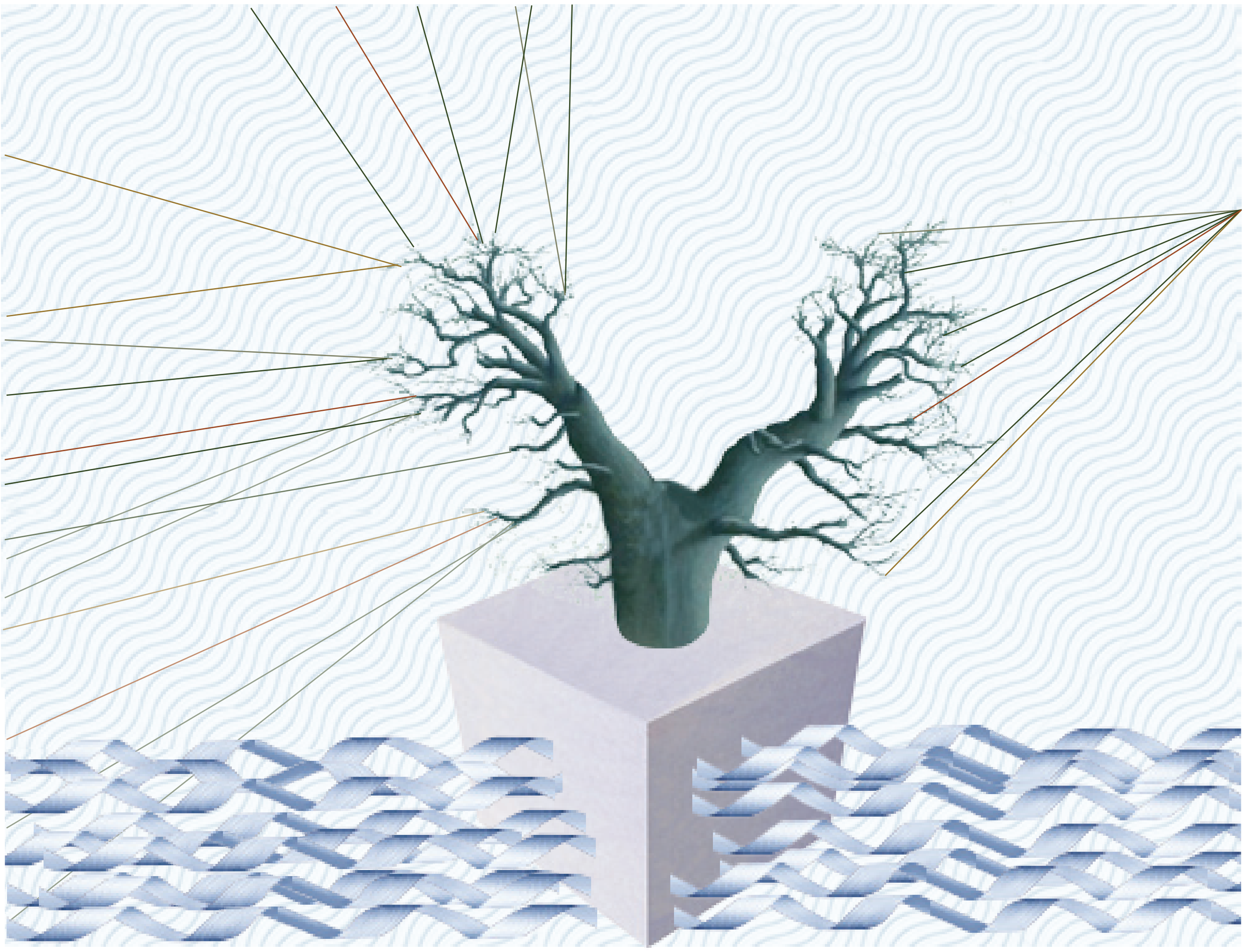
Can Basic Research Prevent Economic Stagnation?

Andreas Schibany, Christian Reiner



Decreasing performance in innovation may lead to re-enforcement of economic stagnation in developed countries. Well-balanced development of projects aimed at finding answers to the 'grand challenges', in parallel to curiosity-driven research, could make notable contribution in preventing such a negative trend.

Evidence from Austria shows the contradictions intrinsic to well-established innovation systems. The authors recommend re-adjusting mechanisms that foster career development in academia and creating organizations with sufficient administrative capacities and autonomy to attract qualified staff and funding.

Andreas Schibany — Research Fellow

Christian Reiner — Research Fellow.
E-mail: christian.reiner@ihs.ac.at

Institut für Höhere Studien — Institute for Advanced Studies, Austria

Address: Stumpergasse 56, 1060 Vienna, Austria

Keywords

basic research;
applied research;
free research;
'European paradox';
Austria

Citation: Schibany A., Reiner C. (2014) Can Basic Research Prevent Economic Stagnation? *Foresight-Russia*, vol. 8, no 4, pp. 54–63.

Stagnation Theory and Innovation Deficits

Recently, the debate surrounding technological progress has adopted an unusually pessimistic tone, as shown by US economist Tyler Cowen in his much talked-about book 'The Great Stagnation' [*Cowen*, 2011a]. This was supported pictorially by *The Economist* in 2013 with the headline picture of Rodin's *Thinker* shown sitting on a plinth made of a toilet complete with cistern [The Economist, 2013]. This illustration can be understood through the ideas of one of the well-known pessimistic economists, Robert Gordon [*Gordon*, 2012], who proposed the so-called 'toilet test' to assess the significance of innovations arising in different historical periods. He identified declining innovation performance in the Western world's most recent past and predicted that this trend would continue for the foreseeable future. According to the 'toilet test', let us assume you are offered the choice of the following options:

- Option A: You may use all innovations which were invented *up to* 2002, including PCs, running water and indoor flushing toilets;
- Option B: You may use all innovations, notably those invented *since* 2002 (e.g. Twitter, Facebook) but you must do without running water and indoor flushing toilets.

If you picked A, you are with the majority of all previous participants who have done the toilet test for innovation performance. Clearly, inventions from the 19^{th} century are considerably more useful and more fundamental than all the innovative electronic gadgets which we seemingly benefit so much from using.

The essence of these arguments is that advanced, modern economies have reached a technological plateau. In contrast to previous eras, the capacity for technological modernization in the recent past appears to be nowhere near that of the 1960s. This is in spite of unprecedented volumes of human resources, financial investment and competition in research. As Cowen vividly argued, we have already harvested all the '*low hanging fruits*' [*Cowen*, 2011a] which makes it increasingly difficult to generate new impulses for growth from today's plateau.[1] Even the achievements to date of the digital age do not reflect on better labour productivity, as shown by the example of the US from 1891 to 2012 (Figure 1).

Andreas Schibany (1966–2014)

This article (in English and Russian) is a reprint of a working paper in German by the Austrian Institute for Advanced Studies [*Schibany, Reiner*, 2013]. It commemorates one of its co-authors, Andreas Schibany (1966-2014).

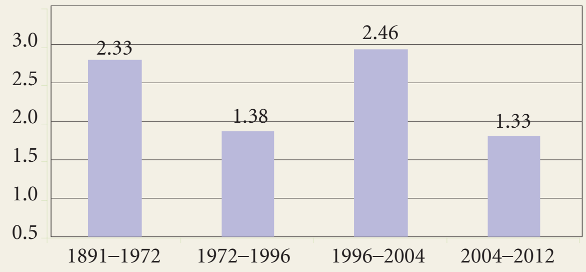
Andreas was born in 1966 and grew up in Vienna, Austria. His intellectual interests and inquisitive mind covered a broad variety of subjects and found expression in his successive studies at Vienna University, first of philosophy and sociology, and later of economics.

Andreas worked at the Austrian Research Centre Seibersdorf (in the Austrian Institute of Technology), the Institute for Technology and Regional Policy of the Joanneum Research Centre, and then at the Institute of Advanced Studies in Vienna. Andreas was a well-known and widely respected authority on a wide range of questions related to science, technology, and innovation policies, the internationalization of R&D, higher education, evaluations and comparative studies of national innovation systems, and the interactions between research and industry.

His academic and research output includes well over a hundred research papers, reports, book chapters and policy briefs. For many years, Andreas was the main author and coordinator of the annual Austrian Research and Technology Report. Andreas was a frequent speaker at public events and a frequent commentator in the media. He was a much respected for his razor-sharp logical thinking, his ability to review and discuss issues in their wider historical and societal context, and his constructively-critical approach to analyse current political, economic and social affairs. After a protracted illness, Andreas Schibany died in June 2014 at the age of 48. He is much missed by all those who knew him.

[1] 'Undoubtedly, high technology gadgets such as personal computers and smartphones have triggered massive changes. The quality of many goods and services has increased and their range has expanded. But if you go with what my grandmother says, the most important used objects have remained the same.' [*Cowen*, 2011b].

Figure 1. **Labour productivity growth in the USA** (as a percentage per year)



Source: [*Gordon*, 2012].

The computer-driven third industrial revolution began in the 1960s and could not prevent the considerable reduction in productivity growth in the ensuing decades (1972–1996). The famous quotation from Robert Solow came from this period: '*We can see computers everywhere except in the productivity statistics.*' [*Solow*, 1987]. Certainly, a considerable increase in productivity of 2.46% on average occurred shortly afterwards in the period from 1996 to 2004. The ICT sector and the new economy seemed to fulfill their expectations. However, in truth, the benefit of hindsight allows us to understand that it was just a relatively breathless growth spurt, which was replaced in the years to follow by a new drastic reduction in productivity growth. Admittedly, some remain optimistic and argue that this gloomy scenario is because the full productivity benefits of computer technology will not be fully realized for a long time (as shown already by a plurality of new technological uses of computer technology, such as 3D printers). Despite this, on a realistic medium-term development path economic stagnation remains possible as the reason for fewer basic innovations which would increase productivity growth over time. If one considers the burdens of an ageing population and rising debt levels which have arisen as a result of the great recession, this scenario looks ever more likely [*Krugman*, 2013].

Science policy must address how to overcome this negative economic scenario. There are many lively discussions about growth policy and innovation policy instruments [*Keuschnigg et al.*, 2013]. This article concentrates on the role of basic research systems in growth processes and its recent dynamics. Ultimately, science is an important catalyst for innovation, which is, in turn, the most important driver of economic development: '*Fundamental R&D, mostly undertaken and funded by governments, provides the foundation for future innovation*', as the OECD states in its innovation strategy [OECD, 2010]. However, a more rigorous analysis of the basic research system highlights several problems and organizational deficits in basic research which restrict its potential stimuli effects on innovation and growth.

Basic Research versus Applied Research

The official definition of basic research has remained mostly unchanged since 1963, when it was stated as follows by the OECD's Frascati Manual:

'*Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.*' [OECD, 1994].

Before the 1963 OECD definition appeared, there was much debate in the USA about how to appropriately classify research. The results of this process were the establishment of the National Science Foundation (NSF), and creation of a statistical database, which led to greater understanding of atricky and all-encompassing concept. To date, it has not been possible to clearly distinguish between *basic* and *applied* research. For this reason, debate continued about suitable definitions of the terms. New definitions of free, basic research that were generated include: '*pure, strategic, curiosity- driven*'. It was suggested that the differences between '*basic pure*' and '*basic-oriented*' research be highlighted.

Benoît Godin has a provocative theory as to why such a *fuzzy concept* could endure so long despite much criticism:

'*The concept of basic research has existed for so long because society defines itself according to it and significant resources and actions (science policy) are attached to the idea. Above all else, the concept is a category; and categories very often acquire social and political existence through numbers.*' [*Godin*, 2000, pp. 2–3].

The definition of basic research does not just have a semantic nature, but also determines financing streams and obligations. In providing financial resources, the state — represented by various institutions or agencies — starts from a self-definition. The definition of *basic research* remains, however, illogical. In the literal sense, it means that a research project is applied when the researcher knows the purpose of the research, and basic when this is not the case. Today there is a complementary, not diverging, relationship between basic and applied research. Distinguishing between the two types of research is harder and we witness a continuum of research where both types complement each other and partially overlap. This can be best observed in universities.

According to the latest Austrian R&D surveys published by Statistics Austria (*Statistik Austria*), 54% of university-based R&D projects is basic research and 46% is applied research. This explains why it makes more sense to talk about 'academic research' as this can be more freely defined, rather than divide research into specific types as the latter is increasingly becoming irrelevant and meaningless.

Even the integral criterion of excellence is of little use for spelling out what basic research means. The scientific community (or the *science lobby*, according to [*Arnold, Giarracca*, 2012, p. 4] and businesses interpret R&D excellence in different ways. For if the excellence criterion alone determines the selection and funding of research projects, the other criteria for allocating funding reduce the relevance of the single 'excellence' criterion. It is clear that the significance and originality of research results and social and/or economic relevance do not always contradict each other. If nearly half of Austria's research carried out in the higher education sector is applied, then the state cannot exclusively fund 'free and curiosity-driven research.' Greater competition for funding only has a limited effect as the excellence criteria differ so much across scientific disciplines and even research projects, which it makes it hard to compare.

Finally, even when all the elements come together — competition, excellence criteria, and the *peer review* process — the science sector is still suffering a crisis of quality. This is explicitly supported by a quote from a recent issue of *The Economist*:

'*Professional pressure, competition and ambition push scientists to publish more quickly than would be wise. A career structure which lays great stress on publishing many articles exacerbates all these problems. This means that the majority of the 'discoveries' in academia are the result of negligent experiments or superficial analysis.*' [The Economist, 2013].

The American Age and the 'Mark II' Innovation Model

Technical sciences proved their military utility during the Second World War, and could finally establish themselves at American universities in the succeeding years. These developments enabled the distinction between '*applied*' and '*basic research*' to become sharper. Basic research was aided by the way American universities self-identified as the protectors of true and pure science, as only their representatives fully possessed academic impartiality: hence universities saw themselves as the source of scientific progress.

Basic research was understood as servicing this hierarchy of values. Robert Merton declared, as early as the start of the 1940s, that the research university was the only institutional home of science [*Merton*, 1942]. The surprising point is that Merton's ideology of the 'ivory tower' found support from a source he would have least expected it: from the management of large commercial laboratories [*Hirschi*, 2013]. Thus, Kenneth Mees, head of the Eastman Kodak Research Library for many decades, stressed the optimal organizational advantages of a university in particular and attempted to reconstruct this commercially. Industrial academics should be able to research as freely and independently as possible, and to do this they need as little interference from outside as possible and flat hierarchies internally. Like Merton, Mees did not believe that scientific researchers' capabilities were the deciding factor for the success of research, but rather the academic culture and university structure. In Merton's and Mees' time, the issue of making research more efficient was not as pressing as it is today. The prevailing view was that it was necessary to invest however much resources (personnel, ideas, money and time) as was required. Mees saw *basic research* as the most important source of innovation and the starting point for all further technological development [*Ibid.*].

A similar 'linear model' was championed by physicist Mervin Kelly, who between 1934 and 1959 led the Bell Labs within the AT&T company. He named Bell Labs an '*Institute of Creative Technology*' [*Gertner*, 2012] and directed his focus particularly towards establishing communication structures between the 5700 scientists, engineers and technicians in order to achieve the knowledge exchange and necessary integration which was necessary for the production of commercial goods. The monopoly of AT&T was ultimately broken up by regulatory and judicial interventions between 1974 and 1984. It is noteworthy that the Bell Labs of AT&T was not the only firm to combine innovative basic research with a monopoly position on the market. Until the 1960s, several research-intensive monopolies, including Eastman Kodak and IBM, developed transformative innovations. These innovations arose not because of competition but because of the companies' monopolistic status that allowed the market leaders to invest significant financial resources, personnel and time in basic research. This innovation process is called the 'Mark II' model in economics and comes from the theory proposed by Joseph Schumpeter in his later work. While Schumpeter's earlier ideas argued that the main drivers of innovation were the dynamic, small and medium companies ('Mark I' model) [*Schumpeter*, 1934], he later argued that the main determinants of innovation were established monopoly companies [*Schumpeter*, 1942].

This American dream ended on October 4, 1957. On this day, the Soviet Union sent its first satellite into orbit and the USA fell into a state of shock, perceiving that its technological advantage was threatened. Politicians felt the need to intervene by significantly increasing state R&D expenditure. The National Science Foundation (NSF) was founded at the start of the 1950s; its annual budget increased from USD34m in 1959 to USD134m, and USD500m in 1968.

The status of research establishments also changed at this time. The existing policy up to the late 1950s had been to allow basic research complete freedom for ten years without imposing any guarantees of success, as Mees had demanded; after 1957, this appeared a luxury which could not be afforded in the face of the technological threat of the Soviet Union. With the rapid growth of state R&D support, a battle over the distribution of the funding between diverse research establishments broke out and certain rules were needed to regulate funding distribution. The research sector first saw the introduction of something resembling competition as a selection mechanism, which signaled the beginning of the 'age of marketing and self-representation in science.' Every publication, however unimportant, served as a signal and every small innovation was trumpeted as an immense breakthrough in an attempt to acquire funding.

Thus not only did the nature of industrial research change, but so too did the relationship between industry and universities. The corporate industrial giants withdrew from costly lab work and turned instead to co-operation with universities and state scientific institutions. Greater division of labour between industry and universities began. At the same time, new research areas were developed which attracted the interest of basic research. The most prominent example is the biotechnology sphere, where thanks to developments in the technological base the boundaries between basic research and industry have begun to erode [*Pisano*, 2006].

This brief historical perspective helps us to better understand what forms of interactions between science and industry are possible and the value of basic research for companies. In this context, we often hear critiques about the insufficient intensity of knowledge transfer from research to the commercial sector. A closer examination, however, disproves such beliefs to some extent.

The European Paradox

Many of the funding measures on a European level in the 1990s were induced by grave and hard-to-correct problems which dominated much of European innovation policy. Thse problems came to be known as the '*European Paradox*': the situation where Europe has great strengths in research compared to the USA but weaknesses in converting these scientific results into innovations [European Commission, 1995]. The European framework programmes were largely implemented under the influence of this paradox [*Arnold et al.*, 2011]. The problem of transforming research into innovation was seen by many European decision makers as a failure, which they proposed to overcome by emphasizing the development of networks, co-operation, and effective co-ordination of research. The belief in this paradox is still widespread today, as shown by the European Council's decisions in 2011 and 2012: '*Innovation and research are at the heart of the Europe-2020 strategy. Europe has a strong science base but is not yet capable of transforming research into new innovations targeted to market demands – an issue that needs to be addressed if the Europe-2020 strategy is to be implemented successfully.*' [European Commission, 2012, p. 1].

At the same time, many commentators also saw in this '*networking frenzy*' [*Dosi et al.*, 2006, p. 1461] one of the reasons for a less successful European innovation policy. While the US remains the leader[2] for the quality of research, '*Europe is bad at innovation because it is bad at innovation; the amount and quality of European research has little to do with this.*' [*Arnold, Giarracca*, 2012, p. 46].

Table 1 shows the main indicators of research productivity in the US and EU. The most important result is in the last line, which summarizes all research areas. While the quantity of articles is higher in the EU than the US, US articles are cited significantly more frequently than EU publications. Despite problems

Table 1. **The productivity of research in the EU and US: 1998–2002***

	Share of total articles (%)		Share of total citations (%)		Normalized average number of citations	
	USA (1)	EU (2)	USA (3)	EU (4)	USA (5)=(3)/(1)	EU (6) =(4)/(2)
Social Sciences	55.90	27.60	66.90	25.50	1.20	0.92
Natural Sciences	25.20	37.40	37.90	42.00	1.50	1.12
Life Sciences	38.00	39.20	51.00	39.30	1.34	1.00
All Sciences	32.90	36.70	46.30	39.50	1.41	1.08

*Data comprise 3.6 million articles and 47 million citations.
Source: [*Albarran et al.*, 2010].

[2] 'Despite the fact that the US publishes fewer articles than EU countries, US papers overwhelmingly dominate overall compared to those from the EU …' [*Herranz, Ruiz-Castillo*, 2011, p. 12].

associated with bibliometric indicators, they are an important indicator of the high significance and quality of R&D in the US. Hence, the *'EU's* lagging behind is unlikely to be caused by weak industry — university co-operation.' [*Dosi et al.*, 2006, p. 1458].

The aforementioned problem of the 1990s no longer exists in the same form. Development of research-intensive industrial sectors (such as the chemical and pharmaceutical industries, electrical engineering, machinery construction, and the automotive industry) is impossible without inputs of new ideas from research. In addition, researchers co-operate with industry not so much to commercialize their knowledge but more to search for ideas for their research (for example, in the medical industry). Co-operation with companies gives researchers an understanding of current social and economic issues, which in turn gives momentum to their scientific research. Under an effective industry-university partnership, the dangers of reduced autonomy for university research are minimal. Today, knowledge transfers between research and industry should therefore be understood in a broader and more comprehensive way, in particular stressing the benefits for research. This knowledge transfer can work through different channels:

- research by contract and scientific-technical consultancy;
- shared use of research infrastructure;
- mobility of researchers between research and industry[3];
- founding of companies by scientists (spin-offs);
- education of highly qualified human resources (*'knowledge transfer face-to-face'*), the lack of which is a much more serious obstacle for innovation in companies than access to new technologies or finding suitable co-operation partners [FTB, 2012, p. 107].

Although the hurdles for research and industry collaboration on joint research projects have been mainly overcome, a particular '*entrepreneurial spirit'* does not yet seem to have taken root in universities. Getting a worthy research career in a university requires, first and foremost, the proven ability to attract external funding for projects and publications in high-ranking, international journals. The contemporary system of incentives in universities is biased towards the educational process and not on the transfer of new technologies to the real economy. For the situation to evolve, we need to change the image of universities and make researchers aware of companies' needs. A broad array of mechanisms is available to achieve this, including teaching entrepreneurial skills, offering researchers 'creative sabbaticals' for researchers to launch start-ups, and awards for the best university spin-off.

The fear that supporters of the 'Humboldt model' often share and voice — is that such an approach may lead to an 'economization of research', which would thus restrict free, curiosity-driven research. While such worries are not groundless, the majority of research has some immunity against such 'commercialization'. Furthermore, there is evidence of a complementary relationship between the creation of economically relevant outputs (measured by contract research, spin-offs, R&D services, patents, etc.) and the number of scientific publications [*Crespi et al.*, 2008; *Lotz et al.*, 2007; *Link et al.*, 2007) As Crespi et al. wrote:

'*Top researchers succeed [in publishing and patenting] a lot; a high patent output does not seem to [negatively affect] the publication output of the most prolific researchers.*' [*Crespi et al.,* op. cit., 2008, p. 3]. According to bibliometric analysis, research projects carried out on behalf of or in co-operation with industry are capable of producing excellent scientific results [*Arnold et al.*, 2004; *Balconi et al.*, 2006; *Lebeau et al.*, 2008; *Labory et al.*, 2008; *Abramo et al.*, 2009; *Perkmann et al.*, 2011).

[3] '*The best technology transfer is a pair of shoes*' [*Bramwell, Wolfe*, 2008].

How to provide effective support for research in Austria?

In the last 15 years, Austria has become one of the leading nations for innovation. This achievement was helped by first and foremost, joining the EU, the implementation of large structural programmes, the openness of Austrian companies to innovation and their ability to compete, the strong internationalization of academic research, and the creation of new framework conditions. The fact that Austria is frequently described as having a 'mature' innovation system does not insulate the country against different kinds of crises. Besides, as in finance where an ailing bank can ruin the financial sector, the innovation system can be damaged by an ineffective university that receives resources from the state budget for many years. Nevertheless, whether or not the social returns would increase given a stable volume of investment is a question that needs further analysis.

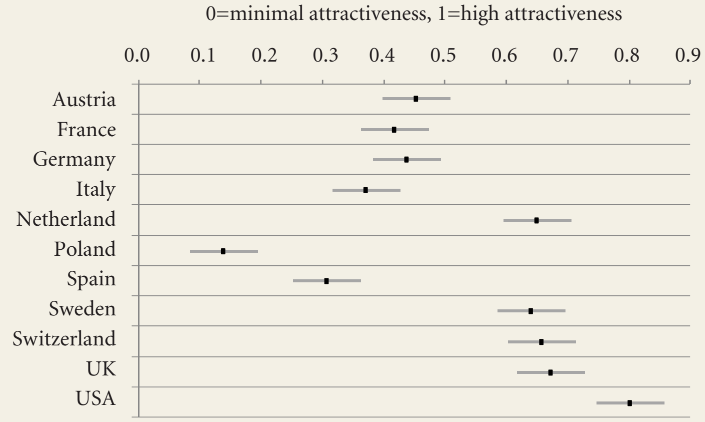
As in many policy areas, the effectiveness of research is assessed by the relationship between inputs and outputs, even though such links are quite hard to measure. However, we note that on this indicator — even taking into account the methodological difficulties — Austria is considered to have an efficient innovation system [DTS, 2012]. When an innovation system still finds itself in the catching-up process, i.e., behind the *technological frontier*, then the funding instruments for research and requirements for this process should be adapted accordingly. Thorough attention to science, technology, and innovation development and comprehensive project support customized to companies' needs indicate that Austria has not adapted the funding instruments to the new environment but simply widened the list of existing instruments.

There have been intense discussions about funding allocations for different research areas as such resources are discretionary. Moreover, Austria's priority goal has for many years been to maintain manufacturing. In connection with this goal, the government has broadened existing programmes to support companies and created new ones. There is evidence to show that the role of state financing in determining a company's choice of location for production is at times exaggerated. Industry tends to emphasize this argument about the importance of state funding [OECD, 2011; *Schibany et al.*, 2013a]. In fact, the decision about a company's production location is really determined by other factors.

Two facts are significant and worth noting. First, recent studies show that 93% of successful export-oriented innovative companies in Austria ('*frontrunner companies*') are not planning to move their production and R&D facilities to other countries [*Schibany et al.*, 2013b]. Second, mobility is key characteristic of Austria's research sector. Although universities cannot change their location, the high levels of mobility among individual researchers can seriously affect the entire university's research strategy. Figure 2 shows that for Austria, inward migration of specialists with higher education is not high enough. In particular, Austria needs to provide opportunities for stable career growth based on performance to increase the country's attractiveness.

A characteristic of innovation-leading nations is that innovations and technologies are increasingly research-intensive. Supporting long-term research enables new knowledge to be created and the country to be embedded in international networks. It is these initiatives as well as advanced technologies and global networks that are the sources of global competitiveness. Austria's science funding system is based on a mistaken idea that any given project should be limited in time and is an isolated project. Thus the whole set-up needs fundamental reform. External funding increases universities' financial autonomy which in turn allows them to overcome some of the systemic constraints, including those related to personnel. At the same time, employees hired for specific projects can find themselves in a precarious situation if the new project contracts are not authorized or adequately supported. According to Austria's 2002 University Law (*Universitätsgesetz*), universities can independently make personnel deci-

Figure 2. **Index of Academic Workplace Quality in an International Comparison**



Source: [*Janger*, 2013].

sions. However, even though this is not put into practice to the extent permitted in the Employees Law (*Angestelltengesetz*), universities still find themselves in a contradictory situation because of their legal responsibility to provide a certain number of state-funded student places and provide employees with attractive career development opportunities.

The share of R&D employees financed from external funds at Austrian universities has increased continuously since 2002 — and reached 42% in 2009.[4] Such a high proportion not only creates an environment of uncertainty for full-time staff but it also means a possible loss of competent researchers. Highly qualified specialists are rare in Austria — a fact confirmed by universities and large and small enterprises. The training of highly qualified specialists along with ensuring long-term funding for research are two of the most high priority tasks facing the Austrian state.

Conclusion

Basic research has the potential to help overcome stagnation in the economy and innovation sphere. To do this it needs long-term, constant funding and large research networks that have greater visibility and a critical mass. Research teams with international members are more effective and attractive for foreign researchers. There is no need to launch new programmes to address these challenges: the 'Initiative for Excellence in Science' programme *(Exzellenzinitiative Wissenschaft)* has been in place since 2006 and aims to create excellence clusters [FWF, 2006; RFTE, 2013]. A suitable approach would be to support different areas equally, including curiosity-driven research and research that addresses the 'grand challenges' of developed societies.

The Austrian contemporary system of basic research is highly specialized and needs long-term investment in human capital. This provides opportunities for stable career development. Thus such investments can bring the necessary social yield.

The Austrian research system has gained solid experience in research management over recent years. There is an understanding of the need for institutions that help a research-intensive innovation system to function. Examples of such institutions include the Institute of Science and Technology Austria (IST Austria) and the Research Centre for Molecular Medicine (Ce-M-M). Such research organizations possess sufficient administrative capabilities and internal autonomy to independently define their own projects and, with long-term financing, build bridges towards future innovations, which may only appear after 10 or 20 years.

[4] These external resources include state funds (for example, the Austrian Science Fund, FWF) and private investments [FTB, 2012, p. 142].

Abramo G., d'Angelo C.A., di Costa F., Solazzi M. (2009) University — industry collaboration in Italy: A biblio-metric examination. *Technovation*, vol. 29, no 6–7, pp. 498–507.
Albarrán P. (2010) A comparison of the scientific performance of the U.S. and the European Union at the turn of the 21st century. *Scientometrics*, vol. 85, no 1, pp. 329–344.
Arnold E., Carlberg M., Giaracca F., Horvath A., Jávorka Z., Knee P., Mahieu B., Meijer I., Sidiqi S., Stroyan J. (2011) *Long-term Impacts of the Framework Programme*, Brussels: European Commission.
Arnold E., Clark J., Bussillet S. (2004) *Impacts of the Swedish Competence Centres Programme 1995–2003* (Vinnova Analysis VA 2004:03), Stockholm: Vinnova.
Arnold E., Giarracca F. (2012) *Getting the Balance Right. Basic Research, Missions and Governance for Horizon 2020*, Brighton, UK: Technopolis Group.
Balconi M., Laboranti A. (2006) University — industry interactions in applied research: The case of microelectronics. *Research Policy*, vol. 35, pp. 1616–1630.
Bramwell A., Wolfe D.A. (2008) Universities and Regional Economic Development: The Entrepreneurial University of Waterloo. *Research Policy*, vol. 37, pp. 1175–1187.
Cowen T. (2011a) *The Great Stagnation: How America Ate All the Low-Hanging Fruit of Modern History, Got Sick, and Will (Eventually) Feel Better*, New York: Dutton Books.
Cowen T. (2011b) Innovation Is Doing Little for Incomes. *The New York Times*, 29.01.2011.
Crespi G., d'Este P., Fontana R., Geuna A. (2008) *The Impact of Academic Patenting on University Research and its Transfer* (SPRU Electronic Working Paper Series no 178), Brighton, UK: Sussex University, SPRU.
Dosi G., Llerena P., Sylos Labini M. (2006) The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'. *Research Policy*, vol. 35, pp. 1450–1464.
DTS (2012) *Innovationsindikator Deutschland 2012*, Bonn: Deutsche Telekom Stiftung.
Economist (2013) How Science Goes Wrong (Coverstory). *Economist*, 19.10.2013.
European Commission (1995) *Green Paper on Innovation*, Luxembourg: European Commission.
European Commission (2012) *Impact Assessment* (Accompanying the document: A Reinforced European Research Area Partnership for Excellence and Growth (Commission Staff Working Document SWD (2012) 212 final)), Brussels: European Commission.
FTB (2012) *Österreichischer Forschungs- und Technologiebericht 2012*, Vienna: BMWF, BMVIT, BMWFJ. Available at: http://www.bmvit.gv.at/innovation/publikationen/technologieberichte/downloads/ftbericht2013.pdf, accessed 17.11.2013.
FWF (2006) *Exzellenzinitiative Wissenschaft. Ein Konzept des Wissenschaftsfonds im Auftrag des Bundesministeriums für Bildung, Wissenschaft und Kultur*, FWF, Das Zukunftsministerium.
Gertner J. (2012) *The Idea Factory: Bell Labs and the Great Age of American Innovation*, New York: Penguin Group.
Godin B. (2000) *Measuring Science: Is There 'Basic Science' without Statistics?* (Project on the History and Sociology of S&T Statistics Paper no 3), Québec: Institut national de la recherche scientifique.
Gordon R. (2012) *Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds* (NBER Working Paper 18315), Cambridge, MA: National Bureau of Economic Research.
Herranz H., Ruiz-Castillo J. (2011) *The End of the 'European Paradox'* (Working Paper Economic Series 11), Madrid: Department of Economía, Universidad Carlos III de Madrid.
Hirschi C. (2013) Die Organisation von Innovation — über die Geschichte einer Obsession. Angewandte Chemie, vol. 125, no 52, pp. 14118–14122.
Janger J. (2013) *Brain Drain in die USA: Attraktivität akademischer Karrieren im Ländervergleich: Österreich im europäischen Mittelfeld*, WIFO-Presseinformation.
Keuschnigg C., Reiner C., Schibany A. (2013) Wachstum durch Bildung, Innovation und Strukturwandel. *Wirtschaftspolitische Blätter*, vol. 3, pp. 423–445.
Krugman P. (2013) A Permanent Slump? *New York Times*, 17.11.2013. Available at: http://www.nytimes.com/2013/11/18/opinion/krugman-a-permanent-slump.html?partner=rssnyt&emc=rss&_r=0, accessed 12.03.2014.
Labory S., Lorio R., le Paci D. (2008) *The determinants of research quality in Italy: Empirical evidence using bibliometric data in the biotech sector*. Paper presented at the 25th Celebration Conference on Entrepreneurship and Innovation — Organizations, Institutions, Systems And Regions, Copenhagen, CBS, Denmark, June 17–20. Available at: http://www2.druid.dk/conferences/viewpaper.php?id=3547&cf=29, accesed 24.12.2013.
Lebeau L., Laframboise M., Lariviére C., Gingras Y. (2008) The effect of university — industry collaboration on the scientific impact of publications. *Research Evaluation*, vol. 17, no 3, pp. 227–232.
Link A., Siegel D., Bozeman B. (2007) An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change*, vol. 16, no 4, pp. 641–655.
Lotz P., Larsen M., Davis T. (2007) *To what effect? Scientists' perspectives on the unintended conse-quences of university patenting*. Paper presented at the DRUID Conference, June 18-20, Copenhagen.
Merton R.K. (1942) Science and Technology in a Democratic Order. *Journal of Legal and Political Sociology*, no 1, pp. 115–126.
OECD (1994) *The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris: OECD.
OECD (2010) *The OECD Innovation Strategy, Getting a Head Start for Tomorrow*, Paris: OECD.
OECD (2011) *Attractiveness for Innovation. Location Factors for International Investment*, Paris: OECD.
Perkmann M., King Z., Pavelin S. (2011) Engaging excellence? Effects of faculty quality on university engagement with industry. *Research Policy*, vol. 40, pp. 539–552.
Pisano G. (2006) Can science be business? Lessons from Biotech. *Harvard Business Review* (October), pp. 1–12.
RFTE (2013) *Bericht zur wissenschaftlichen und technologischen Leistungsfähigkeit Österreichs*, Wien: Rat für Forschung und Technologieentwicklung.
Schibany A., Reiner C. (2013) *Kann Grundlagenforschung die wirtschaftliche Stagnation verhindern?* (IHS Policy Brief no 2, November), Vienna: Institut für Höhere Studien — Institute for Advanced Studies.
Schibany A., Berger M., Gassler H., Reiner C. (2013a) *Frontrunner-Unternehmen in Österreich. Strategien und Herausforderungen auf dem Weg zum Innovation Leader* (Joanneum Research Report Series 156/2013), Vienna: Joanneum Research.
Schibany A., Ecker B., Gassler H., Reiner C. (2013b) *Ergebnisse der F&E-Erhebung 2011 und Standortqualität* (IHS-Policy Brief no 1, Oktober), Wien: HIS.
Schumpeter J.A. (1934) *The theory of economic development: An inquiry into profits, capital, credit, interest and the business cycle*, Cambridge: Harvard University Press.
Schumpeter J.A. (1942) *Capitalism, socialism and democracy* (1st ed.), New York: Harper.
Solow R. (1987) We'd better watch out. *New York Times Book Review*, 12.07.1987.