternommen. Gleichzeitig muss beachtet werden, dass die Unterschiede zw. Österreich, Dänemark und Schweden systemischer Natur sind und diesbezügliche Anpassungen einer langfristigen Perspektive bedürfen. In der Zwischenzeit sind weitere Anstrengungen nötig. So können private Stiftungen in Dänemark und in Schweden Forschungsausgaben mit bis zu 125% auf ihre Kapitaleinkommen steuerlich geltend machen. Die weitere Ausweitung der steuerlichen Begünstigung der F&E-Finanzierung durch Privatstiftungen in Österreich daher eine potentielle Option.
- Gleichzeitig muss auch die Diskussion um potentielle Kehrseiten in der großen Vielfalt unterschiedlicher Finanzierungsquellen in Dänemark und Schweden beachtet werden. Dies betrifft insbesondere die mit einem hohen Anteil wettbewerblicher Finanzierung einhergehende Notwendigkeit zur Ko-Finanzierung, die wiederum institutionelle Freiheitsgrade reduziert bzw. unterschiedliche Anreize in Bezug auf Spezialisierung schafft. Beispielsweise wird in Dänemark auf den großen Einfluss in Bezug auf die wissenschaftliche Spezialisierung durch thematisch orientierte Stiftungen wie NovoNordisk hingewiesen. Darüber hinaus erhöhen unterschiedliche Formalismen die Komplexität der Antragstellung. Die Abstimmung öffentlicher und privater Interessen in der Forschungsfinanzierung und das Abgleichen strategischer Ziele sind daher eine Notwendigkeit wenn es um die Ausweitung der privaten Finanzierung geht.

Tertiäres Bildungssystem

- Sowohl in Dänemark als auch in Schweden wurden in den letzten Jahren Schritte zur Weiterentwicklung der jeweiligen Hochschulsysteme unternommen. Neben einer massiven Ausweitung der öffentlichen Finanzierung in beiden Ländern seit Mitte der 2000er Jahre wurden auch Anstrengungen in Bezug auf institutionelle Reformen unternommen. Insbesondere die Zusammenlegung von Hochschulen und Forschungseinrichtungen in Dänemark brachte eine grundlegende systemische Änderung. Beide Länder sind sehr erfolgreich in Bezug auf die Zahlen der Studierenden und Absolventen sowie (insb. im Fall von Dänemark) der Produktion exzellenter wissenschaftlicher Forschung, wobei sich die Dynamiken unterscheiden. So wird in Schweden die seit Jahren anhaltende Stagnation in Bezug auf die Produktion exzellenter (High-impact) Publikationen diskutiert. In beiden Staaten gibt es zudem zunehmende Debatten in Bezug auf die Qualität der Lehre und die Produktion geeigneter Absolventen für den Arbeitsmarkt. Insgesamt erscheinen jedoch die Reformen und Entwicklungen in den betrachteten Hochschulsystem wichtige Anhaltspunkte für eine Reform des österreichischen Hochschulwesens zu liefern. Neben institutionellen Reformen muss dies jedoch auch die Finanzierung der Hochschulen auf Dänisches bzw. Schwedisches angehoben werden um eine tatsächliche Weiterentwicklung zu gewährleisten.

- Forschung ist sowohl in Dänemark als auch in Schweden auf eine vergleichsweise kleine Zahl von Institutionen konzentriert. Während diese Konzentration im Schwedischen Hochschulsystem „organisch“ gewachsen ist, eingedenk der kleine Zahl „alter“ traditioneller Universitäten, wurde die Reduktion der Anzahl an Institutionen in Dänemark durch eine aktive Politik der Zusammenlegung von Hochschulen forciert. Diese Reform – d.h. eine Reduktion der Anzahl und eine Erhöhung der Größe der Institutionen mit dem Ziel Ressourcen zu bündeln und die internationale Sichtbarkeit zu erhöhen – sollte handlungsleitend für die österreichische FTI-Politik sein.
- Dem Beispiel der Innovation Leader folgend, sollte sich Österreich weiterhin die Erhöhung der Anzahl tertiärer Absolventen zum Ziel setzen. In Österreich haben die Universitäten mit Abstand den höchsten Anteil an der Hochschulausbildung, was jedoch einen ineffizienten und teuren Weg in Bezug auf die Bereitstellung berufsorientierter Ausbildungen und geeigneter Absolventen für den Arbeitsmarkt darstellt. Die Verteilung der Studierenden auf unterschiedliche Hochschultypen ist fundamental unterschiedlich in Dänemark und Schweden wo berufsorientierte Ausbildungen und Fachhochschulen eine größere Rolle spielen. Eine weitere Erhöhung der Absolventenzahlen in Österreich, ohne verstärkten Fokus der Ausbildungssysteme auf die Anforderungen am Arbeitsmarkt, läuft sonst Gefahr zu einer „Inflationierung“ tertiärer Abschlüsse anstatt einer tatsächlichen Vermittlung von notwendigen Kompetenzen zu führen.
- In Bezug auf die Bereitstellung von Humankapital für Forschung und Entwicklung weist Österreich einen im Vergleich zu Dänemark und insb. Schweden einen geringeren Anteil an DoktoratsabsolventInnen (insb. in STEM-Fächern) auf. Den Beispielen der beiden Länder folgend, sollte daher die Erhöhung der Qualität sowie die Verbesserung der Strukturen der Doktoratsausbildung den Grundpfeiler einer Hochschulreform in Österreich bilden. Diese sollte sowohl auf eine Erhöhung der regulär Beschäftigten Doktoranden sowie auf eine verstärkte Konnektivität der Ausbildung mit der Industrie (z.B. nach dem Vorbild des dänischen Industrial PhD Programmes) abzielen. Auch Universitätsübergreifende Doktoratsschulen sowie die interuniversitäre Vernetzung der Ausbildung mit hochqualitativen Forschungsinfrastrukturen sind empfehlenswert, mit dem Ziel die Interaktion und Durchlässigkeit zw. Institutionen und Sektoren zu erhöhen.
- In Bezug auf die Erhöhung der Attraktivität Österreichs für die international besten Köpfe und Talente sollte ein verstärkter Fokus darauf gelegt werden, in Österreich ausgebildete Talente zu halten. In diesem Zusammenhang sollten die Zugangsbarrieren für Hochschul-Absolventen aus Nicht-EU-Staaten zum Arbeitsmarkt reduziert werden. Dies betrifft eine notwendige Reform der Rot-Weiß-Rot-Karte insbesondere in Bezug auf das erforderliche Mindest-Einstiegsgehalt sowie die limitierte Dauer der Jobsuche.
- Sowohl in Dänemark als auch in Schweden werden keine Studiengebühren eingehoben. Auch gibt es keine im Vergleich zu Österreich fundamental unterschiedlichen Zugangsregelungen zu Studien (wie z.B. einen numerus clausus). Die Aufnahme von Studierenden ist jedoch in beiden Ländern direkt mit der Finanzierung der Hochschulen verknüpft, indem eine Ausweitung der Studierendenanzahl eine Ausweitung der

Finanzierung bedeutet. In diesem Zusammenhang sollte Österreich die Einführung der Studienplatzfinanzierung vorantreiben.

Hochschulfinanzierung

- Österreich gibt annähernd gleich viel für die Finanzierung von Forschung an den 22 Universitäten aus wie Dänemark für acht. Auch das Ausmaß der wettbewerblichen Finanzierung, sowohl über die öffentliche Grundfinanzierung als auch über öffentliche und private Fördergeber und Stiftungen ist in Dänemark und Schweden stärker ausgeprägt. International sichtbare und wettbewerbsfähige Forschung erfordert daher eine grundlegende Reform der österreichischen Universitätslandschaft, beispielsweise durch strategische Allianzen oder die Zusammenlegungen von Universitäten, Fakultäten oder Departments. Eine notwendige Voraussetzung für eine Ausweitung der kompetitiven Finanzierung ist die flächendeckende Einführung der Vollkosten-Rechnung an allen Hochschulen.

- Sowohl in Dänemark als auch in Schweden erfolgt die Finanzierung der Hochschulen getrennt nach Forschung und Lehre. Letztere erfolgt auf Basis der Studierendenzahl sowie des Studienerfolges. Darüber hinaus wird in beiden Ländern – das bestätigen die durchgeführten Interviews und auch empirischen Befunde - strategischen Konzentrationen und der Forcierung „kritischer Massen" vor dem Hintergrund internationaler Wettbewerbsfähigkeit von Forschung große Bedeutung beigemessen. Während die Zusammenlegung von Hochschulen und Forschungseinrichtungen in Dänemark mit finanziellen Anreizen für die neu entstandenen Institutionen verbunden war, ist die öffentliche Finanzierung der Hochschulforschung traditionell auf einige wenige „alte" Institutionen konzentriert. Die „neuen" Universitäten in Schweden sind dagegen auf die Finanzierung ihrer Forschung durch kompetitive öffentliche Instrumente und die Zusammenarbeit mit Industrie angewiesen.

- Der Grad der Autonomie der Hochschulen in beiden Ländern ist sehr hoch, jedoch mit schwach ausgeprägten inneruniversitären Governance-Mechanismen. Die Hochschulsysteme in Dänemark und Schweden können jedoch durch eine deutlich höhere Lenkungswirkung der öffentlichen Finanzierung durch die Verwendung von Key-Performance Indikatoren in der Finanzierung charakterisiert werden. Die Bewertung der jüngst eingeführten Finanzierungsmodi der Basismittelzuweisung für Forschung in Dänemark und Schweden ist jedoch ambivalent in Bezug auf ihre bisherigen Effekte und darüber hinaus verfrüht, da derartige Mechanismen mit Verzögerungen in Bezug auf Auswirkungen auf die Forschungsperformance der Hochschulen verbunden sind. Aufgrund der erst kürzlich erfolgten Einführung haben diese zudem keine Erklärungskraft in Bezug auf die vergangene Performance Dänemarks und Schwedens in den letzten beiden Dekaden. Diese erklärt sich eher durch die über einen langen Zeitraum hinweg höheren Mittel und das institutionelle Setting, welches Konzentrationen begünstigte. Nichtsdestoweniger beinhalten diese Ansätze wichtige Anhaltspunkte für eine notwendige Ausweitung der Performance-basierten Finanzierung in Österreich.

  Die österreichische Praxis der Leistungsvereinbarungen als administrative Grundlage für die Zuweisung der Basisfinanzierung stellt keine Performance-finanzierung im engeren

Sinn dar, solange die Erreichung der darin enthaltenen Meilensteine nicht im Einzelnen direkt an Finanzierungszuweisungen gebunden sind. Eine Lösung im Sinne der Erhöhung des leistungsorientierten Finanzierungsanteils würde aber auch eine deutliche Erhöhung der Hochschulraumstrukturmittel bedeuten. Darüber hinaus ist eine separate Finanzierung von Forschung und Lehre erforderlich. Ebenso sollte die Einführung einer Studienplatzfinanzierung, eingedenk der Ziele des Hochschulplanes 2011, vorangetrieben werden.

Unternehmens-F&E und Innovation

- Die Struktur der Forschungsfinanzierung im Unternehmenssektor unterscheidet sich in Österreich grundlegend von jener in Dänemark und Schweden. Während in Dänemark und Schweden ein Großteil der F&E-Finanzierung durch den nationalen Unternehmenssektor erfolgt, trifft dies für Österreich nur auf etwas weniger als zwei Drittel der unternehmerischen F&E zu. Dies ist bedingt durch eine hohen Anteil an Auslandsfinanzierung von in Österreich durchgeführter F&E sowie der Finanzierung durch die öffentliche Hand.

- In Schweden ist der Anteil der öffentlichen Finanzierung für Unternehmens-F&E geringer ausgeprägt als in Österreich (auch aufgrund der Präsenz großer F&E-intensiver Unternehmen). Darüber hinaus können F&E-Ausgaben durch Unternehmen in Schweden, anders als in Österreich und Dänemark, nicht steuerlich abgesetzt werden. Auch gibt es in Dänemark kaum öffentliche Mittel für große F&E-intensive Unternehmen. Öffentliche Finanzierung von Unternehmens-F&E- konzentriert sich in Dänemark im Wesentlichen auf KMU sowie die Unterstützung von Start-Ups und der Markteinführung von Produkten. Die Unterstützungsleistungen für Unternehmens-F&E in Österreich werden insgesamt als sehr vorteilhaft eingeschätzt. Der Fokus liegt auf der Förderung von Unternehmens-F&E und Innovationen anstatt auf Investmentmechanismen. Darüber hinaus werden gut ausgebauten Förderstrukturen auch als Standortargument für die Ansiedlung von F&E-Einheiten ausländisch kontrollierter Unternehmen in Österreich verwende.

  Trotz einer ausgeprägten Evaluationskultur auf Ebene individueller Instrument fehlt jedoch bis dato eine systemische Evaluierung der Wirkungen des öffentlichen Förderportfolios sowie dessen Zusammenspiel. Österreich sollte daher sowohl seine direkten als auch indirekten Finanzierungsmechanismen für Unternehmens-F&E und Innovation evaluieren.

- Die sektorale Struktur Österreichs unterscheidet sich fundamental von Dänemark und Schweden. Während sowohl in Dänemark als auch in Schweden ein vergleichsweise hoher Anteil der Wertschöpfung auf Hochtechnologiesektoren entfällt, ist diese in Österreich sehr stark im in Mittel- und Niedrigtechnologiesektoren konzentriert. Zwar verfügt Österreich über Wettbewerbsvorteile in diesen Sektoren, auch in Bezug auf die Einbindung in europäische Wertschöpfungsketten (insb. mit Deutschland). Nichtsdestoweniger hat der Abstand Österreichs in Bezug auf den Anteil der Wertschöpfung in Hoch-Technologiesektoren im Vergleich zu den nordischen Ländern seit 2002 zugenommen. Da der IUS und die hier einbezogenen Indikatoren auf die Industriestruktur anstatt auf die Performance innerhalb einzelner Sektoren abstellen, führt dies zu einer Verschlechterung des österreichischen Rankings. Jedoch zeigt auch eine strukturbereinigte Berechnung der

F&E-Intensitäten, dass strukturelle Unterschiede nur rund ein Drittel der Performance-Unterschiede erklären können. Das bedeutet das österreichische Unternehmen auch nach Bereinigung um strukturelle Effekte weniger F&E-intensiv sind als Dänische oder Schwedische. Aus diesem Grund ist es von großer Bedeutung die Forschungs- und Innovationsintensität sowie auch die Diffusion von Key Enabling Technologies in diesen Sektoren deutlich zu verbessern.

- Österreich verfügt im Vergleich zu Dänemark und Schweden über eine geringere Gründungsdynamik. Die Anzahl der Gründungen stagnierte insbesondere zw. 2009 und 2012. Dies kann durch Unterschiede im regulatorischen Umfeld erklärt werden, die aber gleichzeitig die hohen Überlebensraten in Österreich bedingen. Die Forcierung innovativer Gründungen muss jedoch im Sinne des notwendigen Strukturwandels vorangetrieben werden.
- Unterschiede in der Unternehmensdemographie zwischen Österreich Dänemark und Schweden (insb. in Bezug auf den großen Zuwachs an Ein-Personen Unternehmen in Dänemark) werfen die Frage auf, inwieweit die Rahmenbedingungen für unternehmerischer Tätigkeiten in Österreich verbesserungswürdig sind. Auch wenn jüngste Initiativen in Österreich mit dem Ziel implementiert wurden, Österreich zu einer führenden Gründernation in Europa zu machen, muss auch in Zukunft große politische Aufmerksamkeit auf diesem Bereich und einer Vielzahl an notwendigen Schritten liegen (Regulierungen, Bereitstellung von Risikokapital, Ausbildung, IPRs, akademische Gründungen etc.). Österreich verfügt über ein breites Spektrum an Förder- und Unterstützungsmaßnahmen für Start-Ups in der Frühphase (awareness building, Inkubatoren, Förderungen. Die ganzheitliche Entwicklung des unternehmerischen Ökosystems ist nicht im Fokus. Hot-Spot-Regionen in Dänemark und Schweden (bspw. die Hauptstädte) können hier wichtige Lehren liefern. Darüber hinaus muss die *later-stage*-Finanzierung in Österreich ausgebaut werden (nach Vorbild bspw. der dänischen Accelaratoren).
- Die Innovationsneigung österreichischer Unternehmen ist vergleichbar mit Dänemark und Schweden. Insbesondere große und mittlere Unternehmen weisen einen höheren Anteil an Innovationen auf als in Dänemark und Schweden. Dies betrifft vor allem auch den Anteil an Firmen mit nicht-technologischen Innovationen. Während Österreich im EU Vergleich eine überdurchschnittlich hohe Anzahl an Patenten aufweist, ist der Abstand zu Dänemark und Schweden in Bezug auf die Anzahl von EPO-Paten pro millionen Einwohner beträchtlich, insb. im Vergleich mit Schweden. Im Vergleich zu IKT-Patenten pro millionen Einwohner ist der Abstand zu Schweden uneinholbar, wobei Österreich hier sogar vor Dänemark liegt. Darüber hinaus verfügt Österreich über Stärken im Feld der Bio-Technologie.
- Auch wenn die Patent und Innovationsintensität in Österreich vergleichsweise hoch ist - nicht zuletzt aufgrund der ausgeprägten öffentlichen Finanzierungstrukturen für Unternehmens-F&E - gibt es noch Notwendigkeiten für Verbesserungen. Dies betrifft insbesondere die Input-Output-Relationen und die Kommerzialisierung von Erfindungen (bspw. durch Instrumente wie Marktstart) sowie die Unterstützung der

Markteinführungsphase für KMU. Strukturelle Veränderungen der Industriestruktur und eine Erhöhung der Innovationskraft sind jedoch mittel- und langfristige Perspektiven. Im Vergleich zu Dänemark und Schweden weist Österreich hier jedenfalls keine Nachteile, was die öffentlichen Unterstützungsleistungen anbelangt, auf.

- Ein Vergleich der Bereitstellung von Risikokapital in Österreich, Dänemark und Schweden zeigt, dass das Volumen in Österreich deutlich unter jenem der Vergleichsländer liegt, jedoch nicht in Bezug auf die Anzahl der finanzierten Unternehmen. Die Risikofinanzierung in Österreich betrug nur 1/8 Dänemarks und 1/9 Schwedens. Diese Lücke existierte auch schon vor dem Ausbruch der Finanzkrise 2007. Ungeachtet dessen ist die Zahl der Risikofinanzierten IKT-Start-Ups in den letzten Jahren deutlich gestiegen. Der vergleichsweise geringe Anteil des IKT-Sektors in Österreich im Vergleich zu Deutschland, Schweden und Dänemark mag mit ein Grund für die geringe Performance Österreichs in Bezug auf die Bereitstellung von Risikofinanzierung sein. Darüber hinaus besteht eine generell stärkere Tradition der Bankenfinanzierung im Unternehmenssektor, die nunmehr insbesondere für junge Firmen problematisch ist. Die early-stage Finanzierung von Gründungen weist seit 2007 zudem den höchsten Rückgang in der österreichischen Risikokapitalfinanzierung auf.
- In Dänemark konnte die Risikokapitalfinanzierung nach der Finanzkrise sogar noch ausgeweitet werden. Verantwortlich dafür ist insbesondere der Danish Growth Fund (DGF) der mit seinem Funds-to-Funds Modell äußerst erfolgreich die Ausweitung privaten Risikokapitalinvestments vorantrieb. Allerdings scheint eine Überleitung dieses Modells auf Österreich in Abwesenheit einer nationalen privaten nationalen Risikofinanzierungskultur wenig erfolgversprechend. Semi-öffentliche Fonds können dennoch mittelfristig, in Abhängigkeit von der verfolgten Beteiligungsstrategie, eine wichtige Rolle spielen.
- Insgesamt muss demzufolge in Österreich insbesondere die Risikofinanzierung des Privatsektors ausgebaut werden. Innovationen in Hochtechnologie-Branchen inkludieren hohe Risiken und benötigen große Ressourcen die nicht alleine durch die öffentliche Hand getragen werden können. Das Ziel der öffentlichen Hand muss die Bereitstellung einer geeigneten und gut verwalteten Plattform für die Attraktivierung privater Risikokapitalinvestitionen sein.
- Ein weiterer wesentlicher Unterschied zwischen Dänemark und Schweden besteht in der Rolle von IKT für die Entwicklung der jeweiligen Forschung- und Innovationsysteme. Sowohl die Größe des IKT-Sektors als auch die generelle „IKT-Readiness" ist in beiden Ländern stärker ausgeprägt als in Österreich. Letzteres trifft insbesondere auf periphere Regionen in Österreich zu. Die Bevölkerungen in Dänemark und Schweden sind (im Durchschnitt) stärker IT-orientiert und mit besserer Infrastruktur ausgestattet. Dies gilt auch für den Unternehmenssektor. Während die Industriestruktur nicht kurzfristig geändert werden kann, kann die Diffusion von IT vorangetrieben werden. Dies umfasst die Weiterentwicklung und das Vorantreiben von eGovernment, Smart City Initiativen oder auch ausreichende Breitbandinfrastruktur. Wie Dänemark und Schweden würde auch Österreich von einer nationalen Digitalisierungsagenda profitieren.

Kooperation Wissenschaft-Wirtschaft

- Aufgrund der strukturell unterschiedlichen Gestaltung der Kanäle und Instrumente des Wissenstransfers zwischen Wissenschaft und Unternehmen in Dänemark und Schweden, lässt sich schwer sagen inwieweit diese als Vorbilder für Österreich dienen können. Österreich steht hier vergleichsweise gut dar, was die Zusammenarbeit zwischen den wissenschaftlichen Einrichtungen und Unternehmen betrifft. Unterschiede zu Dänemark und Schweden sind im Wesentlichen der unterschiedlichen Industriestruktur und der stärkeren Kooperationsneigung großer Unternehmen insb. in IKT und den Life Sciences geschuldet, wo sowohl Dänemark als auch Schweden Spezialisierungsvorteile aufweisen.

  Des Weiteren lässt sich argumentieren, dass in beiden Staaten die Forcierung des Themas Wissenstransfer durch die Universitäten bereits zu einem früheren Zeitpunkt erfolgte als in Österreich. In Dänemark geschah dies mit Schwerpunkt auf universitäre Patente, in Schweden bspw. durch die Einführung des Kompetenzzentren Programmes, welches bereits in Österreich übernommen wurde. Spezifika wie das Vorhandensein großer F&E-intensiver Unternehmen in beiden Staaten lassen sich wiederum nicht übertragen. Wohingegen Schweden auf dezidierte Fördermaßnahmen setzt um Wissenstransferaktivitäten an den Universitäten zu forcieren, ist dies in Dänemark ein kompetitives Interesse der Universitäten selber, ihre Aktivitäten und deren Wirkungen in der Zusammenarbeit mit dem Unternehmenssektor darzustellen. Gleichzeitig wird die Notwendigkeit betont, dass Universitäten Forschungs- und Innovationskooperationen insbesondere mit innovativen KMU sowie in- und ausländischen Unternehmen in Hochtechnologie, wissensintensiven und schnell wachsenden Sektoren weiter forcieren.

- Insgesamt hat Österreich einen bemerkenswerten Aufholprozess in der Forcierung der Beziehungen zwischen Wissenschaft und Unternehmen durch die Implementierung von Maßnahmen und Programmen seit 2000 bewältigt, der sich bereits auf die Erfahrungen aus anderen Ländern stützt. Der Fokus sollte daher aktuell auf die Verfolgung und Implementierung jüngster Empfehlungen für die Weiterentwicklung existierender Programme wie COMET gelegt werden. Darüber hinaus sollten Anreizsysteme für die Intensivierung der Beziehungen zw. Wissenschaft und Unternehmen etabliert werden durch die Universitäten, beispielsweise durch ambitionierte Zielsetzungen und diesbezüglicher Monitoringsysteme im Wege der Leistungsvereinbarungen. Dänemark ist in diesem Zusammenhang ein interessantes Vorbild, insbesondere in Bezug auf die Implementierung von Wirkungsanalysen.

- Eine weitere wichtige Lehre liegt in der Forcierung des intersektoralen Austausches von Individuen in Dänemark durch spezifische Programme. Österreich könnte in diesem Zusammenhang von der Einführung eines Instrumentes wie dem dänischen *Industrial PhD*-Programm profitieren.

Die Rolle von ERA für die nationale FTI-Politik

- Die Forschungs- und Innovationssysteme Dänemarks und Schwedens sind international sichtbar und verankert. Nichtsdestoweniger gibt es in beiden Ländern Debatten über die Attraktivität für StudentInnen und WissenschafterInnen aus dem Ausland. Diskussionen über das Vorantreiben der Internationalisierung konzentrieren sich insbesondere auf

Länder außerhalb Europas und die Positionierung von Hochschulen und Unternehmen in globalen Wertschöpfungsketten. Gleichzeitig nehmen nationale Politikmaßnahmen bis dato relativ wenig Bezug zu FTI-politischen Maßnahmen auf EU-Ebene sondern sind von nationalen Zielen und Überlegungen geprägt, vor dem Hintergrund finanziell gut ausgestatteter Systeme. Nichtsdestoweniger finden ERA-bezogene Prioritäten, insbesondere die Adressierung gesellschaftlicher Herausforderungen als Folge der Lund-Deklaration, vermehrt Eingang in die nationale FTI-Politik. In Bezug auf die Entwicklung diesbezüglicher Maßnahmen deutet auch einiges darauf hin, dass Österreich eher für Dänemark und Schweden als Vorbild herhalten kann als umgekehrt, was die Implementierung von ERA-Initiativen und Instrumenten angeht (bspw. ERA-Observatory, FFG-EIP, ERA-Roadmap).

- In Bezug auf die Performance in den EU Rahmenprogrammen liegt Österreich jedoch deutlich hinter Schweden, was den Anteil der rückholbaren Fördermittel oder die Beteiligung an Projekten das 6. und 7. Rahmenprogrammes und Horizon 2020 betrifft. In Bezug auf ERC Grants liegt Österreich mit aktuell 16 Bewilligungen in H2020 hinter Dänemark (19) und Schweden (18), was jedoch im Vergleich zur nationalen Finanzierung für F&E durchaus bemerkenswert ist. Die Ausstattung des nationalen Forschungssystems ist jedoch die Grundvoraussetzung für die Erreichung der selbstgesteckten österreichischen Ziele im Rahmenprogramm.
- ERA-bezogene Finanzmittel, Instrumente und Initiativen (FPs, ERA-Nets, JPIs etc.) sind eine wichtige Ergänzung nationaler Mittel und Politikmaßnahmen und bestehender Stärkefelder. Die weitere Forcierung des Alignments nationaler Mittel sowie die Antizipation der gesellschaftlichen Herausforderungen wie sie auf EU-Ebene verfolgt werden, bei der gleichzeitigen Verfolgung nationaler Stärken in Bezug auf die eigene Wettbewerbsfähigkeit sind jedoch beständige Herausforderungen der nationalen F&E und Innovationspolitik.
- Missionsorientierte F&E-Programme gewinnen in einer Vielzahl von Staaten an Bedeutung, u.a. in Dänemark und Sweden. Auslöser für diese Entwicklung sind sowohl national geführte Debatten als auch auf EU-Ebene forcierte Priorisierungen in Bezug auf die Notwendigkeit der Adressierung großer gesellschaftlicher Herausforderungen (*societal challenges*). Die Bedeutung dieser Entwicklungen ist schwer einzuschätzen. Für Österreich zeigt sich, dass die Rolle thematischer Programme im Vergleich zur generischen Finanzierung von Forschung relativ gering ist. Die wichtigste Quelle sind die thematischen Programme der FFG, welche insgesamt jedoch nur rund ¼ des gesamten Fördervolumens ausmachen. Priorisiert werden in diesen Programmen insb. nationale und internationale Schwerpunktbereiche wie Energie, IKT, Produktion oder Sicherheitsforschung. In diesen Bereichen ist Österreich auch überwiegend in den EU Rahmenprogrammen erfolgreich, was auf deren Bedeutung für die österr. Wettbewerbsfähigkeit hinweist.
- Gleichzeitig weisen die internationalen Trends in der missionsorientierten Finanzierung weg von einem technologiegetriebenen hin zu einem verbraucher- und nachfrageorientierten Zugang. Die Erfahrungen und Maßnahmen in anderen Ländern, sowie die Priorisierung gesellschaftlicher Herausforderungen auf EU-Ebene, können in

Österreich den Anstoß für einen Prozess der Vereinfachung und Entwirrung nationaler Strukturen, Zuständigkeiten und Finanzierungsmechanismen der FTI-Politik auf allen Ebenen, Bund, Ländern und Gemeinden liefern.

- Insbesondere kleine Länder können von bottom-up getriebenen Prozessen zur Orientierung an Herausforderungen anstatt an bestimmten Technologien profitieren. Dies erlaubt eine größere Flexibilität, da insb. der Staat nicht notwendigerweise in der Lage ist die richtigen Schwerpunkttechnologien zu identifizieren.
- Missionsorientierte Programme erfordern neben einer strategischen Agenda und einer breiten Inklusion aller relevanten Stakeholder, insbesondere auch konkrete Finanzierungsstrukturen. Dies kann auch eine Neuausrichtung bestehender Programme umfassen. Strategische und kompetitive Programme sind insbesondere Anreize für Universitäten Spezialisierungen voranzutreiben. Gleichzeitig sind die Formulierung messbarer Ziele (sowohl qualitative als auch quantitative) sowie Monitoring und Evaluationsmechanismen unerlässlich für die erfolgreiche Implementierung.

7 References

Ahlqvist, V., Andersson, J., Söderqvist, L., Tumpane, J. (2015): A Gender Neutral Process? – A qualitative study of the evaluation of research grant applications 2014. Stockholm: Swedish Research Council

Ahlqvist, V.,Andersson, J.,Hahn Berg, C.,Kolm, C.,Söderqvist, L.,Tumpane, J. (2013): Observations on Gender Equality in a Selection of the Swedish Research Council's Evaluation Panels. Stockholm: Swedish Research Council

AIT, JOANNEUM RESEARCH, IHS, WIFO, ZSI (2015): Stärkefelder im Innovationssystem: Wissenschaftliche Profilbildung und wirtschaftliche Synergien, im Auftrag des BMWFW, http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/publikationen/forschung/AT_Forschungsraum_Endbericht.pdf

Arnold, E.; Åström, T.; Boekholt, P.; Brown, N.; Good, B.; Holmberg, R.; Meijer, I.; Mostert B.; van der Veen G. (2008): Impacts of the Framework Programme in Sweden; VINNOVA Analysis VA 2008:11

Åström, T., Melin, G., Fridholm, G.,T., Terrell, M., Stålfors, S., Ärenman, E., Henningsson, K., Jondell, M., Arnold, A., Arnold, E., Danell, R. (2015): Långsiktig utveckling av svenska lärosätens samverkan med det omgivande samhället – Effekter av forsknings- och innovationsfinansiärers insatser, Technoloplis Group.

Austrian Federal Government (2011): Becoming an Innovation Leader - Strategy for research, technology and innovation of the Austrian Federal Government, Vienna

Austrian Council for Research and Technology Development (2013): Weißbuch zur Steuerung von Forschung, Technologie und Innovation in Österreich, Wien

Austrian Council for Research and Technology Development (2014): Report on Austria's Scientific and Technological Capability 2014, Vienna

AWTI (2014): Balans van de Topsectoren. The Hague: Adviesraad voor Wetenschap, Technologie en Innovatie

Beauftragter der Stadt Wien für Universitäten & Forschung (2015): Vierter Bericht des Beauftragten der Stadt Wien für Universitäten und Forschung. Wien: Stadt, die Wissen schafft. Finanzen, AkteurInnen, Visionen einer europäischen Forschungsmetropole

Bitarre, P., Edquist, C., Hommen, L., Ricke, A. (2008): The paradox of high R&D input and low innovation output: Sweden, WP Lund Universitiy Paper no. 2008/14.

Bloch, C. (2011): Measuring Public Innovation in the Nordic Countries (MEPIN), Nordic Innovation Centre

BMWF, UNIKO (2011): Kapazitätsorientierte Universitätsfinanzierung, Wien, Dezember 2011.

BMBWF, BMVIT, BMWFJ (2013): Austrian Research and Technology Report 2013, Report under Section 8(1): of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria, Vienna

BMWFJ, BMVIT (2009): Systemevaluierung der österreichischen Forschungsförderung- und Finanzierung, Teilbericht 3

BMWFW (2014): Universitätsbericht 2014, gemäß § 11 Universitätsgesetz 2002, BGBl. I Nr. 120/2002

BMWFW (2015): Aktionsplan für einen Wettbewerbsfähigen Forschungsraum

BMWFW, BMVIT (2014): Austrian Research and Technology Report 2014. Status report in accordance with Section 8(1): of the Research Organisation Act on federally subsidised research, technology and innovation in Austria

BMWFW, BMVIT (2015): Austrian Research and Technology Report 2015. Report of the Federal Government to the Parliament (National Council): under Section 8(2): of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria

Boekholt, P., Arnold, E., & De Heide, M. (2007): The use and effectiveness of programmatic policies – Some examples and evidence from around the world. Amsterdam: Technopolis Group

Claeys-Kulik, A.-L.; Estermann, T. (2015): DEFINE Thematic Report: Performance-based funding of universities in Europe; European University Association

Cornell University, INSEAD, and WIPO (2015): The Global Innovation Index 2015: Effective Innovation Policies for Development, Fontainebleau, Ithaca, and Geneva.

Cuntz, A. (2015): RIO Country Report 2014: Austria, European Commission, Luxembourg

Chaminade, C., Zabala, J.M., Treccani, A. (2010): The Swedish national innovation system and its relevance for the emergence of global innovation networks, Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE): Lund University, Paper no. 2010/09

Dachs, B., Dinges, M., Weber, M., Zahradnik, G., Wanke, P., Teufel, B. (2015): Herausforderungen und Perspektiven missionsorientierter Forschungs- und Innovationspolitik, AIT, Fraunhofer ISI im Auftrag der dt. Expertenkommission Forschung und Innovation (EFI).

Damsgaard, E. F., Thursby, M.C. (2013): University entrepreneurship and professor privilege, Industrial and Corporate Change, Volume 22, Number 1, pp. 183–218

DAMVAD (2014): Samproduktion för tillväxt – Resultat och effekter av forskningsfinansiering. Resultatrapport till KK-stiftelsen

Danish Agency for Science, Technology and Innovation (2011): Analysis of the Industrial PhD Programme

DASTI (2011): The impacts of cluster policy in Denmark – An impact study on the behaviour and economical effects of Innovation Network Denmark.

Danish Government (2003): New ways of interaction between research and industry – turning science into business, http://ufm.dk/en/publications/2003/files-2003/new-ways-of-interaction-between-research-and-industry.pdf

Danish Government (2006): Progress, Innovation and Cohesion – Strategy for Denmark in the Global Economy, Kopenhagen

Danish Government (2012): Denmark – a nation of solutions, Enhanced cooperation and improved frameworks for innovation in enterprises, Kopenhagen

Danish Market and Development Fund (2015): http://markedsmodningsfonden.dk/in_english

Danish Ministry of Science, Technology and Evaluation (2009): The University Evaluation 2009, Evaluation Report, Kopenhagen

Danish Ministry of Science, Innovation and Higher Education (2012): RESEARCH 2020, Strategic Research Horizons.

Danish Ministry of Science, Innovation and Higher Education (2013): Inno+ – the innovative Denmark, http://ufm.dk/en/publications/2013/files-2013/pixi_uk_web_pdfa1.pdf

Danish Ministry of Higher Education and Science (2015): Effects of participation in EU framework programmes for research and technological development – for researchers, institutions and private companies in Denmark; Research and Innovation: Analysis and Evaluation 3/2015

DEA (2013): Tech Transfer in Danish Universities – what have we learned from ten years of trying to make money on research?.

Dinges, M.; Zahradnik, G.; Wepner, B; Ploder, M.; Streicher, J.; Linshalm, E. (2015): Wirkungsanalyse 2015 des österreichischen Kompetenzzentrenprogramms COMET, im Auftrag der Österreichischen Forschungsförderungsgesellschaft (FFG)

DNRF Danish National Research Foundation (2014): Annual Report 2014, http://issuu.com/dnrf/docs/dnrf-annual-report-2014

Ecker, B., Kottmann, A., Meyer, S. (2014): Evaluation of the FWF Doctoral Programme (DK Programme); IHS, CHEPS, AIT on behalf of the Austrian Science Fund (FWF)

Edquist, C. (2015): Striving towards a Holistic Innovation Policy in European Countries – But Linearity Still Prevails, STI Policy Review_Vol.5, No.2

Edquist, C., Zabala-Iturriagagoitia, J.M (2015): The Innovation Union Scoreboard is Flawed: The case of Sweden –not being the innovation leader of the EU. Lund Papers in Innovation StudiesPaper no. 2015/16

Einarsson, S.; Wijström, F. (2015): European Foundations for Research and Innovation – Sweden Country Report; European Commission EUFORI-Study

Einarsson, S., Wijström, F. (2004): Foundations in Sweden – Their Scope, Roles and Vision, Stockholm School of Economics

EP-Nuffic (2015): Internationalising education Factsheet-Higher education system in the Netherlands, The Hague

EC (2008): Challenging Europe’s Research: Rationales for the European Research Area (ERA) – Report of the expert group; European Commission DG Research.

European Commission (2008): Progress in higher education reform across Europe, Governance and Funding Reform, Volume 2: Methodology, performance data, literature survey, national system analyses and case studies, CONTRACT – 2008 -3544/001 -001 ERA-ERPROG

European Commission (2011): COM(2011)808, Horizon 2020 – The Framework Programme for Research and Innovation

European Commission (2013a): She Figures 2012: Gender in Research and Innovation. Statistics, and Indicators. Brussels.

European Commission (2013b): The Glass Ceiling Index (GCI): Measures the relative chance for women, as compared with men, of reaching a top position

European Commission (2014a): ERAWATCH Country Reports 2013: Sweden, Luxembourg

European Commission (2014b): RIO-Country Report 2014: Austria

European Commission (2014/15): National Student Fee and Support Systems in Higher Education

European Commission (2015a): Innovation Union Scoreboard 2015

European Commission (2015b): The Digital Economy and Society Index (DESI): http://ec.europa.eu/digital-agenda/en/desi#_ftn1.

European University Association (2015): Public Funding Observatory; http://www.eua.be/publicfundingobservatory

EYGM Limited (2014): Adapting and evolving. Global venture capital insights and trends 2014.

Färnstrand D. E., Thursby, M.(015): University entrepreneurship and professor privilege, in: Industrial and Corporate Change, Volume 22, Number 1, pp. 183–218

FFG/eCorda (2015): EU-Performance Monitoring March 2015: https://eupm-portal.ffg.at/ui/wss/?_=eJw1z8EKgzAMBuBXGTk7ZOzW%2B44DL7t5iZJNwdqSpIpI333pdKf%2BX9okdIdVBNwOy0grcUk66kTgYA5Qgac5dch%2FagjTwY3ELIqa5GTOFWCM3pjEZlWwdqXxZunD0SLbcTcN3JuGcjHrFss2fjN6ElKrcYM6WK2t2%2FrxujbPtm4CK04nL4fs5UI%2B6gZOOdFvuXWVD%2BUvHgVEcA%3D%3D&user=public&pass=1VehiqTcWpwB2dNBUOW4gw%3D%3D#ietsn14i, extracted on 21.07.2015

Fosse, H. B.; Jacobsen, J.; Jacobsen, R. H. (2014): The Short-run Impact on Total Factor Productivity Growth of the Danish Innovation and Research System; Center for Economic and Business Researcher (CEBR) at Copenhagen Business School.

Frietsch, R., Haller, I., Funke-Vrohlings, M., Grupp, H. (2009): Gender-specific patterns in patenting and publishing, Research Policy, Vol. 38 Nr. 4

Frontier Economics (2013): Exploring the impact of private equity on economic growth in Europe, London

Frosch, H.; T. Alslev Christensen, Eds. (2011): Økonomiske effekter af erhvervslivets forskningssamarbejde med offentlige videninstitutioner. Innovation: Analyse og evaluering København, Forsknings- og Innovationsstyrelsen.

FTE – Austrian Science Fund (2013): Weißbuch zur Steuerung von Forschung, Technologie und Innovation in Österreich

FWF – Austrian Science Fund (2014): Annual Report 2014

FWF – Austrian Science Fund (2015): Doctoral Programmes (DKs), http://www.fwf.ac.at/en/research-funding/fwf-programmes/dks/

Gassler, H., Polt, W., Rammer, C. (2008): Priority setting in technology: Historical development and recent trends. In Nauwelaers C., Wintjes R. (eds.): Innovation Policy in Europe Measurement and strategy. Cheltenham, Edward Elgar.

Gassler, H., Sellner, R. (2015): Risikokapital in Österreich -Ein Flaschenhals im österreichischen Innovationssystem?, IHS-Policy Brief, Wien

Georghiou, L. (2008): Europe's research system must change; Nature 452, 04/2008

Greif, M., Mahlow, S., Pruever, T., Welk, V., Wunderlich, F. (2014): Venture Capital and Start-ups in Germany 2014. Berlin.

Griffioen, D. M. E., De Jong, U. (2012): Academic Drift in Dutch Non-university Higher Education Evaluated: A Staff Perspective, Higher Education Policy.

Hallonsten, O. (2014): ERAWATCH Country Reports 2013: Sweden, JRC Science and Technology Reports

Hicks, D. (2011): Performance-based university research funding systems, Research Policy 41 (2012): p. 251-261AIT

Hölzl, W. (2010): Austria's Small and Medium-sized Enterprises in the Financial Market Crisis, AUSTRIAN ECONOMIC QUARTERLY 1/2010

Hollensten, O. (2014): ERAWATCH Country Reports 2013: Sweden, JRC Science and Technology Reports

Ihsen, S., Schiffbänker, H., Holzinger, F., Jeanrenaud, Y., Sanwald, U., Scheibl, K., Schneider, W. (2014): Frauen im Innovationsprozess. Studien zum deutschen Innovationssystem Nr. 12-2014. Berlin: Expertenkommission Forschung und Innovation.

Jacobsson, C., Glynn, C., Lundberg, E. (2007): Equality between men and women in Swedish research funding? – An analysis of the Swedish Research Council's first years (2003-2005): Stockholm: Swedish Research Council.

Klitkou, A. (2013): Mini Country Report Denmark– Thematic Report 2011 under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)

Lähteenmäki-Smith, K.; Halme, K.; Lemola, T.; Piirainen, K.; Viljamaa, K.; Haila, K.; Kotiranta, A.; Hjelt, M.; Raivio, T.; Polt, W.; Dinges, M.; Ploder, M.; Meyer, S.; Luukkonnen, T.; Geoghiou, L. (2013): "Licence to SHOK?" External evaluation of the strategic centres for science, technology and innovation. Publications of the Ministry of Employment and the Economy.

Lundquist, M. (2015): Chalmers: an entrepreneurial university institutionalizing the entrepreneurial, in Foss, L., Gibson, D.V. eds. (2015): The entrepreneurial university – context and institutional change, Routledge.

Musset P., Bloem, S. Fazekas, M.and Field, S. (2013): A Skills beyond School, Review of Austria, OECD Reviews of Vocational Education and Training,

Niederl, A., Breitfuss, M., Ecker, B., Leitner, K-H. (2011): Modelle der Universitären Forschungsfinanzierung: Ausgewählte internationale Erfahrungen, AIT, JOANNEUM RESEARCH, Wien.

Niederl, A., Bader, L. (2014): Maßnahmen zur Standortattraktivität aus internationaler Perspektive, JOANNEUM Research

Norden Nordic Innovation (2012): The Nordic Growth-Entrepreneurship Review 2012, Nordic Innovation Publication 2012:25, Oslo

Nye Veje – Fremtidens videregående uddannelsessystem. Udvalg for Kvalitet og Relevans i de Videregående Uddannelser. 2014

Oddershede, J. (2009): Danish universities – a sector in change, Universities Denmark

Ödquist, B., Benner, M. (2012): Fostering breakthrough research: a comparative study, https://www.kva.se/globalassets/vetenskap_samhallet/forskningspolitik/2012/akademirapport_breakthrough_research_121209.pdf

OECD (2002): Frascati: Manual, Proposed Standard Practice for Surveys on Research and Experimental Development

OECD (2008): OECD Reviews of Tertiary Education: The Netherlands

OECD (2012): Meeting Global Challenges through Better Governance: International Co-operation in Science, Technology and Innovation, OECD Publishing.

OECD (2012): Reviews of Innovation Policy: Sweden, OECD Publishing

OECD (2013a): Commercialising Public Research: New Trends and Strategies, OECD Publishing

OECD (2013b): OECD Science, Technology and Industry Scoreboard 2013, OECD Publishing

OECD (2015): OECD Science, Technology and Industry Scoreboard 2015, OECD Publishing

OECD (2014a): OECD Reviews of Innovation Policy: Netherlands 2014, OECD Publishing

OECD (2014b): Education at a Glance 2014: OECD Indicators, OECD Publishing

OECD (2014c): OECD Science, Technology and Industry Outlook 2014, OECD Publishing.

OECD (2014d): Project of OECD CSTP working group TIP on Strategic Public/Private Partnerships (PPP)

OECD Publishing and DAMVAD (2015): Case Study Sweden, Copenhagen/Stockholm

Öquist, G., Benner, M.(2012): Fostering breakthrough research:a comparative study, AKADEMIRAPPORT, Stockholm

Österreichische Universitätenkonferenz (2015): Internationalisierungs Panorama I/2014, Wien

Österreichischer Wissenschaftsrat (2012): Fachhochschulen im österreichischen Hochschulsystem – Analysen, Perspektiven, Empfehlungen, Wien.

Pro Inno Europe (2011a): Mini Country Report/Denmark under Specific Contract for the Integration of INNO Policy TrendChart with ERAWATCH (2011-2012)

Pro Inno Europe (2011b): Mini Country Report/The Netherlands, under Specific Contract for the Integration of INNO Policy, TrendChart with ERAWATCH (2011-2012)

Sandström, U. (2015): Är forskning med svagt genomslag, Report for the Knowledge Foundation.

Scapolo, F., Churchill, P., Viaud, V., Antal, M., Cordova Gonzalez Castillo, H, L, De Smedt, P. (2014): How will standards facilitate new production systems in the context of EU innovation and competitiveness 2025?, JRC Foresight Study, Final Report

Schiefer, A. (2015): Innovationsaktivitäten der Unternehmen im internationalen Vergleich 2010-2012; Wissenschaft und Technologie, Statistische Nachrichten 2/2015, Statisik Austria.

Schibany, A.; Dinges, M.; Reiner, C.; Reidl, S.; Hofer, R.; Marbler, F.; Leitner, K.-H.; Dachs, B.; Zahradnik, G.; Weber, M.; Schartinger, D. (2013): Ex-post Evaluierung der Kompetenzzentrenprogramme Kplus und K_ind/K_net; im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie (BMVIT) und des Bundesministeriums für Wirtschaft, Familie und Jugend (BMWFJ).

Stern, P.; Arnold, E.; Carlberg, M.; Fridholm, T.; Rosemberg, C.; Terrrell, M. (2013): Long term industrial impacts of the Swedish competence centres; Technolopolis, VINNOVA Analysis 11/2013.

Swedish Agency for Growth Policy Analysis (2011): The Performance and Challenges of the Swedish Nation Innovation System, Östersund

Swedish Agency for Growth Policy Analysis (2013): Affärsänglar, riskkapitalfonder och policyportföljer; Rapport 2013:08

Swedish Government Bill 2008/09: 50, A Boost for Research and Innovation, Stockholm Ett lyft för forskning och innovation (translation: A rise for research and innovation): p. 51-66 http://www.regeringen.se/contentassets/05cb6c62a34e4b37a114611a3ebcbd5b/ett-lyft-for-forskning-och-innovation-prop.-20080950

Swedish Government Bill 2009/10: 139, Focus on knowledge – quality in higher education http://www.regeringen.se/contentassets/d82a2b51013248f799ccde61f329d3f3/fokus-pa-kunskap---kvalitet-i-den-hogre-utbildningen-prop.-200910139

Swedish Government Bill 2012/13: 30, Research and Innovation, http://www.government.se/contentassets/9131b15c802a44b9b196d442b498afdb/research-and-innovation---a-summary-of-government-bill-2012_13_30.pdf

Swedish Higher education authority (2013a): Decisions on criterions for evaluation 2013: http://www.uka.se/download/18.6c7a6cce13fa8f6b8e6232/1403093613298/412-582-13-beslut-generell-yrkesexamen-omg6-ny.pdf

Swedish Higher Education Authority (2013b): Universitet och högskolor Årsrapport 2013 https://www.uk-ambetet.se/download/18.1c251de913ecebc40e78000854/Arsrapport-2013.pdf

Swedish Higher Education Authority (2014): Forskningsfinansiering vid universitet och högskolor, http://www.uka.se/arkiv/effektivitet/forskningsfinansieringviduniversitetochhogskolor.5.10c9f1e5145028239db38.html

Swedish Higher Education Authority (2015): Annual report 2015 http://www.uka.se/download/18.68b9da0d14d8a7e2f5aab4e/1434628864514/eng-arsapport2015.pdf

Swedish Higher Education Authority (2015a): Higher Education in Sweden: 2015 Status Report

Swedish Higher Education Authority (2015b): Report on educational attainment and economic investment in the OECD, Tertiary education from an international perspective – a comparison based on Education at a Glance: http://uka.se/download/18.5bb4875214acdd3d8c854e85/1426234982290/rapport-2015-3-education-glance-eng-del1.pdf

Swedish Higher Education Authority (2015c): Trender och tendenser i Högskolan 2015: http://www.uka.se/download/18.6e65a54814c9d64344d17c4f/1433148038697/sammanfattning-arsrapport-2015.pdf

Swedish Knowledge Foundation (2014): Annual Report 2014, http://www.kks.se/om/SiteAssets/SitePages/In%20English/2014%20Annual%20Report.pdf

Swedish Research Council (2015): Evaluation of the strategic research area initiative 2010-14

The Swedish Agency for Growth Policy Analysis (2014): Riskkapitalstatistik 2013: Venture Capital – Investeringar i svenska portföljbolag

Thomson et al. (2015): European Foundations for Research and Innovation – Denmark Country Report, European Commission EUFORI-Study

Tijssen, R.J.W. (2012): Co-authored research publications and strategic analysis of public private cooperation, Research Evaluation, Oxford University Press

Tykvova, T., Borell, M., Kroencke, T.-A. (2012): Potential of Venture Capital in the European Union. Brussels.

Unger, M., Polt, W. (2014): OECD-TIP Case Study: Christian Doppler Research Association, on behalf of the Austrian Ministry for Science, Research and Economy.

UNIKO (2014): Internationalisierungspanorama, Publikationen I/2014

Vestergaard, J. (2003): Promoting university interaction with business and community – a comparative study of Finland, Sweden and UK, Institute of Management, Politics and Philosophy at Copenhagen Business School on behalf of Danish Ministry of Science &Technology

VINNOVA (2011): Innovative Growth through Systems Integration and Globalisation – International Evaluation of the 2004 VINNVÄXT Programme Initiatives

VINNOVA (2013): Challenge Driven Innovation – Societal challenges as a driving force for increased growth

Vossensteyn, H. (2011): The PhD system, policies and infrastructure of the Netherlands – A critical analysis, Report for the EMUNI PhD Policy Group

Wennerås, C., Wold, A. (1997): Nepotism and sexism in peer-review. Nature, 387/6631, pp. 341-343.

WIFO, Prognos, KMU Forschung Austria (2009): Systemevaluierung der österreichischen Forschungsförderung und -finanzierung, Teilbericht 5: Das Angebot der direkten FTI-Förderung in Österreich

8 Annex

Table 19: Interviewees in Sweden

Interviewee	Position	Institution
Joakim Appelquist	Director, Head of International Division	VINNOVA
Harriet Wallberg	Chancellor	Swedish Higher Education Authority
Charlotte Brogren	Director General	VINNOVA
Carl-Henrik Heldin	Vice-President (ERC); Deputy vice-chancellor	ERC; Ludwig Institute for Cancer Research
Anders Malmberg	Deputy vice-chancellor at University Management and Management Council	Uppsala University
Enrico Deiaco	Director of the Department	Tillväxtanalys - Swedish Agency for Growth Policy Analysis
Anders Flodström	Former Vice chancellor	KTH
Michael Jacob	Senior adviser	Ministry of Enterprise & Infrastructure
Göran Marklund	Director, Department Business Development and Analysis	VINNOVA
Ulf Wahlberg	Industry and Research Relations	Ericsson
Madelene Sandström	CEO	Swedish Knowledge Foundation
Olof Sandberg	Strategy & Financing	RISE
Annette Moth Wiklund	Chief Adviser International Affairs	Swedish Research Council

Table 20: Interviewees in Denmark

Interviewee	Position	Institution
Jens Oddershede	Former dean	University of Southern Denmark
Stina Wrang Elias	Director	DEA
Thomas Alslev Christensen	Director	Novo Nordisk Fonden
Jens Maaløe	President and CEO	Terma
Birte Holst Jørgensen	Deputy head of department	Danish Technical University
Nicolai Zarganis	Head of department	The Danish Agency for Science, Technology and Innovation
Maria Theresa Norn	Director of Analysis	DEA
Kim Brinckman	Director of Research and Innovation	University of Copenhagen
Jonas Orebo Pyndt	Senior Advisor	DI-Confederation of the Danish Industry
Hanne Leth Andersen	Dean	Roskilde University
Ragnar Heldt Nielsen	Director	GTS
Ole Lehrman Madsen	CEO	IT-specialized GTS institute Alexandra
Conni Simonsen	Director	Engineering School, Aarhus Universitet, Innovation Council
Katrine Nissen	Head of Division	DASTI
Lars Fremerey	Chief Consultant	GTS
Susanne Kure	Vice Chair	Vaekstfonden

Table 21: Indicators to measure the national innovation strategy in Sweden

Main targets and suggested indicators 2014	
1.	**Innovative people**
1.1	People have knowledge, competence and skills to contribute to education
-	Skills of Swedish 15 year-olds
-	Skills of Swedish adults
1.2	People dare and want to contribute to innovation as entrepreneurs, leaders, co-workers, users and citizens
-	Attitudes towards entrepreneurship
-	New entrepreneurs as share of population
1.3	Sweden's labor market international attraction and openness
-	Labor immigration from non-EU countries
-	Share of Ph.D students from non-EU countries
2.	**Research and higher education of high quality**
2.1	The contribution of Education and research at universities and university colleges with world class quality and relevance to innovation
-	Swedish higher education in comparison in international comparison
-	Swedish research in international comparison
2.2	Research institutes in world class meets the knowledge and development needs in business and society
-	FP-7 participation
2.3	Strong nodes of research well positioned in global knowledge networks
-	Swedish participation in the EU framework for research
-	Co-publications between Swedish and foreign researchers
3.	**Frameworks for infrastructure and innovation**
3.1	Regulation, market terms and norms promoting innovation
-	Doing business indicators
3.2	Well-functioning access to competent capital that promotes the innovation and growth of businesses
-	Externally invested capital in early stage
3.3	Sustainable physical and digital communication that promotes innovation
-	Development of transport investments
-	ICT-investments in capital services
4.	**Innovative businesses and organizations**
4.1	Businesses in Sweden growing by offering innovative solutions to global markets
-	Share of domestically produced value added in exports
-	Share of innovative companies being active on markets outside of Sweden according to innovation surveys.
4.2	Existing and new firms work systematically with strengthening its innovation ability
-	Share of innovative businesses that introduced a market innovation
4.3	Use the potential in social innovation and "society-entrepreneurship" to meet challenges in society
-	Share of yearly equivalents in exclusion (people not working and getting government support)
5.	**Innovative public organizations**
5.1	Public organizations work systematically with innovation to improve efficiency and quality
-	SCB:s pilot survey: Measuring Public Innovation (MEPIN)
-	R&D expenditure in the public sector
5.2	Public organizations contribute to developing innovation solutions to meet societal challenges
-	Innovation activity in Swedish companies 2010-2012
5.3	Efficient public solutions to innovation supporting organizations with focus on client-utility
-	The UNs e-management report
6.	**Innovative regions and environments**
6.1	Swedish regions develop its innovation based on its unique capabilities
-	R&D in universities per municipality
-	R&D in businesses per municipality
-	Number of new business/work establishments
6.2	Regional strategies for innovation is rooted in a comprehensive regional strategy
-	Smart specialization and cluster initiatives per municipality

Source: The Swedish Agency for Growth Policy

Table 22: Participations (%) in FP6 by program (numbers in % of total national)

Pillar	Program	AT	DK	NL	SE	Total FP
Euratom	Euratom	0,51	0,55	1,35	2,61	1,39
Integrating and strenghtening the ERA	Life sciences, genomics and biotechnology for health	9,31	12,37	11,51	14,01	11,87
	Information society technologies	22,06	12,13	14,19	16,92	16,05
	Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices	7,92	6,52	6,65	7,74	7,15
	Aeronautics and space	3,08	1,40	3,85	4,68	3,53
	Food quality and safety	3,14	8,41	6,46	3,78	5,45
	Sustainable development, global change and ecosystems	15,84	19,13	16,76	16,09	16,79
	Citizens and governance in a knowledge-based society	3,50	2,68	2,75	2,49	2,81
	Horizontal research activities involving SMEs	7,87	7,43	6,50	5,93	6,76
	Policy support and anticipating scientific and technological needs	5,66	9,57	8,89	5,70	7,57
	Specific measures in support of international cooperation	2,37	1,77	1,50	1,28	1,65
	Support for the coherent development of research & innovation policies	0,62	0,12	0,22	0,26	0,29
	Support for the coordination of activities	3,24	2,32	2,06	2,11	2,34
Structuring the ERA	Human resources and mobility	8,48	10,42	12,40	10,54	10,87
	Research and innovation	2,47	2,01	1,15	2,08	1,78
	Research infrastructures	1,65	1,34	2,43	2,45	2,11
	Science and society	2,31	1,83	1,33	1,32	1,59
	Total FP	100	100	100	100	100

Source: FFG, eCorda

Table 23: Participations (%) in FP7 by program (numbers in % of total national)

Pillar	Program	AT	DK	NL	SE	Total FP
Cooperation	Energy	3,61	5,95	3,47	3,17	3,79
	Environment (including Climate Change)	5,92	6,35	7,01	4,90	6,21
	Food, Agriculture and Fisheries, and Biotechnology	4,84	10,35	8,00	4,62	6,95
	General Activities	0,31	0,18	0,09	0,13	0,15
	Health	7,99	9,62	10,76	10,96	10,13
	Information and Communication Technologies	21,25	10,78	14,28	15,20	15,29
	Joint Technology Initiatives (Annex IV-SP1)	6,06	5,70	5,50	5,73	5,69
	Nanosciences, Nanotechnologies, Materials and new Production Technologies - NMP	6,88	8,10	6,31	8,32	7,15
	Security	3,53	1,53	3,02	3,37	2,98
	Socio-economic sciences and Humanities	2,87	2,36	2,21	1,73	2,24
	Space	1,96	1,53	1,55	1,31	1,56
	Transport (including Aeronautics)	6,14	3,59	6,42	9,03	6,58
Ideas	European Research Council	3,61	3,45	5,77	4,08	4,63
People	Marie-Curie Actions	12,63	15,72	13,88	13,20	13,75
Capacities	Activities of International Cooperation	1,56	0,18	0,20	0,27	0,46
	Regions of Knowledge	0,80	0,69	0,63	0,95	0,74
	Research for the benefit of SMEs	4,81	7,88	3,99	5,42	5,05
	Research Infrastructures	2,99	3,30	4,42	3,68	3,81
	Research Potential	0,03	0,00	0,00	0,02	0,01
	Science in Society	1,79	2,14	1,39	1,44	1,59
	Support for the coherent development of research policies	0,17	0,04	0,09	0,11	0,10
Euratom	Fusion Energy	0,06	0,07	0,04	0,02	0,04
	Nuclear Fission and Radiation Protection	0,20	0,47	1,03	2,31	1,10
	Total FP	100	100	100	100	100

Source: FFG, eCorda

*Table 24: Participations (%) in H2020 by program (numbers in % of total national)**

Pillar	Program	AT	DK	NL	SE	Total FP
Excellent Science	European Research Council	3,25	5,04	5,24	3,43	4,44
	Future and Emerging Technologies	2,23	1,59	1,16	2,29	1,67
	Marie Sklodowska-Curie actions	12,37	30,24	20,53	16,00	19,44
	Research infrastructures	3,45	1,59	5,60	4,57	4,37
Industrial Leadership	Information and Communication Technologies	16,43	7,16	11,64	13,14	12,22
	Nanotechnologies, Advanced Materials and Production	2,64	0,80	1,07	0,57	1,23
	Advanced materials	0,00	0,00	0,18	0,19	0,12
	Biotechnology	1,01	0,80	0,62	0,19	0,63
	Advanced manufacturing and processing	3,45	0,27	2,67	4,95	2,94
	Space	2,64	1,59	1,69	1,90	1,90
	Access to risk finance	0,00	0,00	0,36	0,00	0,16
	Innovation in SMEs	1,42	0,80	0,18	0,76	0,63
Societal Challenges	Health, demographic change and wellbeing	7,51	11,41	12,44	10,10	10,83
	Food security, sustainable agriculture and forestry, marine and maritime and inland water research	2,64	10,88	6,40	3,62	5,75
	Secure, clean and efficient energy	12,37	9,28	7,11	9,90	9,05
	Smart, green and integrated transport	11,97	9,55	9,60	9,33	10,00
	Climate action, environment, resource efficiency and raw materials	6,29	4,77	7,11	6,86	6,55
	Europe in a changing world - inclusive, innovative and reflective Societies	3,04	1,86	1,60	2,86	2,18
	Secure societies - Protecting freedom and security of Europe and its citizens	2,64	0,80	2,13	2,67	2,14
Spreading excellence and widening participation	Teaming of excellent research institutions and low performing RDI regions	3,25	0,27	1,51	3,24	2,02
Science with and for Society	Develop the governance for the advancement of responsible research and innovation	0,41	0,27	0,00	0,19	0,16
Euratom	Euratom	1,01	1,06	1,16	3,24	1,55
	Total FP	100	100	100	100	100

* based on approved submissions until 03/2015
Source: FFG, eCorda

JOANNEUM RESEARCH
Forschungsgesellschaft mbH

Leonhardstraße 59
8010 Graz

Tel. +43 316 876-0
Fax +43 316 876-1181

pr@joanneum.at
www.joanneum.at

oef mfg 12 008