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THE AUSTRIAN SCIENCE FUND: EX POST EVALUATION AND PERFORMANCE OF FWF FUNDED RESEARCH PROJECTS

Michael Dinges

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JOANNEUM RESEARCH Forschungsgesellschaft mbH – Institut of Technology and Regional Policy (InTeReg)

Vienna Office:
Wiedner Hauptstraße 76
A-1040 Vienna, Austria
Phone: +43-1-581 75 20
E-Mail: intereg@joanneum.at

Graz Office:
Elisabethstraße 20
A-8010 Graz, Austria
Phone: +43-316-876 1488
E-Mail: intereg@joanneum.at

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STUDY COMMISSIONED BY THE AUSTRIAN SCIENCE FUND

MICHAEL DINGES

VIENNA, DECEMBER 2005

Contact:
Michael Dinges
Joanneum Research
Institute of Technology and Regional Policy
Wiedner Hauptstraße 76, 1040 Wien
e-mail: michael.dinges@joanneum.at
Tel.: +43 1 581 75 20/2813

FWF - Austrian Science Fund

The Austrian Science Fund (FWF) is Austria's central body for the promotion of basic research. It is equally committed to all branches of science and in all its activities is guided solely by the standards of the international scientific community.

Source: FWF- Homepage

FWF Contact:

Austrian Science Fund (FWF)
Weyringergasse 35 - A-1040 Wien
T: +43-1-505 67 40 F: +43-1-505 67 39
e-mail: office@fwf.ac.at web: www.fwf.ac.at

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0 Introduction

The Austrian Science Fund (FWF) is Austria's major agency for competitive basic research funding and has been subject to several external evaluations within the last 2 years. In the course of the Evaluation of the Austrian Industrial Research Promotion Fund (FFF) and the Austrian Science Fund (2003/2004), FWF's governance and processes [Van der Meulen (2004)], and an Impact Analysis [Sreicher et al., (2004)], which mainly aimed at identifying parameters which influence the funding decisions of the FWF, have been conducted. Zinöcker and Dinges (2004) have highlighted the position of FWF's funding instruments in the context of other R&D funding agencies and instruments in Austria. Furthermore, PREST and Fraunhofer (2004) have recently evaluated the thematic "Research Network Programmes" and an evaluation of the international mobility grant programme "Erwin Schrödinger Fellowship is currently being performed".

The present study aims to appraise the performance of FWF funded projects within the grant scheme of stand-alone projects (Einzelprojekte), which constitutes the core research funding of FWF, accounting for about two-thirds of FWF's budget in 2004. The emphasis of the study is to identify the inter-relation between ex ante and ex post evaluation, and to identify critical factors that influence the results of the ex post evaluation. Furthermore, the study examines relevance and appropriateness of FWF's ex post project evaluation procedure.

For the Austrian Science Fund the study should offer valuable clues to improve the quality of its processes and project evaluations. Furthermore, the study should deepen the knowledge on the effects of FWF's research funding particularly with regard to the legitimation of its funding, and with regard to future modifications that improve monitoring system and funding processes respectively.

Therefore, the present study also revisited FWF's funding procedures, focuses on various methods for funding allocations and associated problems, along with methods to demonstrate the effects of funding. A data based analysis including a multiple linear regression analysis of the FWF-funded projects tries to identify critical factors that influence the results of the ex post evaluation. Where applicable, the study considers gender aspects in order to review the fairness FWF's procedures.

The study addresses the following research questions:

- What is the concrete value of ex post project evaluations?
- Do ex post evaluations constitute a solid source of information for FWF and/or other stakeholders in the policy process?
- What can be learnt from ex post evaluations with respect to the success of a project?
- Do ex post evaluations pose the right questions?
- Do the results of the ex post evaluation provide any hints for the potential of commercialisation of the projects?

0.1. The structure of this report

The report is subdivided into four sections. Chapter 1 revisits FWF's project selection procedure and highlights the findings of the FWF evaluations along with FWF's reactions. Furthermore, the section highlights typical problems that arise with different selection methods.

Chapter 2 focuses on the intended results of FWF funded projects in the context of ways to evaluate the effects of funding programmes. The section surveys performance criteria for basic research and indicators to demonstrate the results.

Chapter 3 provides a quantitative and qualitative analysis of FWF's ex post evaluation. The section tries to determine crucial factors that influence the performance of FWF funded projects. The chapter comprises a multiple regression analysis in order to identify critical factors that influence the performance of FWF funded projects.

The final Chapter 4 summarises the main findings of the report.

0.2. Methodology

The following research methods were used for the study:

- A literature review in order to highlight possible benefits and drawbacks of project selection procedures, project evaluation methods, and practicable performance evaluations.
- Information on procedures of ex ante and ex post evaluations were gathered from the relevant official FWF documents and guidelines for reviewers.
- A descriptive, quantitative analysis of the FWF project database was performed to characterise the projects.
- A multiple linear regression analysis was carried out in order to identify crucial factors that influence the performance of FWF-funded projects as measured via the ex post evaluation procedure.

1 FWF's funding procedures revisited: Ex-ante project evaluations

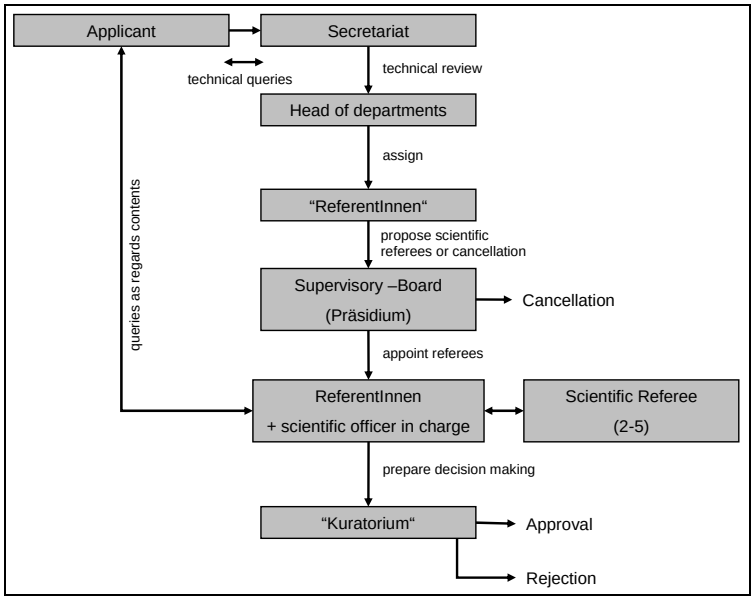
Both FWF evaluation reports on Governance and Processes [Van der Meulen (2004)], and Impact Analysis [Streicher et al. (2004)] put a focus on the peer review system and the funding decision respectively. This part of the study highlights the results of the evaluation reports concerning FWF's funding decisions and procedures, together with several key types of problems and options regarding research-funding schemes respectively. We aim to illustrate why the FWF uses peer review as primary allocation mechanisms and to discuss the use of possible alternatives.

1.1. FWF's selection process

FWF's project selection process includes an international peer review system in which reviewers submit a written statement of the project under consideration and are asked to rate the project on a scale from 0 to 100 (with 100 being the best rating); the number of peers is at least two and mainly depends on project size. This allows for quantitative modelling of funding decisions, though one should keep in mind that the actual funding decision is NOT based predominantly or even solely on the rating, but almost exclusively on the verbal assessment [see Streicher et al. (2004, p. 22)].

Concerning the peer review system itself, the FWF evaluation concluded that no changes in the peer review system seem to be necessary within the current regime. The satisfaction of researchers with the review system is high, the peer review system is open to newcomers in terms of disciplines etc. and no a priori barriers are set up in the decision procedures that would give some researchers better access than others.

Figure 1: Sequence of selection procedure



Source: FWF-leaflet „Begutachtungsverfahren und Arbeitsweise des FWF"

However, funding decisions do not solely rely upon the results of peer review, but are part of a governance structure in which two bodies of FWF play a decisive role within the project selection framework. Figure 1 illustrates the sequence of the project selection process.

The **FWF - Reporters ('ReferentInnen')**, a group of renowned scientists along the 3 FWF-departments Biology/Medicine, Humanities/Social Sciences, and Natural Sciences/Engineering Sciences propose possible peers to the executive board of FWF ('Präsidium'), which then officially selects the peers. In advance applicants are allowed to claim exclusion of single peers, peer review itself is anonymous. The reporters act as scientific reporters and prepare the decisions on funding of proposals via presenting the results of the peer review process to the 'Kuratorium', which takes the final decision in the selection procedure. Van der Meulen (2004, p.7) pointed out that there are no clear selection criteria for the scientific reporters.

The '**Kuratorium'** consists of representatives of universities, social organisations and the government (non-voting) and takes the final funding decision. As written in the notes on Project Assessment and FWF-Procedures[1] the Kuratorium takes funding decisions only after detailed discussions and comparisons across different projects. Table 1 lists the present membership of the Kuratorium. With September 12th 2005, the composition of the Kuratorium will change significantly (see chapter 2.2).

Table 1: Membership of the Kuratorium

VOTING MEMBERS		
1 MEMBER OF EACH AUSTRIAN UNIVERSITY (INCLUDING UNIVERSITY OF ARTS)		14
1 MEMBER OF THE AUSTRIAN ACADEMY OF SCIENCES (ÖAW)		1
1 MEMBER OF SCIENTIFIC INSTITUTIONS		1
1 MEMBER OF SCIENTIFIC INSTITUTIONS OUTSIDE THE UNIVERSITY		1
"SOCIAL PARTNERS"		6
	TOTAL	*23*
NON VOTING MEMBERS (BMVIT, BMBWK, BMF, 2 FFF*)		5
CO-OPTED MEMBERS OF THE "REFERENTINNEN" (11 OUT OF 28 ELIGIBLE)		
	TOTAL	*28*

BMVIT: Federal Ministry for Transport, Innovation and Technology, BMBWK: Federal Ministry for Education, Science and Culture, BMF: Federal Ministry of Finance, FFF: now FFG, Austrian Research Promotion Agency Ltd., General Programmes
Source: Homepage FWF (present status)

In the descriptive analysis of the Impact Analysis Streicher et al. (2004, p.10) showed, acceptance rates are highest in the Natural Sciences with close to 58%. Most rejections take place in the Agricultural and Social Sciences: only about one third of their applications receive funding (35 and 34%, resp.), which is well below the average approval rate 51%. Despite the overall high satisfaction with the procedures of FWF, the survey results published in the Impact Analysis (ibid. p. 33) reveal that quite lot submitters of rejected projects complain about incompetent reviewers or poor selection of reviewers. The binary choice model of the Impact Analysis, which looked at the predictivity of the rating system[2], showed that the *social science*s have significantly lower chances of approval given the same ratings.

[1] "Begutachtungsverfahren und Arbeitsweise des FWF: Forschungsprojekte"
[2] If the rating system perfectly predicted the final decision of rejection or approval, all other variables should become insignificant.

In this respect, concerns may arise that selection procedures suffer from bias towards dominant groups or insiders from the side of the Kuratorium or the reporters. The Evaluation on Governance and Processes [(Van der Meulen,(2004) p. 13] pointed out, that in a more competitive research system[3], trust in an organisation like FWF may easily go, if parts of the decision procedure are opaque to those affected by the decisions.

The evaluation suggested either to increase the number of reporters or to allow a larger role of the scientific staff in the peer review procedure. Equidistance in terms of scientific disciplines in the organisational bodies that take funding decisions (not necessarily in terms of funding volumes) would help further minimise concerns with regard bias towards dominant groups or insiders.

1.2. FWF's reaction

FWF took the results of the evaluation seriously and has already launched initiatives to improve its funding procedures:

- Regarding to the problems of role and selection of reporters, FWF is currently making the selection procedure for FWF-reporters more transparent. In September 2005, the Delegiertenversammlung[4] (Assembly of Delegates) will elect 26 reporters along with 26 deputy reporters. FWF points out that the choice of the Delegiertenversammlung will assure that scientific competence of deputy reporters are complementary.
- In November 2004, FWF has conducted a fact-finding mission that reviewed peer assessment and selection procedures of six foreign research councils, in order to further discuss and improve FWF's own selection mechanisms and the role of the reporters. FWF has identified various ways to modify procedures of project selection, which are within the scope of the New Research and Technology Promotion Act (FTFG 2004).

1.3. Any other selection procedures?

This section aims to amend the ongoing discourse on selection procedures by highlighting typical problems that arise with different selection methods. The section identifies the challenges a research-funding agency faces concerning its funding decisions.

Martin (2000) states that any research grant scheme is likely to generate a great deal of informal complaint: Some researchers are left with rejected proposals and, not surprisingly, dissatisfaction among unsuccessful applicants may arise accompanied by complaints about bias in the selection procedures and wasted effort. Programme administrators are likely to worry about making the system work efficiently, and reformers are seeking for methods to increase accountability via changing selection criteria, the processes in the administration, or the selection of peers and the peer review system.

[3] In terms of research funding, Austria still has a very high share of bloc funding via the General University Funds (GUF). GUF represents more than 80% of higher education expenditures on R&D (HERD). Competitive grants for research funding only play a minor role up to date.

Martin categorises four typical problems arising in the process of funding decisions, and applies them onto proto-typical methods of allocation. The categorisation allows to discuss the legitimisation of funding schemes in general (as done by Martin), but from a more practical point of view the identified problem classes provide a good baseline to reflect challenges and/or prejudices that FWF faces against its funding procedures.

Problem classes occurring along funding decisions are **bias**, **waste**, **discouragement** and **orientation to interest**. Explanations of the problem class are discussed along with the relevance for FWF's work:

Different sorts of **bias**:

- **Success-breeds-success bias**: using grants to produce outputs necessary to attract further grants, while others never have the chance to get started.
    - *Success-breeds-success bias is not only a problem for research funding, but also widely discussed with regards the peer review mechanism and publications. For the work of FWF, it is important to constantly review the rate of newcomers applying for grants and their acception rates respectively. According to data delivered by FWF, the rate of "newcomers" defined by FWF as researchers applying for funds only once in 6 years is about 40%. The share of applicants that apply for more than one project per year is about 12%.*
- **Insider bias**: decision making by cliques of insiders, who think highly of and award most grants to themselves and a small group of favourites.
    - *As referees and 'Kuratorium' play a crucial role in the selection procedure of FWF via proposing peers and being finally responsible for the funding decision, it is important that the selection of referees and the composition of the 'Kuratorium' follow transparent and fair procedures. Suggestions to increase the numbers of referees point at this direction.*
- **Dominant group bias**: includes discrimination against groups such as female scientists, ethnic minorities, specific scientific disciplines or lower status institutions.
    - *The issue of dominant group bias is an important issue for FWF as the natural sciences and human medicine account for about two-thirds of all research funding provided by FWF. The results of the FWF evaluation did not find hints that FWF discriminates against specific scientific disciplines in its funding decisions.*
- **Conventional approach bias**: leaving most grants to those who propose tried-and-true approaches, while challenging, innovative or unorthodox proposals are rarely funded

[4] The assembly of delegates is responsible for the annual report of FWF, the financial report and budget. It elects the Executive Board and the Kuratorium.

- *To deal with the conventional approach bias is a very difficult issue for funding agencies, as the final decision takers have to rely upon the project evaluation of the peers. One important guideline in this respect is to question the origin of occurrence of very unequal peer-ratings in the ex-ante project evaluation.*

- **Personal bias**: in terms of obstruction of referees or administrators towards researchers they do not like.

    - *As FWF solely relies upon an international peer review system and as the members of the 'Kuratorium' consists of a variety of research institutions and social partners, there is little room for personal bias to influence the funding decisions. Due to the relatively small number of reporters, personal bias in FWF's funding procedures may be a problem. FWF is aware of this problem and has installed mechanisms trying to prevent personal influence.*

- **Waste**: Includes administrative overheads to assess applications and the individual time spent by researchers that are preparing applications. Waste of financial resources occurs, especially if grants are small, procedures are complex, and allocation is highly competitive (low success rate).

    - *In the course of the FWF evaluation, governance and processes of FWF have also been analysed. Compared to other like-wise organisations FWF's current administrational costs are low, FWF's staff is actually too small to intensify international interactions, and activities to connect to society (see van der Meulen p.14). From a clients perspective a Spectra survey that was performed in 2002, revealed that the top reason (29% of the respondents) not to apply for FWF funding was that the success rate is considered to be too low compared with the time needed to prepare applications.*

- **Discouragement**: There can be significant effects on those who are unsuccessful. They can be disheartened by rejections or become resentful. Any competitive system creates this problem and there is considerable evidence that competition reduces motivation per se [Kohn (1993)].

- **Orientation to interest:** The possibility of getting a grant provides incentives to do research that pleases those dispensing the money. Grants provided by a corporation or government department for research in a particular field, obviously orient researchers to particular problems, while grant schemes provided to contribute generally to the acquisition of knowledge (basic research), will be awarded to those who best make the case that they are pushing back the scientific frontiers e.g. in astronomy or brain structure. Even in these cases, it can be argued that there is an indirect orientation to outside interests, which can occur through paradigms, potential applications of pure research, or job prospects. Researchers have naturally interest in their own careers, including positions and status. In as much as top researchers are influential in decision making it is

likely that the existing system of research will be perpetuated. This may be at the expense of other priorities, such as pressing social problems.

Though **peer review** for researchers is the most familiar control-mechanism on publication decisions, and to some extend funding decisions, several other methods for allocating funds exist and actually heavily influence science systems.

Administrative decisions are common for most high-level priority setting in research policy (e.g. specific research programmes for biotechnology etc.), but also decisions to provide research infrastructure, and at university level distribution of funds between scientific disciplines are based on administrative decisions.

Performance based funding uses output criteria such as patents or publications of researchers to distribute funding. Once output criteria are defined, direct payments to authors of journal articles or departments performing better than others could be effected.

An expertise to the German Ministry of Research and Education, [Gläser et al. (2002) p.12] reports that formula based funding for allocation of resources in the Australian funding scheme for university research[5] gives raise to concerns about the continued use of formulas in their existing forms. Studies documented a significant increase in the country's journal output, accompanied by a worrying decrease in the relative international impact of these publications as measured by citations.

Funding based on an **equality** approach means, that funds for every researcher are either distributed equal among researchers or with equal chance for funding. A researcher's salary could be said to be allocated by using a method of rough equality, if he/she has to spend a certain amount of time doing research vs. teaching.

Yet another method of allocation is the **community-based allocation**, in which research priorities and funding are decided by a range of community groups, such as groups of workers, parents or neighbours. Closest to community-based allocation methods are so-called "science shops" – in which questions from community groups (e.g. small businesses) are turned into researchable topics, and seek to find researchers to carry out relevant projects [Farkas (1999)].

1.3.1 Relevance for FWF's work

FWF's funding procedure constitutes a mix between peer review and administrative decision, as the referees and the 'Kuratorium' play a decisive role in the allocation process. In this respect especially the problems of bias and waste that may arise in the process of research funding need active surveillance. The results of the performed evaluations and the reactions of FWF have showed that FWF is aware concerns about fairness and transparency may easily arise in a competitive research grant system.

[5] Australia has introduced performance based funding criteria for university research institutes since the early 1990s. The distribution of research funds is based on graduate student numbers or completion rates, research income, and publications.

2 Intended results of FWF funded projects

This section focuses on the intended results of FWF funded projects and considers possible ways to evaluate the effects of research funding programmes. The chapter tries to answer questions whether performance criteria for basic research can be identified, and whether quantitative indicators are able to demonstrate the results of basic research or not. In this respect the ex ante evaluation criteria and FWF's corporate policy are used to identify intended results of FWF's funding activities followed by a review of methods to evaluate research promotion programmes.

2.1. Ex ante evaluation criteria and aims of FWF's funding activities

FWF follows a strict bottom-up procedure without thematic oriented calls for separate scientific disciplines. FWF's review criteria are as follows:

1. Scientific quality of the project
    a. Position in the appropriate international scientific community
    b. Extent to which the project could break new ground scientifically
    c. Importance of the expected results for the discipline
    d. Clarity of the goals
    e. Appropriateness of the methods
    f. Quality of the co-operations
2. Scientific quality of the scientists involved
    a. Scientific qualifications and/or potentials of the scientists involved
    b. Expected importance of the project for the career development of the participants
3. Financial aspects
    a. Appropriateness of personnel and non-personnel costs of the worthwhile parts
    b. What cuts could be made without jeopardizing the success of these parts
    c. Suggestions for improvement to the equipment requested
4. Other suggestions to increase the projects chance of success.

FWF's mission outlined in the corporate policy document of FWF is to invest in new ideas that contribute to an advance in knowledge, and thereby to further developments. FWF is equally committed to all branches of science and the *Humanities* and is guided in its operations only by the standards of the international scientific community. FWF's responsibilities are the promotion of

- **High-quality scientific research**, which represents a significant contribution to society, culture and the economy
- **Education and training through research**, because support for young scientists represents one of the most important investments in the future

- **Knowledge transfer and the establishment of a science-friendly culture** via an exchange between science and other areas of society.

The aims of FWF are:

- Continued **improvement of science** in Austria and an increasing of its international competitiveness
- Enhancement of the **qualifications of young scientists**
- **Strengthening of the awareness** that science represents a significant aspect of our culture.

The specific aims of FWF's research projects scheme are to promote high-quality research not oriented at a financial profit through a competitive grant scheme, in order to foster Austria's research position and to contribute to cultural, economic and societal life [FWF (2004, p.19)]. FWF's homepage states that the goal of the stand-alone projects is the funding of individual research projects not oriented at financial profit.

2.1.1 Relevance for FWF's work

Concerning a performance analysis of FWF funded projects one should follow the advice of the Austrian "Plattform Forschungs- und Technologieevaluierung" (fteval), that performance criteria can only stem from the formulated objectives, which are a pre-requisite for evaluating any kind of policy measure, be it a programme, an institution or a project [see fteval (2004)]. The *Evaluation Standards in Research and Technology Policy* of fteval state that the responsible level should clearly develop concrete ideas with regard to what constitutes the success or failure of a programme. The objectives are to be very carefully developed in accordance with these ideas so that decision-makers, programme managers, evaluators and, not least, the addressees (e.g. the employees of an institution, those supported by the programme, etc.) are clear on and agree on what is to be achieved by the programme.

FWF formulates the overall goals for stand-alone projects in a very distinct way. The promotion of scientific excellence is the core of FWF's funding activities and FWF's peer review process is the key measure to ensure that the bottom-up research ideas stemming from the scientific community guarantee scientific quality and high-class output in terms of publications etc. in the best possible way.

The ex ante evaluation criteria for FWF funded research projects reveal that the scientific quality of a project and the extent a project could break new ground scientifically constitute core criteria for FWF's funding activities. Besides scientific excellence, also the expected importance of the project for the career development of the participants plays an important role. This opens the field for evaluating the performance of FWF funded research project about the effects on the development of human resources.

Until quite recently FWF has not made any efforts to demonstrate effects, or intended results of its funding activities for stand-alone projects except from the ex ante review process. FWF did not lay down whether it is possible or useful, to develop quantifiable objectives or alterna-

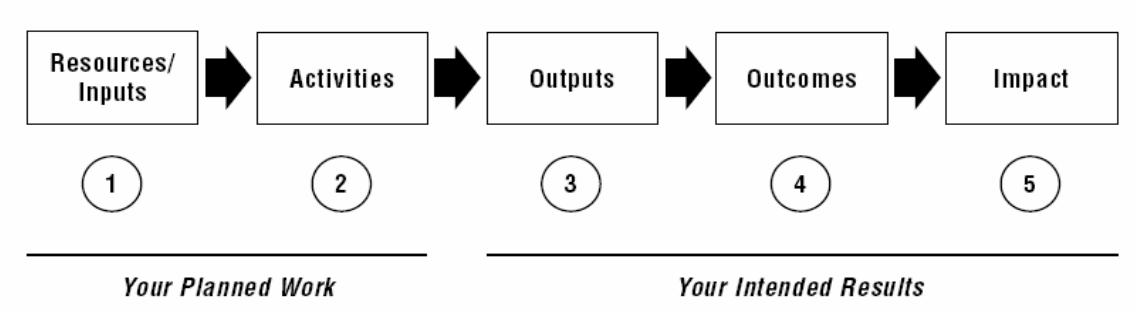
tively, to set up procedures to review the objectives from a qualitative point of view. However, the recently established strategy department of FWF has launched initiatives to explicitly state, how - and by means of which mechanisms - the grant scheme of stand-alone projects is supposed to affect research system, economy and society.

2.2. Thinking of research promotion programmes in terms of a logic model

Logic models[6] are a useful and common used tool when outlining the planned work and intended results of a programme (see Figure 2 for a logic model mainly used in the USA and Canada).

For FWF the international peer review process is the crucial element that decides upon use of available resources, and activities performed (research projects) in order to achieve the mission's underlying aim - to contribute to a continued improvement of science in Austria and an increasing of its international competitiveness.

Figure 2: The basic logic model



Source: Kellogs Foundation (2002)

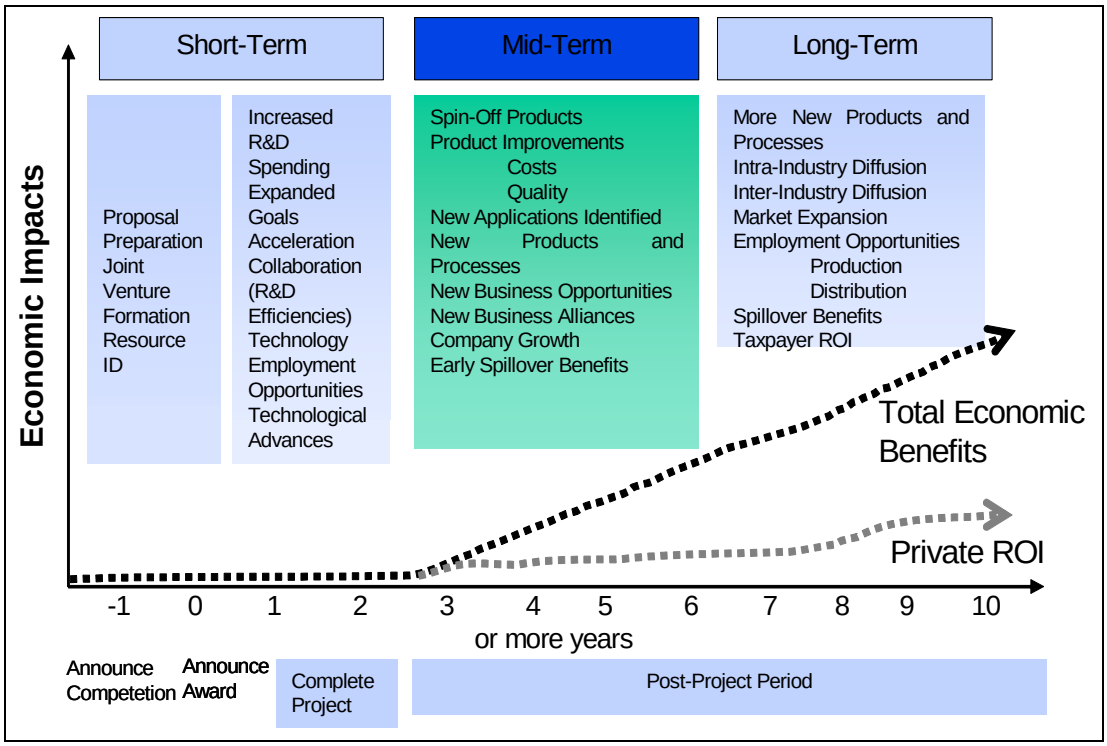
The right hand side of the basic logic model depicts outputs, outcomes and impact of a program, which are the intended results of a program within a framework of time:

1. **Outputs** are the direct products of program activities and may include types, levels and targets of services to be delivered by the program. The timeframe is short term and includes in the case of research activities research reports, conference papers, posters, articles in scientific journals etc.
2. **Outcomes** are the specific changes in program participants' behaviour, knowledge, skills, status and level of functioning. The timeframe is medium to long-term and includes e.g. economic application of research results, improvement of scientific career of project participants (promotion etc.)
3. **Impact** is the fundamental intended or unintended change occurring in organizations, communities or systems because of programme activities. In the case of a research grant scheme, this could be the strengthening of the excellence of the science system, improvement of the attractiveness of research location etc.

[6] A logic model is a systematic and visual way to present and share the understanding of the relationships among the resources available to operate a program, the activities planned, and the changes or results that should be achieved. [Kellogs Foundation (2002)].

Figure 3 shows a diagram on the expected outcomes of more technology oriented, or guided R&D programmes.

Figure 3: Impact of technology oriented R&D programmes



Source: Ruegg & Feller

2.2.1 Relevance for FWF's work

Whereas a multitude of ways exist to demonstrate the effects of applied research, and thematic oriented research, this does not hold true for the evaluation of basic research. The peculiarities of basic research vs. applied research limit the ways to demonstrate the effects of research: the ultimate outcomes of research into fundamental processes are seldom predictable or quantifiable in advance. It is normal and necessary for basic research investigators to modify their goals, change course, and test competing hypotheses as they move closer to the fundamental understandings that justify public investment in their work [Cosepup (1999), p. 30].

When it comes to the evaluation of the results of basic research, it is necessary to evaluate the performance of basic research programs by using measures not of practical outcomes as patents, spin-off products, new products or processes, but of performance measures, such as:

- generation of new knowledge
- quality of research
- attainment of leadership in the field
- development of human resources (training of skilled graduates etc.).

Furthermore, at least for a long-term analysis on the impact of FWF's science funding respective studies should outline the contribution to the cultural, economic and societal life. Concerning this however, one has to take into account that these impacts of science are at least different to measure, as most of the output and impact of science is intangible, and often occurs with considerable lags.

2.3. How to measure the impact of science?

Basic research impact analyses often focus on direct quantifiable indicators (journal publications, citations), or are concerned with economic impact as outlined in Figure 3. There are very few indicators as such that link science and technology directly to these economic payoffs (e.g. scientific journal citations in patent applications).

Systematic measurements and indicators on impact on social, cultural, political, and organisational dimensions are almost totally absent from the literature [Godin and Gore (2003, p.5)]. Based on interviews with 17 research centres Godin and Gore constructed a typology with eleven dimensions corresponding to as many categories of impact of science on society.

2.3.1 Relevance for FWF's work

Whereas the impact of science is manifold, the ways to measure the impact are scarce. Table 2 provides a preliminary list of indicators susceptible of measuring the impact dimensions of science except from economic impacts. Godin points out that the evaluation of the impact of science is only at an early stage, and most of the empirical analysis so far has concentrated on econometric analysis that is not suitable for evaluating the impact of basic research programmes.

For FWF a thorough analysis of the impact of its funding activities will require the use of surveys on specific types of impact. Case studies covering specific research projects could also provide important sources of information concerning the effects of FWF's research funding especially for demonstrating the effects on human resources and training. Furthermore, indicators based on acceptance rates and indicators based on publications could provide deeper insight into the effects of FWF's research funding. Applicability and relevance of these frequently used indicators are consequently discussed in the following two subsections.

Table 2: The impact of science and tentative indicators to measure the impact

Impact Field	***Indicator 1***	***Indicator 2***	***Indicator 3***	***Indicator 4***
Science				
Advances in Knowledge	Invention of a new theory and its use	Conception of a new methodology and its use	Discovery of a new fact and the use of it	The appearance of a new training programme
Research Activities	New publications	Intensification and diversification of the research performed	Publication growth in interdisciplinary collaboration	Growth of the number of publications in international collaboration
Training	Research Competence	Nr. of PhD – Theses in the course of the project		
Technology				
Products and processes	Nr. of Patents	Nr. of licences	Nr. of users and frequency of use	Citations to the scientific literature
Services	New Services	Market shares		
Know-how				
Culture				
Knowledge	Rate of university graduates in sciences	The level of understanding of scientific concepts		
Know-how	The development of new skills as creativity, critique and analysis	The presence of new technologies at work and home	The frequency and duration of use of new technologies at work and at home	
Attitudes	Participation in scientific activities	Number of hours dedicated by an individual listening to scientific programmes	The level of coverage of science news in the media	Number of visitors to S&T museums
Society				
Welfare	Improving of social and economic conditions of individuals	Number of individuals having modified or changed one or several customs and habits		
Discourses and actions of groups	Appearance of new discourses on S&T in public (e.g. genetically modified crops etc.)			
Policy				
Policy-makers	New interest or attitude towards questions of public interest with S&T			
Citizens	Political implication as new regulations, public commissions on S&T			
Public programmes	A new programme, regulation or norm			
National Security				

Impact Field	*Indicator 1*	*Indicator 2*	*Indicator 3*	*Indicator 4*
Organisation				
Planning	New strategic orientations, missions or objectives			
Work organisation	The allocation of staff (work division)	The degree of specialisation of the jobs	Acquisition of advanced labs or production techniques	
Administration	Administrative restructuring	Number of people affected by the restructuring		
Human Resources	Number of new employees in R&D	Level of qualification of the workforce	Experience and expertise of the employees	Work perspectives and amounts invested in training
Health				
Public health	Health care	Life expectancy		
Health system	New prevention programmes	Rate of occurrence of chronic diseases	Prevalence of diseases	Health expenses
Environment				
Management of natural resources and the environment	Bio-diversity plans etc.	Surveillance tools for pollutions and its causes	Development of anti-pollution norms	
Symbolic				
Legitimacy/credibility/visibility	Prizes	Promotions	Invitations to Conferences etc.	
Training				
Curricula	Training Programs			
Pedagogical tools	Teaching manuals			
Qualifications	Acquired competencies			
Graduates	Nr. of graduates			
Insertion into the job market	Duration between end of studies and the start of a job			
Fitness of training/work				
Career	Career path	Salary		
Use of acquired knowledge	Use of knowledge at work or in daily life			

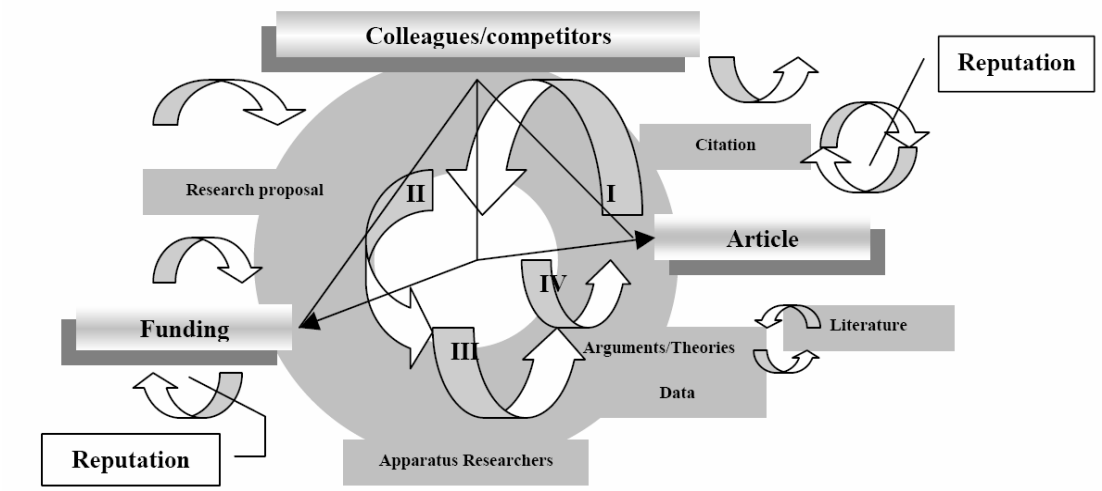
Source: Joanneum Research based on the tables of Godin and Dore (2003)

2.4. Competitive grants as an indicator for scientific reputation – indicators based on acceptance rates

Ex ante project evaluations play a critical role in a system of modern science policy, and peer review procedures (as used by FWF), constitute a frequently used and highly valued control mechanism to assess the academic quality of research grant proposals and journal submissions [Chubin (1991)]. R&D investment decisions based on ex ante evaluation procedures such as peer reviews provide funding authorities with sufficient legitimacy on funding decisions [Rip (1994)]. The fact that FWF allocates funds based on excellence by use of a competitive selection process implies that FWF is likely to fund only the best available research activities.

Funding decisions for competitive grants, and thus the results of peer review also contribute to the **scientific reputation** of the grant recipients. Latour and Woolgar (1979) were first to see research funding as part of a scientists' reputation and credibility cycle, which links production, communication, and collective evaluation of research results into a concept of reputation. Whereas the right hand side of Figure 4 shows that reputation of scientists is created via the production of scientific articles in refereed journal, the left hand side shows that grants distributed via competitive mechanisms constitute yet another dimension of reputation creation.

Figure 4: The reputation cycle for scientists



Source: García and Sanz Menéndez (2004)

Analysis of the outcome of competitive funding procedures (grants received) allows introducing differentiations among research institutions and researchers with regard to their research capabilities, effort, and their competitiveness [Garcia and Sanz Menéndez (2004)]. The German Research Foundation (DFG) for instance [DFG (2004)], has published funding rankings "Funding Rankings 2003: Institutions, Regions, Networks" of its own funding together with data on general significance of third party funding income to universities and a network analysis to visualise the structures of co-operations between institutions involved in coordinated programmes. Traditional bibliometric indicators augment the analysis and offer further insight into relevance or prominence of research carried out at different locations.

2.4.1 Relevance for FWF's work

Analyses focusing on the distribution of grants provide a tool to demonstrate research quality of institutes and personal researchers. Other elements are secondary. With the existing database on funding decisions, FWF can easily produce funding rankings, success rates, and R&D awards by faculty, R&D submissions by faculty etc. However, within a system consisting of various funding opportunities and differing associated relevance of funding institutions for the different scientific disciplines, the benefit of such analysis is limited. Furthermore, also the size of the Austrian research system limits the usability of this type of analysis on a national level, as for many research disciplines only few research institutes exists at all in Austria.

2.5. The use of bibliometric analyses for impact analysis

Bibliometric analyses include journal-publications, journal-citations, and patent counts. Bibliometric analyses focus on the impact of science funding on science output, and advances in knowledge. Bibliometric analyses rely upon peer review in a sense that it only counts manuscripts, which are published in a refereed journal, so that the scientific community approves the quality of the manuscript.

Citation counts of published work by other researchers provide information on the recognition, dissemination and impact of new models, theories etc. within the scientific community. The more times a work is cited, the greater its merit. A citation of journal articles by a company applying for patents testifies economic relevance of research. By extension, the more times a work is cited, the greater its merit.

The benefits and drawbacks of bibliometric analysis have been widely discussed and are well known. Bibliometric indicators are able to provide both quantitative and qualitative proxies for the impact of R&D programmes in terms of research output (= paper) and in terms of research impact (= citation), which allow for rankings of individuals and institutions. However, the potential use of bibliometric indicators differs enormously between areas of research, both in terms of scientific or technological disciplines and in terms of types of research (basic, applied…). Differences are generally so great, that a harmonised approach by definition is impossible [see OST/Technopolis (2004, p. 3)].

2.5.1 Relevance for FWF's work

Taking into account the mentioned shortcomings and further practical obstacles as attribution of papers to FWF funded projects, bibliometric analysis could nevertheless provide an important source of information concerning impact of FWF's work. The database of FWF provides good standardised collection of publication data in specific, separate fields that link the FWF project to the publications. Data include:

- type of publication: (refereed journal articles, non-refereed journal articles, monographs, books, publications in mass media),
- title of the journal,
- volume of the journal,
- publication year,
- authors.

Unfortunately, data on academic publications are available only in private databases for high costs. Nevertheless, bibliometric analyses could serve several purposes:

- Bibliometric analyses could illustrate the results of FWF funded research in terms of total scientific production and of Austrian universities specifically.
- Bibliometric analyses could assess the contribution of FWF's funding to the productivity of the researcher's that receive the funding, and to the impact of their papers.
- Bibliometric analyses could also compare the impact of FWF funded publications with that of other publications published in the same journals or countries.

3 FWF's ex post project evaluation

Since 2003, FWF has installed an ex post review procedure, which tries to explicate performance issues of FWF-funded projects via ex post project evaluations. The following analysis bases on:

a. data available in the project database,

b. FWF's ex post evaluation project data,

c. guidelines for the evaluation of an end of project report.

3.1. Review of the guidelines for the evaluation of an end of project report

The referees for ex post project evaluations stem from the group of referees that have performed the ex ante review. The procedures for the evaluation of an end of project evaluations are as follows: Referees are requested to provide a brief review (no longer than two sides) giving their opinions on five aspects of the project report. They are also requested to assign a numerical rating to each aspect. Points addressed are:

1. **Scientific success** of the project
   Contribution and importance of the work to the further development of the scientific discipline, any importance for related disciplines (transdisciplinary questions and methods), quality of dissemination of the scientific results (publications, activities at conferences and so on);
2. **Development of human resources** in the course of the project
   Improvement of the project leader's standing in the relevant scientific community; involvement of young scientists in the project work; development of international contacts;
3. **Effects beyond scientific field**
   Applications in or impacts on social, cultural, ecological, medical, economic and/or technological areas;
4. **Project performance**
   In the sense of efficient use of available resources;
5. **Future perspectives** of the research work
   Should the topic be pursued or should the scientists involved be advised to switch their attention to a different area.

The rating scale is from zero to one-hundred:

- 100-80 excellent projects,
- 80-60 very good projects,
- 60-40 acceptable projects,
- below 40 problematic projects.

An important feature is that the complete review, which is no longer than two pages, will be made available to the project leader. The name of the referee will not be transmitted to the project leader.

3.1.1 Relevance for FWF's work

Compared with the ex ante review criteria, the ex post review takes an extended perspective on FWF funded projects. Besides the scientific quality, which is the core review criteria of both ex ante and ex post project evaluation, the ex post project evaluation considers explicitly effects that reach beyond the scientific field (cultural, ecological effects etc.), and estimates the concern the future perspective of the research work in general. The following paragraphs give comments on appropriateness of each of the five review criteria:

1. The **scientific success** of a project serves as core criterion for FWF's funding decision and is consequently also a core criterion for the ex post review. Asking peers who have performed the ex ante evaluation about the scientific success of a project provides both FWF and the researchers that have performed the project, with useful information concerning effectiveness of funding and reliability of the ex ante evaluation procedure.

2. The development of **human resources** in the project with regard to the project leader and the involvement of young scientists is also a feature in the ex ante evaluation procedure. It is appropriate to ask the peers about the consequences of FWF's funding concerning the development of human resources. However, FWF should strengthen efforts to show effects not only on a case for case basis, but for the complete funding scheme. Therefore, FWF needs to improve the data gathering of the scientists involved in the project. So far, data gathering mainly serves financial/accounting purposes, but does not provide complete information on the scientists involved in the project. FWF should launch efforts to follow career paths of scientists not only for personal grants scheme (e.g. Schrödinger Grants), but also for grants of individual projects. Quantifiable targets, announced at the beginning of a project, are easiest to be established for effects on human resources.

3. The category **effects that reach beyond the scientific field** does not play a decisive role in the ex ante review criteria. The contribution of research work to the cultural, economic and societal life etc. is difficult to measure, and the effects of basic research might evolve only years after research was conducted. Scientific peers cannot be considered experts with regard the implications of research on economy and society, but the category opens the field for text-based analysis on impacts that reach beyond the scientific field. In order to demonstrate the effects of its research funding FWF would have to rely on more diversified methods such as surveys, focus group interviews, and case studies.

4. The category **project performance** relates to the financial aspects of the research projects and requests comments on the efficient use of available resources. Whereas this criteria is meaningful in the case of the ex ante project evaluation by asking questions concerning financial cuts that could be made without jeopardizing the success of the

research project, the appropriateness for an ex post review is not so clear. It is the task of FWF to control and comment on the appropriate use of financial resources. However, peers might give additional insight concerning the appropriate use of funds.

5. The category **future perspectives** of the research work relates to the extent to which the project broke new ground scientifically, and hence provides the project co-ordinator with useful information with regard to the scientific relevance of performed research. FWF should keep this category in the ex post review criteria.

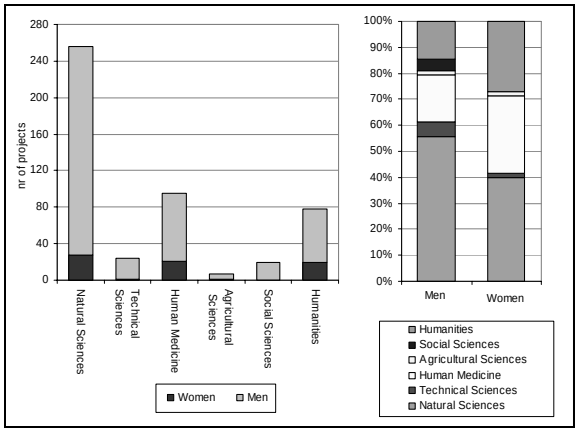
3.2. Descriptive analysis of the dataset

For the analysis, FWF provided a dataset of 503 approved projects, of which 474 had at least two ex ante project evaluations using a rating scheme from 0-100. Out of the 474 approved projects, 176 had already completed FWF's ex post project evaluation procedure. Of the 503 research projects, about 85% were led by a male project co-ordinator and about 15% by a female co-ordinator respectively.

As can be seen by Figure 5, 52% of the projects stem from the *natural sciences*, *human medicine* accounts for about 20% of the projects, and the *humanities* for about 16%. *Technical sciences* account for 5 percent of the project database, *social sciences* 4% and the *agricultural sciences* for 1.6% only.

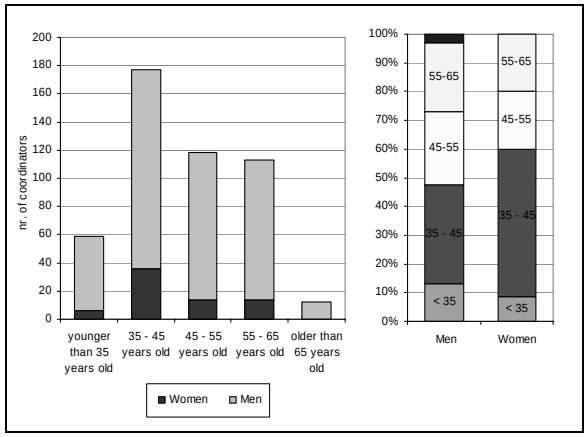
82% of the project co-ordinators are qualified as professors; the remainder of 18% has its highest qualification at the PhD level. Figure 5 shows the distribution of projects based on the main scientific discipline, along with the associated gender of project co-ordinator in absolute and in relative terms (allocation of men and women across different fields of science).

Figure 5: Scientific disciplines of projects



Source: FWF project database

Figure 6: Age of project co-ordinators



Source: FWF-project databas

Figure 6 shows the age distribution of project coordinators in absolute terms and in relative terms for men and women. The average age of a project co-ordinator is 47 years for male

project co-ordinators. With 45 years average age, female project co-ordinators tend to be slightly younger than male project co-ordinators.

3.2.1 Project size: costs and project teams

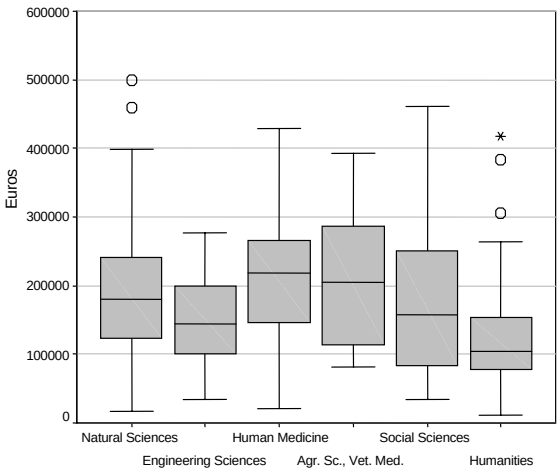
On average, project co-ordinators applied for 181,000 € per project. The granted funding was on 138,000 € per confirmed application and the actual spent amount per project was 152,000 €. Reasons for the deviation between amount granted and amount spent per project are due to prolongations for a third of funding and cost adjustments for personnel.

Figure 7 and Figure 8 show boxplot diagrams for submitted and admitted project costs along the scientific disciplines. Boxplots show the structure of the data along with its skewness and spread. The horizontal line inside the box tells the position of the median and its upper and lower boundaries are its upper and lower quartiles. Any outliers are marked with a circle and extreme cases are marked with an asterisk.

In the dataset the biggest projects can be found in *human medicine* and in the *agricultural sciences / veterinary medicine* asking for 211,000 € per project. On average, *natural sciences* ask for 189,000 € per project and *social sciences* for 170,000 €. The *humanities* apply for about 126,000 € per project. The "funding rate" in terms of solicited amount and amount granted is quite homogeneous, ranging from a low of 75 % in the case of *human medicine* and *engineering sciences* to a high of 85 % for the *humanities*. Gender aspects do not play a significant role concerning project costs. Female co-ordinators applied for 177,000 € per project whereas the average amount applied by male co-ordinators was slightly higher with 181,000 €. Admitted costs per project amount to 76% of submitted costs for both men and women.

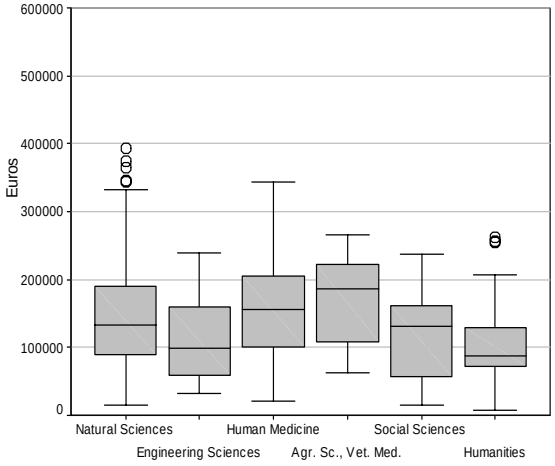
The FWF Impact Analysis [Streicher (2004) p. 10] outlined another important fact concerning funding: proposals of different size face different chances of being accepted, even within the same field of science. The higher the solicited amount, the higher the chance of the project being approved. On the other hand, projects get typically a higher funding rate the lower the solicited amount.

Figure 7: Submitted costs



Source: FWF database, own calculations

Figure 8: Admitted costs



Source: FWF database, own calculations

With regards the project team FWF differentiates the researchers involved in the project via contracts in numerous ways. However, the FWF database does not comprise a full picture on people working in the course of the project except from the contracts financed directly by FWF. Table 3 shows the time spent by researchers, students, and scientific support personnel involved in FWF's Stand-Alone projects in months. Furthermore, the database allowed calculating the number of people involved in the project, the number of contracts awarded in the project, and the average working time per employee.

Table 3: Patterns of the project teams (working time in months)

	Senior Researcher	Junior Researcher	Scient. Support	free arrang.	students	Pers. in Project	Contr. in project	Months p. employee
Natural Sciences (N~263)								
Mean	14.2	31.5	2.9	2.8	8.5	3.7	5.7	20.8
Median	8.9	31.0	0.0	0.0	0.0	3.0	4.0	19.3
Engineering Sciences (N~26)								
Mean	5.9	26.1	1.6	3.5	6.1	2.4	4.2	23.7
Median	0.0	24.0	0.0	0.0	0.0	2.0	3.0	24.0
Human Medicine (N~100)								
Mean	11.6	24.8	7.5	3.8	7.7	3.7	5.6	18.3
Median	1.5	22.2	0.0	0.0	0.0	3.0	5.0	17.3
Agr. Sc., Vet. Med. (N~8)								
Mean	14.1	34.0	4.5	1.2	8.5	3.6	5.0	17.6
Median	10.5	28.5	0.0	0.0	0.0	3.0	3.0	18.3
Social Sciences (N~22)								
Mean	11.2	34.7	0.4	8.2	7.4	4.0	6.2	21.2
Median	0.0	31.5	0.0	0.0	0.0	3.0	4.0	22.8
Humanities (N~84)								
Mean	20.0	17.7	0.7	4.2	1.2	2.4	3.8	27.1
Median	22.5	0.0	0.0	0.0	0.0	1.0	2.0	25.8
TOTAL (N~503)								
Mean	14.1	27.8	3.3	3.5	6.9	3.4	5.3	21.4
Median	5.1	24.0	0.0	0.0	0.0	3.0	4.0	19.7

Source: FWF database, own calculations

On average, 3.4 researchers and scientific support personnel are working on a FWF project, and 5.3 contracts are awarded for a FWF project. Senior researchers (starting with post docs) work about 14 months on a project, contracts awarded to junior researchers (PhD candidates) amount 27.8 months. Concerning the division of labour between junior and senior researchers in a project, considerable differences between the scientific disciplines occur. *Engineering sciences* exhibit substantially lower involvement of senior researchers, whereas the *humanities* on the other end of the scale are well above the average of senior research involvement. On the other hand, the *humanities* exhibit quite lower involvement of junior researchers than the other disciplines. As a matter of course, involvement of scientific support personnel in the *Social sciences* and the *humanities* is only marginal. Except from the *humanities* students receive contracts for about six to eight months, though median values are zero for all fields of science.

Relevance for FWF's work

Project size in terms of costs and involved researchers constitutes critical criteria for research funding agencies. It can be doubted whether a research grant that allows financing about half a researcher and one doctorate candidate over a 2-years period provides sufficient critical mass to strengthen the Austrian research landscape sufficiently; the granted amount barely contributes to a sustainable shape of research teams. However, taking into account the national context FWF funded research projects are still well above the average of Austrian research funding: In 2002 the average research grant was 70,000 € for all national research funding instruments [Block (2003)].

3.2.2 Scientific output of FWF-funded projects

Table 4 illustrates the scientific output of the completed FWF-funded projects. Though the sample for some scientific disciplines in the database is quite small, the results confirm the publication patterns of the FWF-survey performed in the course of the FWF Impact Analysis.

Publications in peer-reviewed journals are the most important output of FWF funded projects, though considerable differences in publication patterns between scientific disciplines occur. On average, a single FWF funded project yields 5.25 publications in peer-reviewed journals, while journal articles in non-reviewed journals only play a minor role. In addition, FWF-funded projects yield about 0.9 publications in anthologies, and about 0.2 publications in form of monographs and journal articles in non-reviewed journals. Significant differences in scientific output occur when differentiating between fields of science, which reflects the specific publication culture of the different fields of science. Whereas in the *natural sciences* and *human medicines* publications in peer reviewed journals account for the most important type of publication, publications in anthologies and in type of monographs play a bigger role in the *social sciences* and the *humanities*. *Engineering sciences* show low output in all types of publications.

Table 4: Scientific output of FWF-funded project, mean values

	Nat. Sc. (N~263)	Eng. Sc. (N~26)	Hum. Med. (N~100)	Agric. Sc. (N~8)	Soc. Sc. (N~22)	Humanities (N~84)	Total (N~503)
Journal Articles (peer reviewed	6.80	1.81	6.36	4.25	1.77	1.17	5.25
Journal Articles (non reviewed)	0.21	0.19	0.15	0.00	0.36	0.08	0.18
Communications	0.21	0.00	0.00	0.00	0.09	0.01	0.11
Monographs	0.18	0.15	0.04	0.00	0.41	0.37	0.19
Pub. in Anthologies	0.55	0.35	0.29	0.50	1.45	2.75	0.89
Pub. in Mass Media	0.33	0.04	0.19	0.63	0.36	0.13	0.26
PhD-Theses	0.85	0.54	0.77	0.25	0.64	0.18	0.69
MA-Theses	1.03	0.38	0.37	0.38	0.73	0.05	0.68
Tenure (Habilitation)	0.27	0.08	0.27	0.25	0.09	0.06	0.22

Source: FWF database, own calculations

On average, FWF projects contribute in equal measure to diploma and doctoral theses. However, considerable differences occur when differentiating between scientific disciplines. Whereas in the *natural sciences* each project is associated with about 0.85 PhD-Thesis and one MA-Thesis, the relevance of FWF-projects about the involvement of young scientists only plays a marginal role in the *humanities*. *Humanities* are the only broad field of sciences, where a FWF project leads on average to more tenures (Habilitation) than MA-theses. Projects of the *humanities* leave hence little scope for training and development of junior researchers in the course of an FWF project.

3.3. Results of the ex ante evaluation procedure

As in the case of the FWF Impact Analysis some projects had to be excluded from the database because evaluators used the old rating scale with just three grades (1...excellent, 2…good/medium, 3… inadequate). Furthermore, one should bear in mind that the funding decision is NOT based predominantly or even solely on its rating, but almost exclusively on the verbal assessments.

Table 5: Average ratings of the ex ante evaluation review

	N	Assessments (Mean)	Mean	Median	Var.	Std. De.
Natural Sciences	252	2.92	88.06	88.33	19.08	4.37
Engineering Sciences	23	2.82	87.10	86.67	13.01	3.61
Human Medicine	95	2.89	86.48	86.67	26.43	5.14
Agric. Sc.& Vet. Med	7	3.14	89.10	89.33	14.29	3.78
Social Sciences	19	2.58	90.61	90.00	15.71	3.96
Humanities	78	2.59	91.69	92.50	31.07	5.57

Source: FWF database, own calculations

On average, every funded project is subject to 2.8 peer reviews, differences in the number of assessments between scientific disciplines are negligible. As the study focuses on funded pro-

jects only, the results of the ex ante evaluation review are as a matter of course high. *Humanities* exhibit the highest ratings with a mean rating score of 91.7, followed by the *social sciences* with a mean rating score of 90.6. With mean rating score of 86.5, *human medicine* shows the lowest mean rating score. Table 5 shows the average ratings of the ex ante evaluation review, along with the average number of ex ante assessments.

3.3.1 Results of the ex post evaluation procedure

The results of the ex post evaluations show that from a peer's point of view FWF funded projects feature very good to excellent performance, though outlier and differences across scientific disciplines occur. Except from ratings for the criterion 'effects that reach beyond the scientific field', all mean values vary slightly around 80. Data on ex post project evaluations reveal that variations between the different criteria, except from 'effects that reach beyond the scientific fields rarely occur. This means that peers give either high or low values for all criteria.

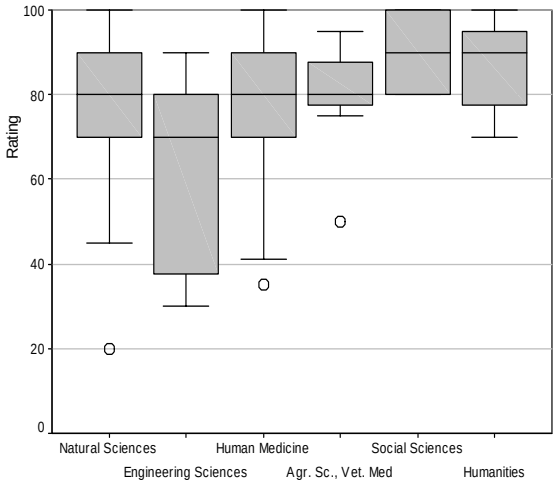
Table 6: Average rating of the ex post evaluation criteria

	N	Mean	Median	Var.	Std. De.
Scientific Success	190	79.48	80.00	250.93	15.84
Effects on Human Resources	187	80.62	80.00	196.26	14.01
Effects that reach beyond the scientific field	165	73.20	77.50	422.22	20.55
Project performance (financial aspects)	164	79.22	80.00	280.86	16.76
Future perspectives of research work	158	80.40	85.00	296.90	17.23

Source: FWF database, own calculations

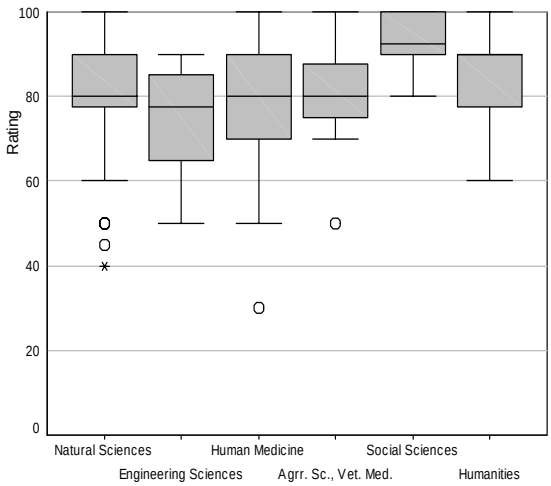
The box-plot diagrams on the next page show results of the ex post project evaluation for all evaluation criteria according to scientific disciplines. Note that the sample is quite small and does not allow for generalisations. In the *social sciences*, the sample consists of six, in the *agricultural sciences* of seven, and in the *engineering sciences* of eight projects only. 76 projects are from Natural Sciences, 37 from *human medicine*, and the *humanities* account for 24 projects.

Figure 9: Scientific success of the projects



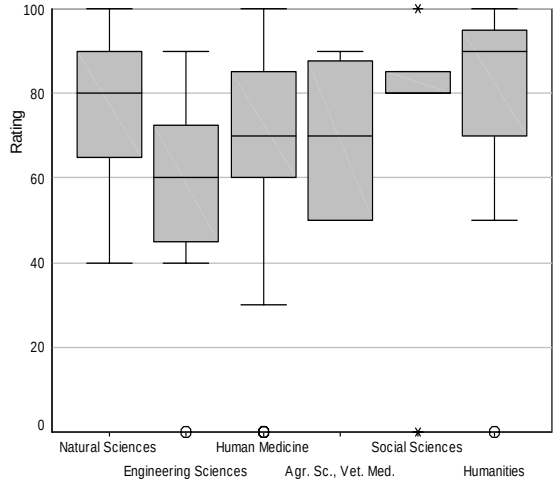
Source: FWF database, own calculations

Figure 10: Effects on human resources



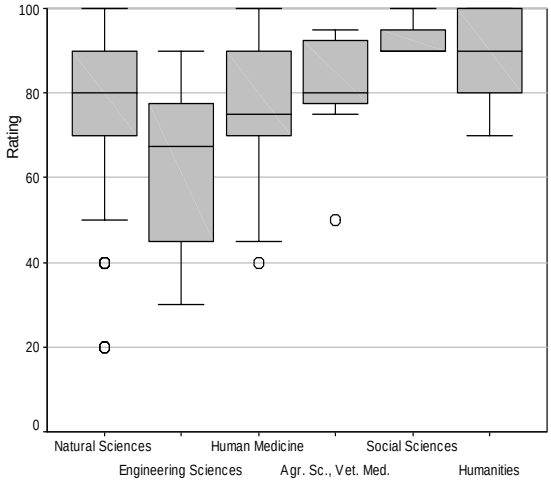
Source: FWF database, own calculations

Figure 11: Effects that reach beyond the scientific field



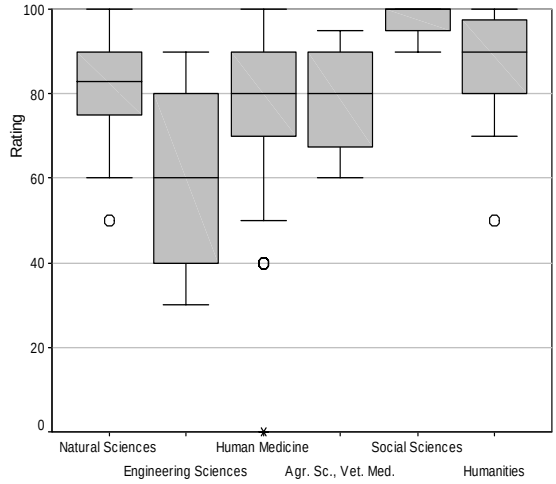
Source: FWF database, own calculations

Figure 12: Financial performance of funded projects



Source: FWF database, own calculations

Figure 13: Future perspectives of the projects



Source: FWF database, own calculations

The diagrams show that the peers considered only a handful of projects in the database as problematic. Variations in ex post evaluations results between scientific disciplines are not considerable except from the field 'effects that reach beyond the scientific disciplines'. Concerning this however, it was already pointed out before that asking peers could only be a starting point for some more appropriate analysis. According to the peers out of the 190 projects in the database, only 4 projects failed concerning the scientific success of the projects. Effects on human resources were considered very positive overall: only 2 out of 187 projects were considered as problematic. The financial performance of funded projects was also considered very positive. Doubts on future perspectives of projects were marginal.

However, the results of the ex post project evaluation have to be interpreted with some caution, as the ex-post reviewer stems from the group of reviewers that has also performed the ex ante project evaluation. This is problematic to some extent: It is very likely that reviewers who recommended funding a project will also judge positively on the results of the specific research project. On the other hand, the same argument could be used in the opposite direction, for reviewers who did not take part in the ex ante evaluation procedure.

3.3.2 Ex-ante and ex post ratings from a gender perspective

The previous two sub-sections have looked at ex ante and ex post evaluation results from a field of science perspective. This section sketches possible variations in ratings from a gender perspective.

Mean values of the ex ante evaluation do not differ significantly between men and women. When looking at mean values, medians, standard deviation of the categories of the ex post evaluation the same results occur: Variations with regard ratings stemming from gender of the project co-ordinator do not occur. Men and women equally contribute to excellent projects, and projects that failed from the reviewer's point of view.

Table 7: Results of ex ante and ex post evaluation from a gender perspective

		Ex-ante results	Scientific Success	Effects on Human Resources	Effects beyond the science	Project perf. (financial asp.)	Future persp.
Male	N	404	162	160	141	140	137
	Mean	88.50	79.30	81.42	73.07	79.35	80.52
	Median	88.33	80.00	80.00	80.00	80.00	85.00
Female	N	70	28	27	24	24	21
	Mean	87.92	80.11	79.26	76.33	80.33	79.62
	Median	88.33	80.00	80.00	75.00	80.00	80.00

Source: own calculation on the basis of FWF data

3.4. Regression analysis of funded projects

The descriptive analysis highlighted the data gathered by FWF in the course of FWF's project funding. The following regression analysis looks whether the data gathered by FWF allow identifying critical factors that influence the performance of projects funded by FWF. Of

course, the small sample of data, which provides only a very small number of ex post project evaluations for some fields of science, limits the reliability of such an analysis. Nevertheless, the regression analysis provides us with information whether specific characteristics of projects as provided in the FWF project database (e.g. size of the project, scientific discipline, inter-disciplinarity) influence the results of the ex post evaluation in form of the rating 'scientific success of the project'. The analysis also demonstrates whether the ex ante evaluation is a good predictor for the ex post evaluation results.

The dependent variable of this model, its left hand side, was the outcome of the FWF's ex post evaluation, the scientific success of the project as evaluated by the peer. The right hand side, the independent variables comprise essentially all the information which is collected in FWF's database. As for the Impact Analysis of FWF, many variables are included as dummies, as the utilisation of size classes allows for a non-linear response of impact on project success (e.g. age of the project co-ordinator, size of the project).

Table 8 lists the variables taken into account for the FWF- performance analysis model.

The variable **scientific success** of the ex post evaluation serves as dependent variable, as the variable relates to the heart of FWF's funding policy, the funding of excellence. Hence, the criterion is closest to the guidelines of the ex ante review.

- The **mean rating of the ex ante evaluation** is included in the regression model, as that rating tackles the question whether the ex ante review serves as a good predictor for good project performance, as measured by the dependent variable. The variance of the ex ante evaluation provides a rough indicator for disagreement among reviewers.
- Several other aspects relate to basic issues that allow differentiating between the projects, among which there are the age of the project co-ordinator, the academic degree of the project co-ordinator, sex of the project co-ordinator, the institutional affiliation, project size and the rate of funding reduction.
- The **scientific discipline** is not only included in terms of affiliation to a broad scientific but also in terms of inter-disciplinarity, as every project co-ordinator classifies the contents of the project according to the international science classification[7]. As almost 50% of the FWF funded projects include several fields of sciences on a 2-digit level, for the analysis only those projects are taken into account for in the analysis, which are interdisciplinary between the 6 broad fields of sciences (20%).
- Scientific output of the project is included in form of a publication activity index[8].

[7] For an explaination of the classification see: Streicher et. al. (2004, p. 13)
[8] The activity index was calculated as the Activity Index of OeUK (see Impact Analysis, p. 27).

Table 8: Variables of the FWF performance analysis model plus summary statistics

N ~ 168	*N*	*MEAN*	*STD. DEV.*
DEPENDENT VARIABLE: SCIENTIFIC SUCCESS OF THE EX POST EVALUATION	168	79.667	15.772
MEAN RATING OF THE EX ANTE EVALUATION	168	88.225	4.649
VARIANCE EX ANTE EVALUATION	168	65.221	97.518
1 IF CO-ORDINATOR IS...			
… YOUNGER THAN 35	17	0.101	0.302
… BETWEEN 45-55	38	0.226	0.420
… BETWEEN 55-65	38	0.226	0.420
… OLDER THAN 65	4	0.024	0.153
… IS A PROFESSOR	142	0.845	0.363
… IS FEMALE	22	0.131	0.338
1 IF FIRST FIELD OF SCIENCE IS...			
... ENGINEERING SCIENCES	7	0.042	0.200
… HUMAN MEDICINE	41	0.244	0.431
… AGRICULTURE AND FORESTRY. VETERINARY MEDICINE	6	0.036	0.186
… SOCIAL SCIENCES	6	0.036	0.186
… HUMANITIES	20	0.119	0.325
1 IF THE PROJECT IS INTER-DISCIPLINARITY ON THE 1ST DIGIT LEVEL	35	0.208	0.407
RATIO SENIOR RESEARCHER	168	0.351	0.373
MONTHS PER EMPLOYEE	168	21.488	9.628
OVERLAP_PERSONELL	168	159.095	66.827
PROJECT DURATION	168	36.286	10.221
PUBLICATION ACTIVITY	168	16.646	21.543
AUSTRIAN ACADEMY OF SCIENCES	7	0.042	0.200
MEDICAL UNIVERSITY	38	0.226	0.420
TECHNICAL UNIVERSITY	13	0.077	0.268
OTHER R&D INSTITUTIONS	20	0.119	0.325
1 IF PROJECT SIZE < 50K	6	0.036	0.186
1 IF PROJECT SIZE 50 -150K€	75	0.446	0.499
1 IF PROJECT SIZE 250-350 K€	20	0.119	0.325
1 IF PROJECT SIZE >350K €	1	0.006	0.077
REDUCTION RATE OF FUNDING	168	0.227	0.196

Source: own calculation on the basis of FWF data

The following Table 9 presents the results of the regression model.

Table 9: Results of the Regression Model

	COEFFICIENTS B	COEFFICIENTS STANDARD ERROR	SIGNIFIC.
CONSTANT TERM	-44.181	32.716	0.179
MEAN RATING OF THE EX ANTE EVALUATION	1.206	0.342	0.001
VARIANCE EX ANTE EVALUATION	0.028	0.014	0.038
IF CO-ORDINATOR IS...			
… YOUNGER THAN 35	3.182	4.346	0.465
… BETWEEN 45-55	6.109	3.229	0.061
… BETWEEN 55-65	-0.250	3.281	0.939
… OLDER THAN 65	-2.849	8.590	0.741
… IS A PROFESSOR	-3.239	3.769	0.392
… IS FEMALE	3.429	3.628	0.346
... ENGINEERING SCIENCES	-13.459	6.362	0.036
… HUMAN MEDICINE	-2.337	3.845	0.544
… AGRICULTURE AND FORESTRY. VETERINARY MEDICINE	2.299	6.728	0.733
… SOCIAL SCIENCES	5.794	6.780	0.394
… HUMANITIES	4.962	4.565	0.279
IF INTER-DISCIPLINARITY ON THE 1ST DIGIT LEVEL	-1.451	3.235	0.655
RATIO SENIOR RESEARCHER	4.693	3.682	0.205
MONTHS PER EMPLOYEE	0.267	0.143	0.064
OVERLAP_PERSONELL	0.030	0.022	0.185
PROJECT DURATION	0.096	0.146	0.510
PUBLICATION ACTIVITY	0.081	0.058	0.165
AUSTRIAN ACADEMY OF SCIENCES	-0.895	6.077	0.883
MEDICAL UNIVERSITY	6.027	4.038	0.138
TECHNICAL UNIVERSITY	3.045	4.916	0.537
OTHER R&D INSTITUTIONS	-0.336	4.020	0.934
PROJECT SIZE < 50K	-12.049	7.357	0.104
PROJECT SIZE 50 -150K€	-0.974	3.084	0.753
PROJECT SIZE 250-350 K€	-5.127	3.912	0.192
PROJECT SIZE >350K €	-11.083	15.707	0.482
REDUCTION RATE OF FUNDING	-0.322	6.889	0.963
DEPENDENT VARIABLE:: SUCCESS EX POST EVALUATION			
DF	*28*		
R	*0.554*		
R^2	*0.306*		
ADJUSTED R^2	*0.167*		
STANDARD ERROR OF ESTIMATOR	*14.397*		

Source: Own calculations on the basis of FWF data

R^2 is the relative predictive power of a model, or the coefficient of variation. R^2 ranges from 0 to 1. It is computed by dividing the estimated sum of squares (ESS) with the total sum of squares (TSS). The higher the R^2 the better the estimated model fits the data. A value of 0.306 is a low, but not unexpected for something as complex as the measured quality of a project. The value tells us that the model explains 30% of the variation in the dependent variable 'Scientific Success of the ex post evaluation'. However, one has to be cautious when using the R^2 coefficient in a multivariate model, because the addition of more explanatory variables can never lower the R^2 and is likely to raise it. The statistics adjusted R^2 adjusts for the degrees of freedom in the model. Value for the adjusted R^2 is 0.167.

By the design of the model, the benchmark project[9] was submitted by a male co-ordinator, who is 35-45 years old and not a professor. The main field of science was Natural Sciences, and the project costs of the benchmark project amounted 150-250 thousand €. The typical project co-ordinator in the model is a researcher from university.

Only a handful of variables are either significant on the five or ten percent level. Explanation of the results is as follows:

- The mean rating of the ex ante evaluation is a good predictor for the ex post evaluation results. Other things equal, a one-point higher rating in the ex ante evaluation leads to a 1-point higher rating in the ex post evaluation. Influence of the variance in the ex ante evaluation, which takes into account the disaccord between reviewers have a significant though marginal positive influence on the results of the ex post evaluation.
- The age of the project co-ordinator, which reflects to some extent experience, plays some role in the model. Other things equal, project co-ordinators who are in the age class of 45 to 55 perform significantly better than the benchmark co-ordinators, who is 35 to 45 years old.
- There is no evidence that the composition of the project team influences the success of ex post project evaluations except from the variable 'Months per employee', no variable is significant.
- Variables taking into account the institutional affiliation do not play a significant role in the model. The same holds true for the size of projects, only very small projects accounting for less than 50,000 € seem to perform worse than the benchmark project – but the variable is not significant either.

[9] "Benchmark variables" are those whose value is 0 in the case of two groups (gender), or those who are excluded from the list of regressors (e.g. age 35-45)

3.4.1 Relevance for FWF's work

The regression analysis shows that differences concerning the results of the ex post project evaluation can hardly be traced with data stemming from the FWF project database. This has two reasons:

- First, the FWF database contains only funded projects, which already run through an ex ante evaluation process. Hence, it is likely and desired that basic differentiations between projects do not influence the quality of the research performed.
- Secondly, the ex post project evaluation stems from the group of reviewers that has performed the ex ante project evaluation. To some extent, this is problematic, as it is likely that positive bias in favour of the projects occurs.

The results of the ex post project evaluation show, that the rating tool is able to identify projects that did not perform as good as expected in the ex ante evaluation. Furthermore, we have to think about possible alternatives. Every project review is time intensive and hence costly. Asking different peers who are not familiar with the project about the performance results of research projects would escalate costs and may not lead to better results, but rather results biased in a different direction.

4 Main Findings

The main findings of this study aim to answer the questions posed at the beginning of the report in a short and distinct way.

What is the concrete value of ex post project evaluations, and do ex post evaluations constitute a solid source of information for FWF and/or other stakeholders in the policy process?

FWF's ex post project evaluation tool is a useful source of information, as it provides FWF and most important the involved researchers with an external feedback on project results. The tool is useful to identify scientific success, and future perspectives of FWF funded projects. However, it is important to mention that a quantitative analysis based exclusively on data provided in databases and/or via surveys, provides only limited information on the effects of research funding.

When it comes to the evaluation of the results of basic research, it is necessary to evaluate the performance of basic research programs by using measures not of practical outcomes as patents, spin-off products, new products or processes, but of performance measures, such as:

- generation of new knowledge,
- quality of research,
- attainment of leadership in the field,
- development of human resources (training of skilled graduates etc.).

The current system of FWF's ex post project evaluations is not a tool that provides thorough analysis on the impact of FWF's research funding. An analysis that studies the impact of FWF's research funding will require the use of surveys on specific types of impact. It will be necessary to perform case studies covering specific research projects to learn more about the effects of FWF's research funding especially for demonstrating the effects on human resources, training, and organisational effects.

Concerning effects on scientific output, bibliometric analyses could provide an important source of information concerning the impact of FWF's work. The database of FWF provides good standardised collection of publication data. Bibliometrics could illustrate the results of FWF funded research in terms of total scientific production and of Austrian universities specifically. Furthermore, bibliometrics could assess the contribution of FWF's funding to the productivity of the researcher's that receive the funding, and to the impact of their papers. Bibliometric analyses could also compare the impact of FWF funded publications with that of other publications published in the same journals or countries.

Do ex post evaluations pose the right questions?

Until quite recently, FWF has not made any efforts to demonstrate effects, or intended results of its funding activities for stand-alone projects except from the ex ante review process. To set up an ex-post project evaluation process was a good step in the right direction.

Compared with the ex ante review criteria, the ex post review takes an extended perspective on FWF funded projects. Besides the scientific quality, which is the core review criteria of both ex ante and ex post project evaluation, the ex post project evaluation considers explicitly effects that reach beyond the scientific field (cultural, ecological effects etc.), and estimates the concern the future perspective of the research work in general.

The **scientific success** of a project serves as core criterion for FWF's funding decision and is consequently also a core criterion for the ex post review. It is appropriate to ask peers about the scientific success of a project in the same manner as it was asked in the ex ante evaluation.

The development of **human resources** is also a feature in the ex ante evaluation procedure, hence it is appropriate to ask the peers about the consequences of FWF's funding concerning the development of human resources. However, FWF should strengthen efforts to show effects not only on a case for case basis, but for the complete funding scheme.

Therefore, FWF needs to improve data gathering of scientists involved in the project. So far, data gathering mainly serves financial/accounting purposes, but does not provide complete information on the scientists involved in the project. FWF should launch efforts to follow career paths of scientists not only for personal grants scheme (e.g. Schrödinger Grants), but also for grants of individual projects. Quantifiable targets, announced at the beginning of a project, are easiest to be established for effects on human resources.

The category **effects that reach beyond the scientific field** does not play a decisive role in the ex ante review criteria. The contribution of research work to the cultural, economic and societal life etc. is difficult to measure, and the effects of basic research might evolve only years after research was conducted. Scientific peers cannot be considered experts with regard the implications of research on economy and society, but the category opens the field for text-based analysis on impacts that reach beyond the scientific field. In order to demonstrate the effects of its research funding FWF would have to rely on more diversified methods such as surveys, focus group interviews, and case studies.

The category **project performance** relates to the financial aspects of the research projects and requests comments on the efficient use of available resources. Whereas this criteria is meaningful in the case of the ex ante project evaluation by asking questions concerning financial cuts that could be made without jeopardizing the success of the research project, the appropriateness for an ex post review is not so clear. It is the task of FWF to control and comment on the appropriate use of financial resources. However, peers might give additional insight concerning the appropriate use of funds.

The category **future perspectives** of the research work relates to the extent to which the project broke new ground scientifically, and hence provides the project co-ordinator with useful

information with regard the scientific relevance of performed research. FWF should keep this category in the ex post review criteria.

What can be learnt from ex post evaluations with respect to the success of a project?

The data of the ex-post evaluation show that among the peers overall satisfaction with the projects is high. Nevertheless, the results of the ex post project evaluation show, that the rating tool is able to identify projects that did not perform as good as expected in the ex ante evaluation.

The regression analysis performed in the course of this study shows that differences concerning the results of the ex post project evaluation can hardly be traced from the data stemming from the FWF project database. The peer review system in the ex ante evaluation procedure seems to be a good predictor for the scientific success of the project. However, in this context one has to keep in mind that the referee performing the ex post project evaluation stems from the group of reviewers that has also performed the ex ante project evaluation: referees stemming from this group are more likely to be in favour of the results of the respective research projects than those who haven't.

However, one has to take into account that every project review is time intensive and hence costly. Asking different peers who are not familiar with the project about the performance results of research projects would escalate costs and may not lead to better results, but rather results biased in a different direction.

Is there a gender bias in FWF's procedures?

The gender specific data analyses in the report show that FWF does not discriminate between men and women in funding decisions. In addition, when looking at the results of the ex post evaluation the same results for both men and women occur: They contribute in equal shares to excellent projects, and projects that failed from the reviewer's point of view. Still, one has to keep in mind that only 15% of projects in the database sample were led by women. However, this reflects the situation at Austrian Universities, not funding and evaluation procedures of FWF.

Do the results of the ex post evaluation provide any hints for the potential of commercialisation of the projects?

The answer is straightforward: No, the results of the ex post evaluation do not provide useful hints for the potential commercialisation of the projects, but unguided basic research projects also do not ask for commercialisation as an end in itself. The peculiarities of basic research vs. applied research limit the ways to demonstrate the economic effects of research: the ultimate outcomes of research into fundamental processes are seldom predictable or quantifiable in advance. It is normal and necessary for basic research investigators to modify their goals, change course, and test competing hypotheses as they move closer to the fundamental understandings that justify public investment in their work [Cosepup (1999, p. 30)].

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JOANNEUM RESEARCH Forschungsgesellschaft mbH – Institute of Technology and Regional Policy (InTeReg)

Vienna Office:
Wiedner Hauptstraße 76
A-1040 Vienna, Austria
Phone: +43-1-581 75 20
E-Mail: intereg@joanneum.at

Graz Office:
Elisabethstraße 20
A-8010 Graz, Austria
Phone.: +43-316-876 1488
E-Mail: intereg@joanneum.at