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A Determinant of Austrian Comparative Advantage

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A Determinant of Austrian Comparative Advantage

by

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Abstract

This paper analyzes the performance determinants of Austrian public membership in intergovernmental research organizations. Performance in terms of membership effectiveness is measured by the ratio between a cost indicator, viz. the Austrian organization-specific budgetary share, and a human capital indicator, viz. the corresponding Austrian share in the staff base of the respective organization. To identify performance drivers, we conduct a logistic regression analysis drawing upon a binary specification of the response variable. We find that in the case of Austria there are three factors that impinge positively on performance. An organization should be predominantly research-focused rather than training-oriented; membership therein should be motivated by a high degree of foreign policy relevance; and, due to increasing returns over time, the joining of an organization should be conditional on an upfront commitment to long-term membership.

Keywords

Intergovernmental scientific research organizations, international collaborative research, logistic regression, performance measurement

JEL Codes: I23, O19, O38, C35

I. Introduction

Frontier academic research frequently involves substantial long term resource commitments that are coupled with enormous implementation complexity. In particular, the installation and maintenance of the necessary research and development infrastructure may significantly exceed the management capacity and budgetary means even of the leading research associations and the corresponding public and private research budgets of individual countries. As a resort, multilateral investment efforts may present themselves as conducive to further the availability of and the access to proper research facilities. This holds a fortiori in the context of the comparatively small-sized, heterogeneous institutional research structures in Europe as compared to the United States.

For comparatively small, high-income economies access to frontier research infrastructure is critical to their future income path. In this paper we address the issue of institutional performance in the utilization of funds for research and development, considering Austria as a case in point. In particular, we seek to map the stake of Austria as a member in international intergovernmental scientific research organizations and to identify the factors that determined it?[1].

Since the organizations under scrutiny differ in budget size and staff size as well as in a lot of other dimensions (legal status, orientation towards infrastructure versus orientation towards education, track record, etc.) a fair evaluation of membership requires deviation from a "one size fits all" approach. Hence, this paper does not aim to evaluate the scientific accomplishments of the organizations covered and their relevance for the international research system in the corresponding research fields.

Rather, we conduct a comparative analysis between the Austrian contributions to the budgets of individual intergovernmental research organizations on the one hand, and indicators that measure the mode and the intensity of the utilization of the potential of these organizations on the other.

The paper is organized as follows. The next section is dedicated to a description of the indicators employed. In the third section we provide exploratory analyses of the data to derive some initial statistical information. In the fourth section we develop logistic regressions and present their results. A final section concludes the paper, inter alia with some forward-looking considerations on possible Austrian membership in the European Southern Observatory (ESO).

[1] ESA (European Space Agency)), (EUMETSAT European Organisation for the Exploitation of Meterological Satellites), EMBC (European Molecular Biology Conference), EMBL (European Laboratory for Molecular Biology), CERN (Centre Européenne pour la Recherche Nucléaire), ILL (Institut Laue –Langevin), EFDA (European Fusion Development Agreement), ESRF (European Synchrotron Radiation Facility), ECT*[1] (European Centre for Theoretical Studies in Nuclear Physics and Related Areas), IIASA (International Institute for Applied System Analysis) und CISM (Centre International des Sciences Mechaniques)

II. Indicators

As a starting point, we expect Austrian membership in international research networks to impinge positively on the number of Austria-affine researchers and thus to add to the pool of researchers that may be potentially recruited by Austrian higher education and research institutions. Likewise this holds for Austrian participants in international scholarship programs.

The Austrian budgetary share of the organizations studied[2] is expressed by cost indicator *k*. This measure is compared to the Austrian share in the respective organization's human capital *h* (scientific staff, scientific users, postgraduate students)[3] as a performance measure in terms of membership effectiveness. If the Austrian proportion of the organization's human capital *h* is greater than or equal to the Austrian share of the organization's budget, then the opportunities offered by the international scientific research organization are intensively utilized. And conversely, if the Austrian proportion of the organization's human capital *h* is less than the Austrian share of the organization's budget, the opportunities provided by the membership in a specific organization have not been fully tapped.

This approach identifies organizations for which the gains (human capital stake) exceed the costs (share of budget) and organizations where that is not the case. More formally, we define a binary variable *Y* and name it *success,*

$$Y = \begin{cases} 1 & \text{if} \quad h \geq k \\ 0 & \text{if} \quad h < k \end{cases} \quad \text{for } h,\ k \geq 0$$

Variable *success* (*Y*) assumes the value one if the annual Austrian proportion of scientific staff, scientific users or postgraduate students is greater than or equal to the annual Austrian contribution (in percentage terms) to the organization's budget and is zero if the annual Austrian proportion of scientific staff, scientific users or postgraduate students is less than the annual Austrian share of the organization's budget.

The factors x_i determining the variable *success* (*Y*) include organizational and scientific variables as well as country-specific variables. Altogether, we consider 14 factors. The *variables of institutional orientation* including mission describe typical characteristics of the organizations including their position in the academic community and their socio-political relevance:

> The factor "focus" is scaled nominally and distinguishes between organizations that are infrastructure-oriented and those that are education-oriented. The former are, for instance, ESA, CERN and ESO. All of them are characterized by enormous investment requirements. Organizations such as EMBC and CISM, by contrast, are a forum for conferences, workshops, and training courses but do not provide an extensive infrastructure.
>
> The factor "membership EIRO" distinguishes between organizations which are members of the EIRO–Forum and those which are not. The EIRO-Forum[4] was established by the federation of seven European scientific research organizations. It is assumed that in the course of the development of the European Research Area the EIRO-Forum is going to play a more prominent role.
>
> The factor "topic" is binary and discriminates between organizations with a wide variety of topics and organizations that deal with a very specific or scientific niche field.
>
> The factor "orientation" is scaled nominally. It assumes three values: basic research (like CERN), application-oriented research (like CISM), and combinations of these (like ESA).
>
> The factor "position in field of expertise" is binary and separates unique organizations (like ESO or CERN) on a worldwide level from organizations positioned in a competitive environment (e.g. IIASA).

[2] Annual proportion of the organisation's budget (1998–2002).
[3] Annual proportion of the organisation's human capital (1998–2002).
[4] www.eiroforum.org

The factor "integration into the international research community" determines if an organization keeps an intensive relationship with the international research community. To illustrate, ESRF entertains a lot of joint projects with EMBL and ILL, whereas CISM operates largely on its own.

The factor "high potential for scientific training" reflects whether international top-level scientific training is provided (e.g., at EMBL) or not (e.g. at EUMETSAT).

The factor "autonomy of the scientific program "takes only two values: "1" for high autonomy of the scientific program (e.g. CERN) and zero for low autonomy of the scientific program (e.g. EUMETSAT).

The factor „high relevance of the scientific results for society" assumes the value "1" for organizations whose scientific results are considered to bear directly for society and zero for the others. Especially research in molecular biology is expected to exercise a long term sustainable impact on society (EMBL and EMBC belong to this field of expertise), whereas the impact of an organization like CERN is not foreseeable.[5]

The Austria-specific variables include factors describing the nature of Austrian membership in detail:

The factor "role of Austria" distinguishes between organizations in which Austria's stake, taking into account its financial contribution, carries weight – either in the scientific field or in the administrative field (e.g. the head of a program is Austrian) –, as in the case of IIASA or ESA, and organizations in which Austria's role is rather moderate or even negligible.

The factor "foreign policy relevance" divides the organizations into two groups – one group comprising organizations with relevance for Austrian foreign policy, and another group for which that is not the case. This applies to ILL, for instance, for which Austria and the Czech Republic constituted a joint membership.

The factor „accordance with the national research plan" is meant to catch the relationship between an organization's field of expertise and the inclusion of the specific topic in the national research plan. "Space sciences" for example are an expressly mentioned priority in the national research plan[6] with relevance for the Austrian memberships in ESA and EUMETSAT.

The factor "duration of membership" is an interval-scaled variable, measuring the duration of Austrian membership by the number of years.

[Table 1: Factors]

III. Explorative analysis

We employ various tools of statistical analysis to explore the data set in order to gain some initial insights about possible correlations between the dependent variable *success* (*Y*) and the independent variables x_i.

III.1. The dependent variable success Y

The frequency table shows the values of the dependent variable *Y*. For seven organizations the Austrian contribution to the budget of the respective organization exceeds the Austrian participation in the human capital of the organization For four organizations the opposite holds. Thus, for nearly one third of the examined organizations the staff/budget ratio is at least well-balanced while for nearly two thirds costs exceed benefits.

[5] Expert judgment by the Fraunhofer Institut für naturwissenschaftlich-technische Trendanalysen, Euskirchen (http://www.int.fraunhofer.de/), on the basis of in-depth cross-disciplinary analyses.
[6] http://www.rat-fte.at/files/NFIP_20021203.pdf

[Table 2: Frequency table of the dependent variable *Y*]

III.2. The independent factors x_i

Inference analysis identifies just three out of 15 examined factors to have a significant influence on *Y*: high potential for scientific training, foreign policy relevance, and duration of membership. For the first two variables, which are nominally scaled, a bar chart is useful; for the third one, which has a metric scale, a box plot is appropriate.

For this factor the bar chart depicts that only one of the four organizations in which membership is considered to be successful (*Y*=1) has a high potential for scientific training. However, six of the seven organizations in which membership is considered to be less successful (*Y*=0) have a high potential for scientific training.

[Figure 1: High potential for scientific training]

For this factor the bar chart demonstrates that three of the four organizations in which membership is considered to be successful (*Y*=1) are characterized by a high degree of foreign policy relevance. But only four of the seven organizations in which membership is considered to be less successful (*Y*=0) document a high foreign policy relevance.

[Figure 2: Foreign policy relevance]

For this factor the box plot shows that the median period of membership, in case that membership is considered to be a success, is 30 years, whereas the median period of membership in case that membership is considered to be unsuccessful is 10 years.

[Figure 3: Duration of membership]

IV. Econometric analysis

IV.1. Logistic Regression

A logistic regression presents itself as an appropriate means to analyze a binary response variable. The response, *Y*, may assume one of two possible values, denoted by 0 and 1. The vector $x = (x_1, x_2, ...x_m)'$ consists of *m* explanatory variables, which can be discrete, nominal, categorical, or interval-scaled.

The following logistic regression model is employed:

$$\text{logit}\{P(Y=1 \mid x)\} = \log\left\{\frac{P(Y=1 \mid x)}{1-P(Y=1 \mid x)}\right\} = \beta_0 + x'\beta = g(x)$$

with β_0 as the intercept parameter and β as the vector of the slope parameters (Hosmer, Lameshow, 1989). For estimating the unknown parameters, we draw upon maximum likelihood estimation (MLE). MLE provides values for β_0 and β which maximize the probability of obtaining the observed set of data.

The parameter β is the rate of change in the log odds ratio for a one unit change in the independent variable. This means that the odds ratio can be interpreted as the "relative risk" for an event to occur:

$$\text{odds ratio} = \frac{P(Y=1 \mid x)}{1-P(Y=1 \mid x)} = e^{g(x)} \rightarrow \log(\text{odds ratio}) = g(x)$$

To test the significance of a coefficient β_{xi}, we use the Likelihood Ratio Test. We thus compare the observed values of the response variable to the predicted values obtained from models with and without the variable in question (x_i). The comparison between observed and predicted values using the likelihood function is based on the following expression, called Deviance (G). The expression in square brackets is called likelihood ratio. Deviance plays the same role in logistic regression as does the numerator of the partial F–test in a linear regression:

$$G = -2\ln\left[\frac{\text{Likelihood}(\text{model without } x_i)}{\text{Likelihood}(\text{model with } x_i)}\right]$$

According to the hypothesis that β_{xi} is equal to zero, the statistic G will follow a chi-square distribution with one degree of freedom,

$G \approx \chi_1^2$

If G is greater than χ_1^2 , the influence of the parameter β_{xi} is significant.

IV.2. Results

Due to the small sample size (n=11), it is not feasible to conduct a multiple logistic regression. Instead, we resort to a logistic regression for each of the 15 factors of which only three display a significant influence on the response variable Y.

<u>High potential for scientific training</u>

The logistic regression quantifies the relationship between Y and x_1 (high potential for scientific training).

[Table 3: Logistic regression x_1 (High potential for scientific training)]

The relationship between Y and x_1 (high potential for scientific training) is estimated by the following equation:

$\log(P(Y=1|x)/\ 1-\ P(Y=1|x)) = g(x) = -1{,}79176 + 2{,}89037 * x_1$

The p-value of the Likelihood Ratio Test is 0,0409. On a 95% confidence level the variable x_1 thus exerts a statistically significant influence on the response variable.

The type of influence can be inferred from the estimated parameter *B* which assumes the value 2,89037 and an odds ratio of 18, respectively. This means that a successful membership occurs 18 times as often for organizations without a high potential for scientific training than for organizations with this kind of potential. In other words, Austrian membership appears to perform much better in organizations that focus on research rather than training.

A cut off-point of 0,5 yields the maximum number of correct classifications. The model treats 82% of the data accurately (74% of the successful memberships and 86% of the unsuccessful memberships were treated accurately).

[Table 4: Classification Table x_1 (High potential for scientific training)]

The logistic regression quantifies the relationship between *Y* and x_4 (foreign policy relevance).

[Table 5: Logistic regression x_4 (Foreign policy relevance)]

The relationship between *Y* and x_4 (foreign affairs relevance) is estimated by the following equation:

$$\log(P(Y=1|x)/\ 1-\ P(Y=1|x)) = g(x) = -1{,}09861 + 2{,}48491 * x_4$$

The p–value of the Likelihood Ratio Test is 0,0907. On the 90% confidence level, x_4 thus turns out to influence the response variable Y significantly. The estimated parameter *B* has the value 2,48491 and an odds ratio of 12, respectively. Hence, a successful membership occurs 12 times as often among organizations with a high foreign policy relevance than among organizations with a low foreign policy relevance.

Using a cut off-point of 0,5 again, the model treats 78% of the data accurately (80% of the successful memberships and 75% of the unsuccessful memberships were correctly classified).

[Table 6: Classification Table x_4 (Foreign policy relevance)]

Duration of membership

The logistic regression quantifies the relationship between *Y* and x_3 (duration of membership).

[Table 7: Logistic regression x_3 (Duration of membership)]

The relationship between *Y* and x_3 (duration of membership) is estimated by the following equation:

$$\log(P(Y=1|x)/\ 1-\ P(Y=1|x)) = g(x) = -1{,}22469 + 0{,}122209 * x_3$$

The p-value of the Likelihood Ratio Test is 0,05. On a 90% confidence level x_3 thus appears to influence the response variable *Y* significantly as well. The estimated parameter *B* has a value of 0,122209 and an odds ratio of 1,13, respectively. The chance for a successful membership is

increased by 13% if Austrian membership is extended for another year. In other words, the longer the membership, the higher the chance for a superior performance.

With a cut off-point of 0,5, the model treats 64% of the data accurately (71% of the successful memberships and 50% of the unsuccessful memberships). A cut off-point of 0,7 yields the maximum number of correct classifications. The model treats 82% of the data accurately (71% of the successful memberships and 100% of the unsuccessful memberships were treated accurately).

[Table 8: Classification Table x_3 (Duration of membership)]

V. Conclusions

The evaluation of Austrian membership in international intergovernmental scientific research organizations is a complex and challenging task. To do so, it is useful to draw upon both qualitative and quantitative methods.

In the present paper we create an indicator to measure the effectiveness of the Austrian memberships. It goes without saying that this indicator documents but one aspect of the many dimensions of a more comprehensive evaluation. According to our analysis Austria appears to benefit from a comparative advantage if the respective organization is characterized by a focus on research rather than training.

By implication, from this analysis no support can be distilled in favor of the present discussion about an Austrian membership in ESO since this infrastructure is characterized by a high potential for scientific training. The predicted probability for a successful ESO membership based on this indicator is a mere 0,14. The low value implies that the likelihood of an Austrian ESO membership to turn in a success is far below average as compared to other space-related memberships.

However, Austrian membership appears to be considerably more successful if the respective membership has a high degree of policy relevance. Contrary to before, this finding provides an argument in favor of a potential Austrian membership in ESO because the foreign policy relevance of ESO is gauged to be above average. According to this factor, the predicted probability for a successful membership is 0,80.

Furthermore, the likelihood of success increases over time. Possibly due to a size effect, it appears that Austria benefits more from its membership if there is more time for integration in the internal processes.

Finally, the outcome that the dependent (*success*) variable does not indicate an Austrian comparative advantage in more than four cases suggests that the justification of membership in large international intergovernmental scientific research organizations builds to some substantial degree on foreign policy considerations such as the participation in the developing European Research Area.

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Table 1: Factors

No.	Parameter	Scale	Parameter Value
1	Focus of the organization	nominal	0 – education, 1 – infrastructure
2	Member of EIRO-Forum	nominal	0 – no , 1 – yes
3	Topic *	nominal	0 – small, 1 – large
4	Orientation of organization*	nominal	1 – fundamental research, 2 – applied research 3 – both
5	Position in field of expertise *	nominal	0 – not worldwide unique 1 – worldwide unique
6	Integration into the international research scene *	Nominal	0 – no, 1 – yes
7	High potential for scientific training *	nominal	0 – no, 1 – yes
8	Autonomy of the scientific program *	nominal	0 – no, 1 – yes
9	High relevance of the scientific results for society *	nominal	0 – no, 1 – yes
10	Role of Austria	nominal	0 – small, 1 – large
11	Foreign policy relevance	nominal	0 – low, 1 – high
12	Advantage of location	nominal	0 – no, 1 – yes
13	Accordance with national research plan	nominal	0 – no, 1 – yes
14	Duration of membership	interval	No. of years
* Derived from organization ratings provided by the Fraunhofer Institut für naturwissenschaftlich-technische Trendanalysen, Euskirchen (http://www.int.fraunhofer.de/).			

Table 2: Frequency table of the dependent variable *Y*

Y	Frequency	Percent (%)
0	7	63,6
1	4	36,4
Total	11	100

Table 3: Logistic regression x_1 (High potential for scientific training)

estimated regression model (Maximum Likelihood)

Parameter	B	Standard error	estimated Odds Ratio
CONSTANT	-1,79176	1,08009	
x1=no[7]	2,89037	1,58112	18,0

Likelihood Ratio Test

Factor	Chi-Square	Df°	P-value
x1	4,18029	1	0,0409*

*** significant on 5% level**
° degrees of freedom

Table 4: Classification Table x_1 (High potential for scientific training)

Cutoff	Y = 1	Y = 0	Total
0,5	75,00%	85,71%	81,82%

[7] indicator coding

Table 5: Logistic regression x_4 (Aspect of foreign policy)

Estimated Regression Model (Maximum Likelihood)

Parameter	B	Standard error	estimated Odds Ratio
CONSTANT	-1,09861	1,1547	
x4=high[8]	2,48491	1,60727	12,0

Likelihood Ratio Test

Factor	Chi-Square	Df°	P-Value
x4	2,8626	1	0,0907**

** significant on 10% level
° degrees of freedom

Table 6: Classification Table x_4 (Aspect of foreign policy)

Cutoff	Y=1	Y=0	Total
0,5	80,00%	75,00%	77,78%

Table 7: Logistic regression x_3 (Duration of membership)

Estimated Regression Model (Maximum Likelihood)

Parameter	B	Standard error	estimated Odds Ratio
CONSTANT	-1,22469	1,20506	
x3	0,122209	0,0841578	1,12999

Likelihood Ratio Test

FACTOR	Chi-Square	Df°	P-Value
x3	3,84258	1	0,0500**

* signicant an a 10% level
° degrees of freedom

Table 8: Classification Table x_3 (Duration of membership)

Cutoff	Y=1	Y=0	Total
0,5	71,43%	50,00%	63,64%
0,7	71,43%	100,00%	81,82%

[8] indicator coding.

Figure 1: High potential for scientific training

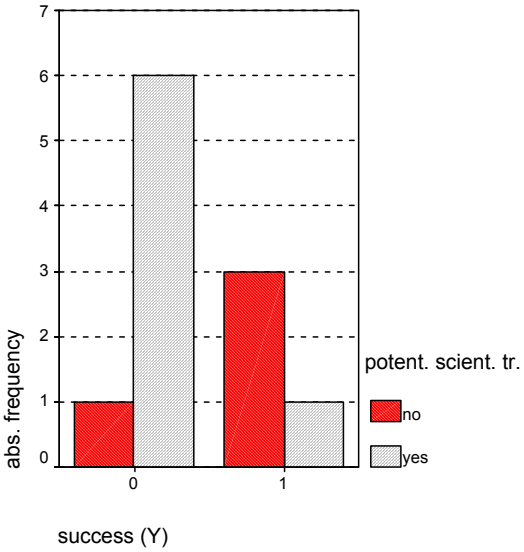
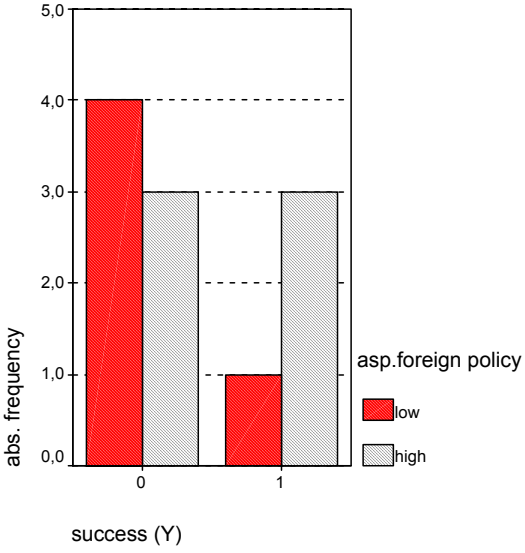


Figure 2: Foreign policy relevance



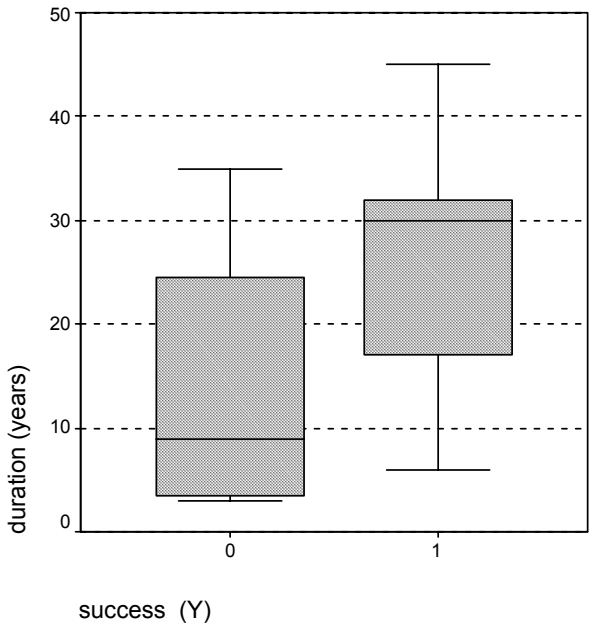


Figure 3: Duration of membership