Key features of the evaluation plan for the BMWi's Sixth Civil Aviation Research Programme

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Background

In the framework of the Aeronautical Research Programme (LuFo), the Federal Ministry of Economic Affairs and Energy (BMWi) is supporting research and technology projects in the field of civil aviation at the German site. The aim is to improve the technological base of aeronautical research in Germany and thereby also to remove existing market imperfections in the field of aeronautical research.In terms of technology, the support programme will in particular follow the Strategic Research Agenda (SRIA) of ACARE and the Federal Government's Aviation Strategy. It shall, in particular, aim at developing a sustainable, economic and efficient air transport system.

With regard to the sectoral promotion of aviation research in Germany, the national/national LuFV programme makes one and a unique and unique position. Although individual Länder such as Bavaria or Hamburg have their own programmes in aviation research. Other Federal programmes (such as the 'Leader-club competition' between 2007 and 2017) also promote, inter alia, aviation projects. However, these are not comparable to Luo, in particular as regards the volume of support.

This is the sixth civil aeronautics research programme (LuFo VI-1), to be launched shortly. The third call in the Fifth Civil Aviation Research Programme (LuFo V-3) is ongoing for the granting phase of the third call for proposals. Projects typically have a maturity of 2018 to 2022. The evaluation plan designed for LuFo VI is addressed by the key content of an evaluation plan as set out in the Commission paper on the Common Methodology for State Aid Evaluation (European Commission 2014).

The concept presented is a revised and extended version of the draft evaluation plan of 03.05.2018. The revision supports all the content of the Commission paper and takes the EU Commission's comments on the first draft version. It outlines key aspects of the evaluation plan with regard to the programme's rationale, objectives and specificities of the evaluation methodology, as well as the time frame and implementation of the evaluation. Enlargement concerns in particular the discussion of methodological issues, the evidence base, the conduct of the evaluation and the publication of the results. The preparation of the evaluation plan is first based on LuFo V-3, where necessary adjustments are made as soon as the process deviates from LuFo V from LuFo V.

Justification for the programme

Economic theory provides clear indications as to when public intervention is necessary and useful to offset various forms of market failure and to avoid that the R & D (R & D) expenditure shows a sub-optimal level of social welfare. The following market imperfections arise in civil aeronautics research and provide justification for the LuFV programme intervention and a corresponding state support for R & D activities:

(M1) Collaborative research is linked to knowledge spillovers. Economic literature shows how collaborative R & D activities in aeronautics research, such as in other areas without State intervention, are sub-optimal because joint research (due to externalities in knowledge transfer) does not allow enterprises to fully acquire the economic return.

(M2) Small and medium-sized enterprises (SMEs) in general and especially in the aviation sector are struggling with a low level of resources and information shortages.These include technological and organisational skills and barriers to financing.There are many indications that these factors, in turn, are linked to innovation barriers that result in reduced levels of R & D activities among SMEs, thus preventing the achievement of optimal levels of R & D activities in the aviation sector.

(M3) There are high risks within the R & D processes, especially in the field of aeronautics research. These risks, which result from the high R & D required and the long innovation cycles, can result in companies failing to make the necessary investments in future technologies and, thus, not to invest in the development of aviation technology.

(M4) In addition to the company specific objectives, there are public objectives (safety in air transport, minimising negative environmental effects and resource consumption), which in the State's view are partly public goods and, as such, would not be readily available without public support. Thus, research in pursuit of these objectives allows the provision of public goods in the air transport sector. This is particularly the case for principle-based research, which has a pre-competitive character and which is associated with high spillover effects.

As the discussed aspects show, the Lupo Programme directly addressed market failures in the aviation sector, so that its implementation there and State support for R & E activities is based on economic theory.

Objectives and economic ratio

LuFo V I have four key objectives, namely "environmentally friendly aviation", "safe and passenger friendly aviation", "capable and efficient aviation" and "total system ability", which includes the independent R & D, which should be present in the overall

understanding and ability of aircraft and its components to the overall system. These objectives are pursued within six programming lines: Eco-efficient flying, SME development, technology development, industry 4.0/Innovative operations, maintenance and repair processes (MRO), electrical/hybrid Flying and demonstration. Different beneficiaries are eligible for funding under the different programme lines. The financial support provided under these lines directly supports the (discussed) economic rationale for market access:

(P1) The programme line "eco-efficient flying" explores themes oriented research topics with a long-term horizon (2030 to 2050) by scientific institutions (universities and non-university research organisations).The objectives of "aviation neutral aviation" and "reduction of environmental footprint and noise" have the character of public goods, which track market imperfections, by internalising externalities. This aspect will be further reinforced by the fact that it is fundamental research and that the implementation perspective is long-term.

(P2) The "SMEs" programme line aims at supporting innovative SMEs in the aviation industry, in particular by enabling collaborative projects (with scientific institutions) and with a precompetitive nature project (support to demonstrate technology by means of a test set-up in an ideal field for deployment).The programme is based on a number of imperfections: in particular, barriers to innovation in SMEs in the aviation industry will be addressed by addressing funding pressures. The promotion of collaborative projects will increase networking and knowledge transfer between SMEs and SMEs with scientific institutions.

(P3) For projects under the Technology Programme line, industrial enterprises (large companies and SMEs) are addressed in the same way as university and scientific institutions, whose application-oriented pre-competitive research and technological development activities are supported. The programme line is based on the following market imperfections: As a first step, collaborative projects will promote the exchange of knowledge between enterprises and science institutions, allowing spill-over effects, while at the same time fostering networking, which allows for additional future joint knowledge development. Since, especially in the long term, the aviation sector often faces important risks in terms of future benefits of research costs, market mechanisms alone are under-performing R & D, so the programme of incentives for additional research addresses this market shortage. The themes supported by the programme, such as the environmental and resource efficient manufacturing processes, have a high social value beyond entrepreneurship.

(P4) In the programme "Industry 4.0/innovative Operation, Maintenance and Repair Processes (MRO)", targeted new technologies, the use of which are expected to produce significant externalities (industry 4.0), or which in the past have not yet developed sufficiently in the past by specific barriers to innovation, are supported by market processes. In the past in the field of MSP, institutional and

organisational factors in the low research intensive enterprises in this area have led to small research activities. The integration of industry 4.0 in particular allows for spill-over effects from applications such as automotive and mechanical engineering.

(P5) The UN climate change conference in Paris (2015) requires all leading industrialised nations to implement long-term CO2 reduction targets through national measures. The new "Electrical/Hybrid Flying" funding line addresses, inter alia, the development of hybrid electric propulsion systems as a leading edge for disruptive aircraft configurations with low environmental footprint.

(P6) The demonstration programme aims at correcting market failures by closing the gap between industrial research and technology development and product development. In particular, the addressed market imperfections consist, in particular, of suboptimal collaboration between developed technologies in the application of developed technologies where system integration is required. The economic theory, however, also shows empirical studies that many barriers to innovation (both internally and between companies) are appearing in systems that require the integration of the competences of different companies. The joint production of a system has the character of a public good, leading to insufficient investment in joint development of the system by each actor.

In the light of the above, the aim of the planned evaluation of LuFo is to demonstrate both the mechanism of action of the programme and to map programme success at different levels of indicators (from input, to activity, out, output, to impact indicators).

Programme specificities and evaluation methods

The development of the evaluation methodology for LuFo is led by the theory and understanding into the evaluation research, taking into account the particular features of the LuFo programme.

Specificities of the aviation sector

When developing the evaluation plan, account will be taken of the specificities of the aviation sector in such a way as to highlight, in particular, the composition of the group (potential) supported operators and the temporal dimension of the support. In this context, the specificities of the aviation sector should be identified:

(B1) *Actors*: The number of aviation stakeholders (enterprises and research organisations) is manageable. The total number of sites identified in the SCE study is approximately2300 company (SCE O.J: 6).The LuFo programme is specifically targeted at this manageable sector, with large enterprises in the sector that are all relevant research organisations, and often with several projects participating in the programme. The SCE study identifies a share of about10 % of large enterprises with 250 or more employees (just over 200), some

of which are not research activities (e.g. some enterprises in the field of MSP).This is not the case with some 2000 SMEs (SCEs O.J.I: 9) where a major group does not regularly participate in the programme. The number of SMEs participating is estimated to be around250 to 400. This estimate takes into account the SME participation in all the lines of the programme.

(B2) *Timeline*: The aviation sector has been characterised by lengthy innovation cycles of around 10-20 years in the development of new aircraft models, which have the effect of extending the effects of the aid, so called programme effects, from the effects of the input through the outsiders to the impacts over a very long period, which can vary greatly between the different projects. It should also be borne in mind that, in the case of long innovation cycles, many processes and influence factors that are changing over time and influence factors make the econometric identification of programme effects more difficult.

(B3) *Public output*:The aviation sector, with its safety and environmental objectives, has dimensions of research that meet overall societal objectives and thus have the character of public goods.These effects are not sufficiently reflected in the direct economic success of the (encouraged) actors such as turnover, profit, employment, growth, etc. Accordingly, the achievement of objectives in this respect should be determined by appropriate indicators.

Evaluation objectives and issues

The evaluation questions to be answered by the evaluation are based on the objectives of the programme and on the right and the approaches to be taken to eliminate market imperfections in the pursuit of these objectives. The following questions are at the centre of the evaluation:

(F1) What has the *incentive effect* of the programme been on the beneficiaries?To what extent have increased input and activity indicators (R & D expenditure and cooperation activities) been extended?

(F2) Are there indications of *deadweight* or negative programme effects here?

(F3) What was the *immediate impact*?Have indicators on outputs and outcomes of R & D activities increased?Whether the output of innovation was extended or did the programme lead to an increase in patenting activities, but also to scientific outputs?

(F4) What was the *indirect economic effect effect*?What future effects on employment or turnover are to be expected?

(F5) What are the additional impact effects for *indirect*, *non-monetary* recorded outputs and outcomes?

(F6) What specific effects (F1) — (F5) result from the six programme lines: 'eco-efficient flying, SMEs, technology, industry 4.0/innovative operation, maintenance and repair (MRO) processes', electrical/hybrid Flying' and ' demonstration':

(F7) What effects from (F1) — (F5) has the support had at the level of different types of actors, i.e. SMEs, large companies and universities/ research organisations?

(F8) Are there any *indirect effects*[1] (in terms of technology spillovers into other enterprises, industries and industries, and technology) observed?

(F9) Are regional heterogeneous *direct* [(F1) (F7)] and *indirect* [(F8)] *effects* of funding possible?

(F10) Did the support have potential indirect negative effects on trade and competition in the aviation sector or in other sectors?If so, have the positive effects on the achievement of the objectives outweighed the possible negative effects?

As part of an overall picture of the aid impact, the question of the extent to which LuFo qualifies as an aid measure satisfies the conditions for appropriateness and appropriateness, i.e. whether the programme is proportionate to the addressed issue. In this context, it is necessary to consider whether the same effects could have been achieved with a lower volume or type of support, and whether other support measures would have been more appropriate to achieve the objective of the aid (see also European Commission 2014: 7).

Evaluations to date

The LuFo programme has already been evaluated in the past. Results of the ex post evaluation of LuFo III (2003 to 2007) and the accompanying evaluation of LuFo IV (2007 to 2015) (Groß et al.) are available on the Internet.2012b).There is also an evaluation study on the economic aspects of the LuFV which relates to LuFo- IV-4 and LuFo V-1 (Rossen et al.2015).At the same time as the evaluation of LuFo III and LuFo IV an evaluation system was developed for the ex ante, accompanying and ex-post evaluation of the programme (Groß et al.2012a).An ex post evaluation of LuFo V is at the time of the preparation of the evaluation plan.

Various methods of collection and analysis are used in the studies referred to above. Focus will be on, inter alia, the analysis of target and target group achievement, the impact and efficient use of resources (Groß et al.2021a: 8).In the study by Rossen et al.(2015) asks for the economic importance of the aviation industry and the overall impact of aerospace research on the economy.

An analytical quantitative calculation of programme effects at micro level using econometric techniques is not yet available for LuFo programmes. The broad recognition of the effects of the programme using econometric techniques, as outlined in the evaluation plan regarding Luto VI, where possible, provides an opportunity to increase significantly the understanding of the effects of LuFo (specific to LuFo VI); this concerns net effects as well as sub-issues (such as programme lines or different types of actors such as large companies, SMEs, universities or research institutes).

[1] The State Aid Evaluation paper of the European Commission identifies as an indirect effect the funding in particular spill-over effects on the activities of other companies or regions (such as cross-border out) (European Commission 2014:6).

Evaluation approach and methodology

In order to answer these questions on the different effects of the programme, the analysis of economic evaluations will be the focus of the analysis. It describes the effects and developments that would have been observed in the absence of the measure. By comparing the situation with the support measure (directly observable) and the situation without action (counterfactual situation), the measure effect can be estimated. The ideal type of aid is given, as well as the counterfactual situation in the implementation of random field experiments, where some of the stakeholders receive support and another part of the actors is not supported. Such a design, however, is not used in the usual policy measures. Accordingly, it is also useful to establish (generic) comparison groups on the comparison between actions to participants and non-participants, which will be used to determine programme effects. In practice, this is often done by using control groups in which econometric estimation methods, such as difference-differ, differing or Propenty — match matching, are applied. If the methods for identifying generic reference groups are not applied or are limited to a limited extent, other procedures such as determination of shadow controls over expert interviews and handling can be used as examination of case studies.

In this context, the aim of the evaluation is to use, on the one hand, *generic control groups* at the places where this is possible and, on the other, *to* achieve a mixture of methods which allows the effects of the programme to be collected as far as possible in the light of the objectives pursued.

In view of the evaluation methodology for the LuFo Programme, the following approach is adopted before the outlined sectoral background:

(S1) *Collection*: Programme effects indicators are widely recognised (short and long term objectives, input, activity, output, outputs and impact indicators).

(S2) *Generic Comparison Groups I*: Econometric associated group approaches will be carried out where possible. The specificity (B1) of the aviation sector implies that the use of these methods is limited in the evaluation of the LuFo programme and is only possible for specific aspects of the programme. The large enterprises in the sector, which are all regularly participating in the support, do not form a generic comparison group within the sector; this could be the case here of large enterprises in this sector in other countries, but it must be ensured that they are not promoted there; we do not generally meet this point for large aviation companies. In contrast, the effects of the LuFo programme are generally made for SMEs, which are generally outside the aviation sector, and also on large companies. Companies in relation to the comparison group can be largely drawn from other industries. In order to review this possibility, the company data from LuFV V-3 have been analysed. It was found that, although the beneficiaries of the programme are in line with the aeronautic supply chain, they are to a large extent attributable to other

industries (more than three quarters).In particular, this is the manufacture of chemical products (CPA 2008 code 20) and plastic products (22), the manufacturing of data processing machines and electrical equipment (26 and 27), the software industry (28), the software sector (62), engineering companies (71) and R & D services (72).

(S3) *Generic Comparison Groups II*: The information contained in the data supplied by the competent project promoter allows another comparison group to be used next to the participants' group and the comparison group, which is based on the SV R & D survey. These are the companies applying under LuFo VI but failed to submit applications. For these companies, non-personal data will not be available for the evaluation purpose to form the composition of those companies. The impact of the programme selection process will have to be taken into account as well.

(S4) *Generic Comparison Groups III*:The LuFo programme is characterised by the sequence of programmes being run through a sequence of programmes, LuFo I to LuFo VI.When establishing reference groups, it is possible to take advantage of the fact that there are companies in the previous programme funded in a previous programme and not promoted in LuFo VI.These companies can be considered as a possible comparator group for programme participants in LuFo IV.[2]It may be critical that the pool from which the comparison group is drawn will be relatively small on the basis of (B1), in particular if one wants to differentiate between groups of participants and thematic areas.

(S5) *Generic Comparison Groups IV*: Similarly, it is clear from the sequential design of the LuFo programmes: When determining the effects on activation and results through the use of generic comparison groups, it should be noted that the effects of the programme will be comparatively lower for those actors already receiving support; once again, the existing level of activity and the level of results may simply be obtained, so that the programme effect of the new funding will be zero. In order to avoid this, it is necessary to carry out analyses on a number of programmes in the case of repeated operators, from the first up to the current relevant support; in line with this, the comparison groups must also be set up inter-temporal, across several funding programmes.

(S6) *Generic Comparison Groups V*:Furthermore, a comparison can be made with enterprises funded in programmes other than Luto. This allows for a reconciliation of federal funding data, which can be identified by the enterprises in the R & D survey data set that have been supported in other federal programmes. However, these are, in general, not aviation funding programmes.[3]However, the extent to

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[2] The sequencing of participation is an important aspect of the heterogeneity of programme effects which can lead to important information in terms of programme effects (see Heckmann et al.1997).Additional consideration of the scale of participation in various CI-1, VI-2 and VI-3 calls would make sense if the evaluation started at a later date and not only on participant data on beneficiaries at VI-1.

[3] In this respect, the LuFo Programme has a unique position in Germany that there are no comparable aviation funding programmes.To a lesser extent, individual countries (or under

which LuFo has a different impact on certain indicators (in particular R & D expenditure or R & D personnel) can be considered, as is the case for other funding programmes at federal level. This comparison can provide important information for the assessment of the adequacy and proportionality of the support, even if the results are more conservative and careful.

(S7) *Shadow controls*: Due to a lack of data, alternative approaches are preferred to those where implementation of a line approach is not possible. This includes the identification of shadow controls which are based on a survey of neutral experts (Bjurulf et al.2012).For this purpose, the development of result indicators is first established, whereas the estimation of programme effects on the basis of plausible data is done by experts. In the evaluation of LuFo, this type of analysis will be applied to large enterprises and possibly also to research organisations.

(S8) *Technological Case Studies*: Elsewhere (for example, when it comes to establishing programme effects in large companies), the transfer processes about technology-specific case studies are followed up with the use of process[4] tracing methods to give guidance on impact relationships (Bjurulf et al.2012, Rothgang et al.2017).

(S9) In addition to the conduct of peer group analyses, the identification of shadow controls and technology-based case studies, it is also possible and appropriate to conduct a comparison with other programmes at national and EU level in Europe. This comparison allows for the identification of similarities and differences in programme design and structure, programme implementation and, where available, programme results. Appropriate programmes include, inter alia, the EU Clean Sky 2 programme under Horizon 2020, and the promotion of aeronautics research in the framework of the French FUI — Fond uniique Interministeriel. However, at least according to our research, there are still not enough evaluations of aeronautical research programmes with comparable methodological tools.

In principle, there are many ways in which different designs of the different designs can be designed. The choice of which comparator groups can ultimately be included in the econometric calculations can only be taken in the context of the preparatory work. This requires more detailed information on how many companies ultimately keep the data set for the econometric invoices.

The chosen approach allows for an extensive mapping of the development of key indicators of the success of the programme, while at the same time the best mix of methods is used to identify causal programme effects.

Evaluation indicators

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individual programmes such as the Federal Ministry for Education and Research), but which are not comparable in volume terms, are also not comparable to the LuFo programme.

[4] process tracing implies a systematic and thorough assessment of the step by step the effects of a process.The aim is to gain an insight on how the measure will impact the results of the support (Collier 2011).

The indicators used in the evaluation are primarily based on the programme objectives, the individual methods used and data availability for quantitative analyses also require the use of different indicators in the different methods of comparison. In principle, the whole range of input, output, output, outcome, and impact indicators are used. Among others, the focus will be on the following indicators and categories of indicators:

(i1) Programme implementation indicators (number of projects, eligibility period and volume), project or business success, plus other indirect effects. Classification schemes for types of projects (e.g. base material/application oriented) are also needed.

(i2) In determining generic controls, in particular R & D expenditure and R & D personnel at the enterprise level are used as input quantities. In addition, many indicators are needed as control variables (enterprise size, interconnectedness, participation in other funding projects, age, etc.).

(i3) Other activity and, in part, output indicators are used to determine shadow controls and technological case studies. This concerns, for example, indicators for the participation of SMEs, the development of the operators, as well as indicators at the level of universities and research institutions (information flows, publications, use of the knowledge generated in the project in other contexts such as university education, doctoral and Master's work).

(i4) At the level of the individual programme lines or groups of players, different impacts can be depicted on the basis of the indicators collected, so that the impact of the support can also be assessed at the level of individual programme lines (e.g. for example: Process innovation for industry 4.0, participation of SMEs on the same programme line).

The evaluation of Outcomres and impact will not be generally observed in the foreseen timeframe for Luco VI because of the long innovation cycles. It is possible to make statements on the basis of an examination of previous versions of the programme.

Data sources and availability

The main sources of data used are the following:

(Q1) The indicators collected in the framework of the Lupo Programme make it possible to cover a large number of the required indicators.This concerns, in addition to project data (start date and end date, funding volume and own funds), including company registration number, turnover and number of employees. In LuFo VI a certain degree of specific indicators (in particular, R & D expenditure and R & D expenditure by the beneficiaries) can be requested in addition to the indicators already recorded for LuFV V-3.

(Q2) For the comparison group calculations, it is possible to combine this data source with the micro data from the SV survey of R & D.This data source has already proved in past evaluations as an appropriate basis for the implementation of comparison group calculations with respect to input indicators (R & D personnel

and R & D expenditure) for both programme participants and in particular the comparator group (Engel et al.2016).It is also necessary to verify the extent to which data on innovation activity permit comparison group analysis with the CIS country or the MIP.

(Q3) In addition to the data for the comparative group calculations, it is useful to use other company data that are still available. Creditreform is the most comprehensive database in Germany; this is provided, for example, by the Dafne-database of Bureau van Dijk (BvD) in electronic form. Data include published company data on balance sheet information and ownership structure. [5]

(Q4) Further extraction data on important federal R & D programmes can be integrated, where appropriate, with the project database PROFI, which, in addition to information on the beneficiaries, also covers the amount and type of support project (individual vs. Collaborative Project).On this basis, the comparison group will be able to identify those enterprises which have benefited from other programmes.

(Q5) In addition, expert discussions will be needed to identify shadow controls. The same applies, in a complementary way, to the coverage of the calculation results and to the implementation of technical case studies to estimate longer programme effects.

(Q6) Past programme evaluation and programme documents are another important source for the implementation of the evaluation.

Time frame and execution of the evaluation

The programme's effects of Ludio have a sector- and technology-specific model to be taken into account when drawing up the evaluation plan as well as the implementation of the evaluation. The specific impact pattern in terms of the different programme effects (input, activity, output, output and impact indicators) should be taken into account. The LuFo VI programme will be published at the end of 2018 (1. Call for aid), approx. In the middle of next year, starting with first authorisations and having a total of 3 aid calls for a duration of approximately 10 years. The impact samples to be expected are as follows:

Input effects (in terms of R & D costs and personnel) will occur immediately after the start of the projects. Changes in activity (e.g. in terms of changes in cooperation patterns) will also be monitored immediately after the start of the project, with the question of the extent to which changes in cooperation patterns are maintained at the end of the project. Output indicators, such as patent applications, are partly initiated during the project's lifetime, some of them after the end of the project. It should be noted, however, that a certain period of time (approx.2 years) from the submission to the publication of the patent applications. Outsourced indicators (product and process

[5]Data from the German Federal Statistical Office's business register are not available for such analyses.

innovations) have a very different pattern, depending on the project. In the case of MSP, innovation is already partly realised about two years after the end of the project, in cases where a new generation of aircraft is required, this period can also be between 15 and 20 years. It is therefore dependent on the timing of the evaluation which programme effects can be measured.

It seems worthwhile to start the evaluation in the final third of the programme period. In particular, input and activity indicators can be recorded in a timely manner. Completed projects also allow for the first medium-term programme effects to be taken at output and outsiders level.Thus, a period of LuFo VI-1 would run from the beginning of 2019 (outline submission) to about2029 (funding of projects under the last call — LuFo VI-3) offered a launch of the evaluation in 2025.However, it is precisely from the point of view of support that significant long-term programme effects cannot be measured. The time between the beginning and the programme effects of LuFo VI is too low to be observed. However, such effects may be approximated for some selected project lines on the basis of older orientations of the LuFV programme.

The evaluation of the aeronautics research programme will be published in 2024. The public tender ensures a high degree of independence of the evaluation. The aim of this call for tender is to allow candidates to contribute their own expertise to propose changes in the evaluation design that can potentially lead to higher knowledge gain.

Following the tender process, the external evaluation will start by LuFo. An interim report will be ready by 2026 and a final report by 2027. The final report will be forwarded to the European Commission. The final report will be published on the Internet in order to make the results available to the interested public.

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