Peer review for the evaluation of the academic research
The Italian experience

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ABSTRACT. Peer review, that is the evaluation process based on judgments formulated by independent experts, is generally used for different goals: the allocation of research funding, the review of the research results submitted for publication in scientific journals, and the assessment of the quality of research conducted by Universities and university-related Institutes. The paper deals with the latter type of peer review. The aim is to understand how the characteristics of the Italian experience provide useful lessons for improving peer review effectiveness for evaluating the academic research. More specifically, the paper investigates the peer review process developed within the Three-Year Research Assessment Exercise (VTR) in Italy. Our analysis covers four disciplinary sectors: chemistry, biology, humanities and economics. Thus, the choice includes two "hard science" sectors, which have similar type of research output submitted for the three-year evaluation process, and two sectors with different types of output. The results provide evidences, which highlight the important role played by peer review for judging the quality of the academic research in different fields of science, and for comparing different institutions' performance. Moreover, some basic features of the evaluation process are discussed, in order to understand their usefulness for reinforcing the effectiveness of the peers' final outcome.

KEYWORDS: Scientific research, Evaluation, Peer review, University, Academic institutions

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INTRODUCTION

Peer review, that is the evaluation process based on judgments formulated by independent experts, is generally used for different goals: the allocation of research funding, the review of the research results submitted for publication in scientific journals, and the assessment of the quality of research conducted by Universities and university-related Institutes.

The paper deals with the latter type of peer review, whose results, in many European countries, impact the Government block grant funding allocation to public research institutions.

The aim is to understand how the characteristics of the Italian experience provide useful lessons for improving peer review effectiveness for evaluating the academic research. More specifically, the paper investigates the peer review process developed within the Three-Year Research Assessment Exercise (VTR) in Italy. VTR is the formalised evaluation exercise launched by the Italian Government at the beginning of 2004, aimed to assess the research performance of the academic institutions (Universities and public research agencies) across scientific fields, for a three-years period (2001-2003).

The analysis is carried out according to the following questions:

- how did peer review reinforce its strengths and avoid its weakness and shortcomings in the Italian experience?
- how did the university rating based on peer review results fit with the rating based on bibliometric indicators (namely the Impact Factor indicator)?
- how far is the internationalisation of peer review applied in Italy?
- what kind of knowledge did peer review provide to the decision-makers at national and institutional level for addressing the resource allocation, the priority setting, and the transformation of both Universities and research Institutes?

In our paper we try to answer these questions in two ways. First, we analyse the peer process management in the light of the assessment criteria which can be considered relevant for the retrospective evaluation (Chubin and Hackett, 1990; Oecd, 2005), namely:

- *rationality*: the rationale of the process must be recognised by all the potential users of the evaluation results, scholars, policy makers, stakeholders, society at large. The knowledge of the internal rules and their coherence with the established ideologies are crucial issues for the acceptance of the outcome of the research assessment,
- *impartiality*: no differences in the peers judgments should derive from personal interests of peers, from positions against or in favour of an author or institution,
- *validity*: the setting up of technical standards and rules aimed to guarantee a good judgment of the research quality,
- *reliability*: peers are expected to judge the quality level of a paper, not the author reputation or the prestigious of the institutions the authors belong to. Thus, reliability of peer review can be controlled through the level of disagreement between different experts views,
- *efficiency*: it can be measured through the cost of the exercise and how it was time consuming,
- *effectiveness*: it refers to the capability of the process to identify high quality research, providing also indication to the decision makers for orienting resource allocation and for supporting the setting up of strategies.

Second, we test some bias of the peer reviewing by using the available data of the Italian VTR. According to Martin and Irvine, the main weaknesses in peer reviewing lie on (Martin and Irvine, 1983):

- subjectivity of the judgments,
- absence of specific expertise of peers,
- bias in favour of prestigious institutions, prominent researchers and research groups based on reputation or other recognitions given to the work,
- interdisciplinary bias (Rinia *et al.*, 1998; 2001).

Third, we analyse the kind of correlation between peer outcome and journal IF values for understanding what is the relationship between the two evaluation tool and the added value of peer reviewing.

Due to the structure of the available data, we cannot test other kind of problems linked to the peer process, namely nepotism and gender discrimination (Wemeras and Wold, 1997), consistence of peer judgments over time, personal bias against researchers (Dinges, 2006).

Our paper covers four disciplinary sectors: chemistry, biology, humanities and economics. Thus, the choice includes two "hard science" sectors, which have similar type of research output submitted for the three-year evaluation process (articles in scientific journals included in the SCI Index), and two sectors with different types of output – books edited by national publishers for humanities; a mixed situation for economics, namely both articles and books edited, respectively, in national and international journals and publishers.

Finally it is important to consider that the scope of the analysis is delimited by the scope of the VTR. As it was said, VTR evaluated the best output produced by the Italian academic institution in the three-years period. Thus, VTR judged only a limited number of publications comparing with the overall production of the institutions, and this is the condition that some authors consider as a possible mean for overcoming the "publish or perish" and the publication inflation effects of scientists (Viale and Leydesdorff, 2003).

The paper is organised as follow. The first paragraph describes the characteristics of the VTR exercise for identifying the size and the limits of the process, the characteristics of the four sectors we are dealing with, as well as the composition of the synthetic indexes, which represent the peer evaluations. The second paragraph discusses evidences coming from the Panels Final Reports and from the CIVR fulfilment for assessing the reliability of the peer process. The third paragraph presents some controls on and the correlation between peer agreement-disagreement and the Panel final judgment, while the fourth tests the bias which affect the peer review, and the fifth discusses the linkages and the effects of Impact Factor (IF) on peer evaluation. Conclusions summarise strength and weakness of the Italian experience, and the transferable approaches of the Italian experience.

1. THE ITALIAN VTR EXERCISE

In December 2003, a MIUR Decree n. 2206/2003 launched the first Three-Year Evaluation Exercise (VTR) which shall end in the second half of 2006.

The Committee for the Evaluation of Research (CIVR) is in charge of the VTR, which is aimed at: *a)* testing rules and procedures for evaluating the national research system, *b)* improving the institutional link between evaluation and resource allocation, *c)* favouring the spread of research results. The evaluation system is directed to assess R&D performed by the public research structure (both universities and academic research agencies) under the MIUR funding. It is based on three components: the Evaluation Committees, working within the evaluated structures (NUV for the Universities and CIVs for the agencies), the Panels (20) for different scientific areas[1], and the CIVR.

VTR is articulated in three phases. First of all, NUVs and CIVs transmitted to the Panels the research products selected autonomously by the research institutions under evaluation (products should not exceed 50% of the Full-Time-Equivalent researchers working in the structure). The typologies of products admitted were limited to articles, books and chapters of books, proceedings of national and international congress, patents, designs, performance, exhibitions, manufactures and art operas. It does not include purely editorial activities, texts and software for teaching purposes, congress abstracts, trials and routine analysis, internal technical reports (CIVR, 2003). Thus VTR was designed as an ex-post evaluation exercise, which assess only the best outputs produced by the Italian research institutions. NUVs and CIVs also transmit to the CIVR a set of input and output data and indicators for both the institution and the scientific areas within it.

In the second phase, the Panels, composed of high level peers appointed by the CIVR, assessed the research products, with additional support from external experts (2 experts for each product evaluation at least), and attributed to each product a final judgment divided in a four

[1] CIVR identified 14 areas corresponding to the basic academic disciplines, and 6 interdisciplinary sectors.

rating scale (Excellent, Good, Acceptable, Limited), that summarize the advices of the experts. Each Panel transmitted a final Report to the CIVR, along with a ranking of the institutions based on the quality assessment results.[2]

As third phase, CIVR shall integrate the outcome of the Panels' analysis with its own analysis of the data and information collected, thereby writing a Final Report that includes a comprehensive assessment of the national research system by structure and by scientific area.[3]

The magnitude of the VTR effort can be described through few indicators listed in Table 1: 102 research Institutions submitted to evaluation about 18,000 products (72% articles, 23% books and chapters of book, 1.7% patents). 20 Panels (14 for disciplinary areas and 5 for interdisciplinary sectors) in charge of peer reviewing, regroup 151 peers. Most of the peers come from the Italian universities (79), but a significant number of members come from abroad (37). Representatives from the Italian public research agencies (19) and from industry (16) are also included.

Rating and excellence index

Panels used two main indicators elaborated by the CIVR for the final judgment: the Rating index and the Excellence index calculated for scientific areas and Research Institution. The Rating index was computed as follows. In each scientific area a score was assigned to each of the four options of judgment:

Excellent (E) = 1

Good (G) = 0.8

Acceptable (A) = 0.6

Limited (L) = 0.2

For every Research Institution the sum of values of each evaluated products, has been divided by the total number of products submitted to Panels by the Research Institution itself. So the Rating for the generic Research Institution i has been calculated according to the following formula:

$Rating_i = [(E_i * 1) + (G_i * 0.8) + (A_i * 0.6) + (L_i * 0.2)] / T_i$

E_i = Number of excellent products submitted by the i-th Research Institution

G_i = Number of good products submitted by the i-th Research Institution

A_i = Number of acceptable products submitted by the i-th Research Institution

L_i = Number of limited products submitted by the i-th Research Institution

T_i = Number of total products submitted by the i-th Research Institution

The Rating ranges from 0 to 1, and it approximates 1 if many products has been assessed "excellent" or "good".

The Excellence index of a Research Institution is the percentage of "excellent" judgments on the total number of the products submitted by the Research Institution itself.

Excellence index = $E_i / T_i * 100$

In this paper we have determined Rating and Excellence indexes for examined scientific areas instead of computing it for Research Institution. We have also attributed the score to the peer judgments by applying the rating rule to each research output.

Table 2 provide key figures of the disciplinary sectors we selected, namely chemistry, biology, humanities and economics. A few characteristics of the four areas can be outlined.

As to the submitted output, we can note that almost all the products in chemistry and biology are articles published in journals with IF, while an opposite situation can be seen in humanities (large majority of books and chapters of books, very limited numbers of articles with IF). Economics is in an intermediate position, both for type of output submitted (articles *vs* books) and for the presence of articles with IF.

As to the internationalisation of the process, we can note that the number of panellists and experts coming from international research organisations is similar for chemistry, biology and economics, while the peers in humanities come mainly from Italy. This characteristic is coherent with the language of the submitted products (the large majority of products are written in English language).

As to the evaluation results, Rating and Excellence indexes outline significant differences of Economics with respect to the other scientific areas.

[2] This phase ended in decembre 2005.
[3] The third phase is still ongoing.

Table 1: Key figures of the VTR 2001-2003

Units Evaluated		102
	of which Universities	77
	Public Agencies	12
	Other	13
Researchers		64,028
Research Areas		20
Submitted outputs (products)		18,508
	of which Articles	13,362
	Books and chapter in books	4,240
	Patents	318
	Other	588
Outputs (products) submitted by two units or more		1,179
Panels		20
Panellists		151
	from University	79
	Public Agencies	19
	Firms	16
	International	37
Experts (reviewers, referees)		6,661
	from University	3,930
	Public Agencies	1,132
	Firms	134
	International	1,465
Direct Cost of the peer process (thousand €)		3,550
Time (months)		18

Source: CIVR

Table 2: Sectors analysed: key figures

	Chemistry	*Biology*	*Humanities*	*Economics*
Panellists				
from University	5	6	19	8
Public Agencies	1	2	0	0
National Experts	3	2	0	0
International	3	3	5	4
Experts (reviewers, referees)				
from national institutions	531	752	731	181
International institutions	148	261	102	104
Submitted outputs				
of which Articles with IF	1,009	1,514	178	526
Articles without IF	5	7	201	156
Books and chapter in books	12	11	2066	289
Patents	54	32	…	…
Other	9	11	78	…
Language of the outputs				
Italian	19	32	1,780	194
English	1,069	1,543	473	769
Other	1		270	8
Total rating	0.81	0.83	0.84	0.67
Index of excellence	0.32	0.33	0.4	0.17

Source: CIVR

2. CHARACTERISTICS OF THE PEER PROCESS WITHIN THE VTR

We now try to assess the peer review within the VTR in the light of criteria proposed by the literature and applicable to the retrospective evaluation (Chubin, Hackett, 1990; Martin, Irvine, 1983).

The process started with the CIVR general invitation (call for experts) for signalling possible experts, even foreigners, for the Panel formation. Criteria and guidelines for the constitution of the Panels was the second fulfilment, carried out with the help of five observers appointed by intermediary bodies representatives of both the scientific community and the stakeholders.[4] The panellists should have a consistent scientific background in the selected disciplinary areas, relevant and recent scientific production and competences, national and international scientific awards, experience in directing and evaluating research, experience in international cooperation. The Panel must include wide scope of appropriate experience and competences of the components, balanced presence of peers from universities, research institutions and industries and, were possible, a balanced composition by gender (CIVR, 2003; 2006).

Furthermore, a code of conduct for the panellists was set up, outlining the need for peers: *a)* to operate as independent subjects and not as representatives of organisations and structures, *b)* to ensure continuity in participating, confidentiality and impartiality of assessments, *c)* to statue in advance the possible conflicts of interest towards products subjected to evaluation. The CIVR maintained the role of arbitration for all kind of controversies.

CIVR selected the panellists autonomously, according to the agreed criteria. The Committee developed the general rules governing the VTR functioning. As to the tasks attributed to the Panels, the assessment of the products must be developed with the help of external reviewers (experts).

The expert judgments were the result of well-constructed remarks upon four advisable characteristics of scientific products: relevance/importance, originality/innovation, international standing and or international competitiveness and quality. The evaluation will end with a comprehensive assessment, with assignment of each product to one of the above mentioned merit levels, Excellent, Good, Acceptable, Limited. Then the Panel developed the consensus report, based on the critical re-examination of the single assessments formulated by the referees. The final evaluation is synthesized in one single assessment for each product, articulated in the four levels mentioned above.

As last step, the Panel calculated the rating and excellence indexes for each institution and delivered the Final Report, which described criteria and methods of work, analysed strengths and weaknesses of the disciplinary area, and provided comments and recommendations for improving the quality of the output. One missing point is the description of criteria and means used by the Panels for identifying the experts for judging the products. Only Economics clearly described the way of working, thus providing a useful indication for the assessment of the reliability of the peers outcome.[5]

The process was characterised by three main features:

– all the interactions between experts, panellists and CIVR were developed with the help of an intranet structure, which was used also for transmitting products and reviews in electronic form. This assured cheaper costs in terms of financial resources and time consumption,
– the process was accompanied by training activities for disseminating the rationale and the rules of the evaluation exercise, although a set of guidelines was delivered the year before (CIVR, 2003, Reale, 2003). Moreover a permanent monitoring on the Panels work was maintained, with a call centre for resolving all doubts or problems, and for supervising the

[4] The intermediary bodies involved in the nomination of the observers were the Conference of the Rectors CRUI, the National Committee for the Universities, the National association of the Italian industries Confindustria, the representative of Public research agencies.

[5] "Each Panellist followed its own criteria in choosing the experts and assigning products. Some Panellists mainly choose experts who work abroad. Others predominantly chose experts from Italian universities. In most cases, experts were chosen among scholars who are used to submit their work to international journals and have acted as referees for international journals." CIVR, 2006.

accomplishment of the CIVR rules. Table 3 give some measures of this kind of work,

– the arbitration role of the CIVR assured the quick resolution of the conflicts.

Table 4 provide an assessment of the way in which the peer process was managed, on the basis of the proposed criteria, also indicating the structure in charge for each task. We can note on the one hand the large autonomy of the Panels for carrying out the reviews and, on the other hand, the continuous and strict control of the CIVR on the overall process, by adopting a style of direction that can be seen as a sort of "steering at a distance"(Oecd, 2003).

Table 3: CIVR monitoring and training activities (2004-2005)

Monitoring activities (e.mail exchange)		
CIVR-Panels messages		1,970
CIVR advice through messages		
	to the units	3,271
	to the Panellists	3,108
	to the Experts	20,301
Training and disseminating activities		
CIVR audits		4
CIVR meetings		
	with the units	39
	with relevant buffer organisations	6
	with stakeholders	4
CIVR participation to seminars and conferences		16

Source: CIVR

Table 4: Criteria for the assessment of the peer review process

Criteria	*Means for coping with the criteria*	*Structure in charge*
Impartiality	Criteria for selecting the Panellists	CIVR
	Code of conduct for the Panellists	CIVR
	Criteria for Evaluating the products	CIVR
	Arbitration role in case of conflicts	CIVR
Validity, impartiality	Monitoring the Panel activities	CIVR
Rationality	Training and dissemination actions	CIVR
Efficiency	Cost for evaluating the product	CIVR
Validity	Selection of the experts	Panels
	Consensus Report	Panels
Responsibility, effectiveness, rationality	Rating of units for each area	Panels
	Index of excellence	Panels
	Panel Final Report	Panels

Source: authors elaboration

3. THE CONCORDANCE BETWEEN THE PEERS JUDGMENTS

One way for testing the reliability of the peer process results is to look at the agreement-disagreement between reviewers identifying the quality of the papers. A high level of agreement is considered a robust result because of the homogeneity of different experts views. Anyway, a low level of disagreement could not always be considered as a negative result, if it could become a mean for improving the quality of the research effort by underling crucial aspects for determining the concept of quality. In this sense some authors suggest the possibility to have a creative and a rationale disagreement among peers, which will reinforce the validity of the peers outcome (Harnard, 1985; Cole *et al.*, 1981).

For testing the agreement between peers, we first would like to evaluate the extent of concordance between the judgments expressed by referees in peer review process. Every scientific product has taken at least two evaluations by referees. In few cases it has been necessary to ask another referee for a third judgment, and rarely a fourth too. Then, the panel gives a final evaluation; it could confirm the referees ones or change them. Every judgment has been expressed by choosing one in a four points scale: "Limited", "Acceptable", "Good", "Excellent". Since there are two or more evaluations for every scientific product, we have two or more vectors of judgments that are ordinal variables. Table 5 shows the discrepancies in the expert judgments, by distinguishing between situations of full agreement and low or high disagreement.

For each of the examined scientific areas we have taken into account the following evaluated products: articles published on journals, books and chapter of books.

Judgments cross tabulations and tests

A useful way of looking at the relationship between two ordinal variables given by reviewers and panel judgments is to cross-classify the data and get a count of the number of cases sharing a given combination of levels of the variables, and then create a contingency table (cross-tabulation) showing the levels and the counts. Nothing would change providing the relative frequencies of the combinations, or the percentages, instead of counts.

So a contingency table lists the frequency of the joint occurrence of two levels, one level for each of the two ordinal (more generally, categorical) variables. The levels for one of the categorical variables correspond to the columns of the table, and the levels for the other ordinal variable correspond to the rows of the table.

We have built some tables in which the rows correspond to judgments assigned by the first referee to the product, and the columns correspond to the judgment assigned by the second referee or by the panels.[6]

The primary aim of contingency tables is usually to determine whether there is any association (in terms of statistic dependence) betweens the two variables whose counts are displayed in the table.[7]

The chi-square tests give an evidence of dependence between the experts judgments and between the experts and panel judgments (Table 6).

Also the expert judgments correlations coefficients are positive, confirming the existence of a relationship between the evaluation processes. The Spearman rho is quite low, usually inferior to 0.46, with a range going from 0.25 in Chemistry to 0.46 in Economics (Table 6). It means that the former area showed stronger disagreement in expert advices than the latter.

High values of correlation spring instead by comparing referees evaluations and panel evaluations. To correlate panel judgments with judgments assigned to products by the reviewers we first calculate the reviewers mean judgment turning the ordinal four points variable into a numerical one[8], according to the CIVR rule.

[6] The table was constructed on the basis of the advices of the first two referees, since the number of products which need more than two evaluation is limited.

[7] Measures of the global association between the ordinal variables represented by experts and panel' evaluations and measures of their correlation we used in the data analysis are described in Annex 1.

[8] See the paragraph "Rating and excellence index".

Table 5: Discrepancies between experts judgments (number of products)

	Types of discrepancies	*Chemistry*	*Biology*	*Humanities*	*Economics*
Full agreement	E/E,B/B,A/A,L/L	444	733	1071	450
Low disagreement	E/B,B/A,A/L	453	665	1058	406
High disagreement	E/A,B/L,E/L	122	132	301	94
Products which needed more than two evaluations		9	2	15	21

E=Excellent, B=Good, A=Acceptable, L=Limited

Source: authors elaboration on CIVR data

Table 6: Spearman rho and chi square tests* on the concordance of peer judgments

Areas	*Spearman rho*		*Chi square*	
	Experts	*Experts/Panel*	*Experts*	*Experts/Panel*
Chemistry	0.25	0.83	76	1,481.19
Biology	0.32	0.82	178.86	2,297.06
Humanities	0.32	0.87	286.34	4,077.83
Economics	0.46	0.90	382.31	1,689.24

* All the tests are significant (p-values = 0)

Source: authors elaboration on CIVR data

Prospect 1: Number of products evaluated by type of consensus of the panellists

Consensus	*Chemistry*	*Biology*	*Humanities*	*Economics*
Unanimous	955	1,444	2,359	832
Not unanimous	67	79	86	135
Missing data	4	9	0	4

Source: authors elaboration on CIVR data

In each area the resulting Spearman rho approximately ranges from 0.8 to 0.9. It means that, in general, higher scores on expert judgments tend to be paired with higher scores on panels, and lower scores on expert judgments tend to be paired with lower scores on panels. Thus, Panel assessment is influenced by expert judgments, as we would expect.

A further control can be carry out by calculating the number of cases where the panellists did not reach an unanimous consensus in the final judgment. As shown in Prospect 1 these occurrences are limited.

In sum, we can observe a concordance between expert advices, even if it is not so strong. Because of the discrepancies are not too relevant, they can be easily re-absorbed by the final judgment of the panels. The limited number of products which needed more than two evaluation is a further indicator confirming the good level of agreement between peers. This behaviour is common to all the examined scientific areas. Furthermore no differences have been observed for different typologies of outputs, namely articles *vs* books or chapter of books, and for different types of institutions, namely Universities, Public Agencies, Others.

Prospect 2: Rating index values of large Universities

	N. of institutions	*Medium value*	*Lowest value*	*Highest value*
Chemistry	10	0.84	0.63	0.92
Biology	22	0.83	0.63	0.93
Humanities	30	0.84	0.75	0.89
Economics	9	0.73	0.58	0.89

Source: authors elaboration on CIVR data

Prospect 3: Rating and excellence indexes by type of institution

	Chemistry		*Biology*		*Humanities*		*Economics*	
	Rating	*Excellence*	*Rating*	*Excellence*	*Rating*	*Excellence*	*Rating*	*Excellence*
University	0.83	0.36	0.83	0.34	0.84	0.40	0.68	0.18
Agencies	0.78	0.24	0.82	0.30	0.80	0.28	0.50	0.08

Source: authors elaboration on CIVR data

4. THE INFLUENCE OF PRESTIGE, REPUTATION AND INTERDISCIPLINARITY ON PEER REVIEWING

Other bias in peer process could derive from prestige of institutions, reputation of scientists, interdisciplinary research. We controlled them by using the following indicators:

- prestige, by looking at the rating indexes of large, old and thus well recognised research institutions in the considered disciplinary sectors,
- interdisciplinarity, by looking at differences which could affect the evaluation of products coming from Universities (generally oriented toward a disciplinary output) and products coming from Public Research Agencies (with a more interdisciplinary oriented research output),
- reputation by referring to the academic standing of the authors of the papers.

As to the first item, Prospect 2 gives an overview of the rating indexes of large Universities participating to the VTR. The size, measured in terms of number of products transmitted (more than 25 products), is a proxy for the presence of well-known and established research groups, which contribute to the prestige of the institution. A large range affects the index within all the disciplinary sectors, so it does not appear that the evaluation of the products was influenced by the scientific visibility of the institutions.

As to the second item, differences emerged in the rating and excellence indexes of the products delivered by Universities and Public research agencies, with a worst position of Public research agencies in all the disciplinary areas, especially in economics (Prospect 3). This result seems to confirm the presence of bias linked to the interdisciplinary research. Another test was developed for controlling the reliability of the VTR peer process by measuring if the academic standing of an author had influenced the peer judgments.

For investigating possible differences in product evaluation according to the author status, we selected four random samples of products for each scientific area (479 outputs selected in total). Then we regroup them in three categories on the basis of the academic levels of career of the first author: Full Professors, which represents the highest level of the academic career in Italy, Associate Professors, which is the intermediate level, and Research Associates, which is the lowest.[9] We then cross-tabulated them with the final judgments assigned by panels to the products obtaining a contingency

[9] The corresponding levels for Public research agencies are: Director of research, Senior researcher, Researcher.

table. From the appearances of the counts (or the relative frequencies) row by row it does not appear that there is much of a variation in judgments across the four scores (Table 7).

The tests confirm this impression. In each examined area the outcome is the same: as the p-values of the statistics are no significant, we may conclude that there is no association between the final judgment and the authors status[10], or, in other words, that the former is independent from the latter.

Table 7: Cross tabulation between academic standing and panel final judgment

Chemistry

Statistic	*Value*	*p-value*
Chi-square	6.58	0.36
Phi-square	0.097	

Biology

Statistic	*Value*	*p-value*
Chi-square	6.25	0.40
Phi-square	0.051	

Humanities

Statistic	*Value*	*p-value*
Chi-square	7.01	0.32
Phi-square	0.035	

Economics

Statistic	*Value*	*p-value*
Chi-square	3.11	0.79
Phi-square	0.034	

Source: authors elaboration on CIVR data

[10] We accept the null hypothesis H_0: *X and Y are independent*, where X is the authors status and Y is the panellist judgment. The distribution of the chi-square statistic is chi-square with (k-1)*(h-1) degrees of freedom, where k is the number of rows and h is the number of columns. In this specific case k = 3 and h = 2, so degrees of freedom are (3-1)*(4-1) = 6. The empirical chi-square value is lower than the theoretical value, which is approximately 12.59 with a 95% confidence level.

5. THE RELATIONSHIPS BETWEEN IF AND PEERS JUDGMENTS

As further step, we will control the linkages between the final judgments expressed by the panels and the IF values of the articles submitted, by using correlation and an ordinal regression model. Humanities is not included in this test since articles have IF values only in very limited cases. We will also test the extent to which the articles with IF received a better judgment in comparison with other outputs, namely articles without IF and books. The last control was carried out for economics. Economics in fact, is a scientific area characterised by a high diversification of types of outputs (see table 2), thus the linkage of IF with peers judgment can be further observed. The aim was to see if "bibliometric indicators may provide important additional information to peers evaluation research performance" acting "as a support to peer review, for instance in cases of incorrect or biased views of peers on a group's scientific quality" (Rinia *et al.*, 1998).

First of all we looked at the distribution of products by Impact Factor values in each selected area.

Chemistry

Chemistry articles on journals have a 5.1 average Impact Factor. The IF distribution is displayed on Graph 1. The values show a sharp peak corresponding to an IF a bit lower than mean value, they decline rather rapidly and the right tail of the distribution is quite heavy because some articles have been published on journals with IF greater than 20. The kurtosis is high, 22.65, and since the IF values are skewed right the skewness is positive, 4.02. Values of kurtosis and skewness are then far from normal distribution values. The median IF is 4.2, meaning that 50% of the evaluated articles have an IF inferior to 4.2.

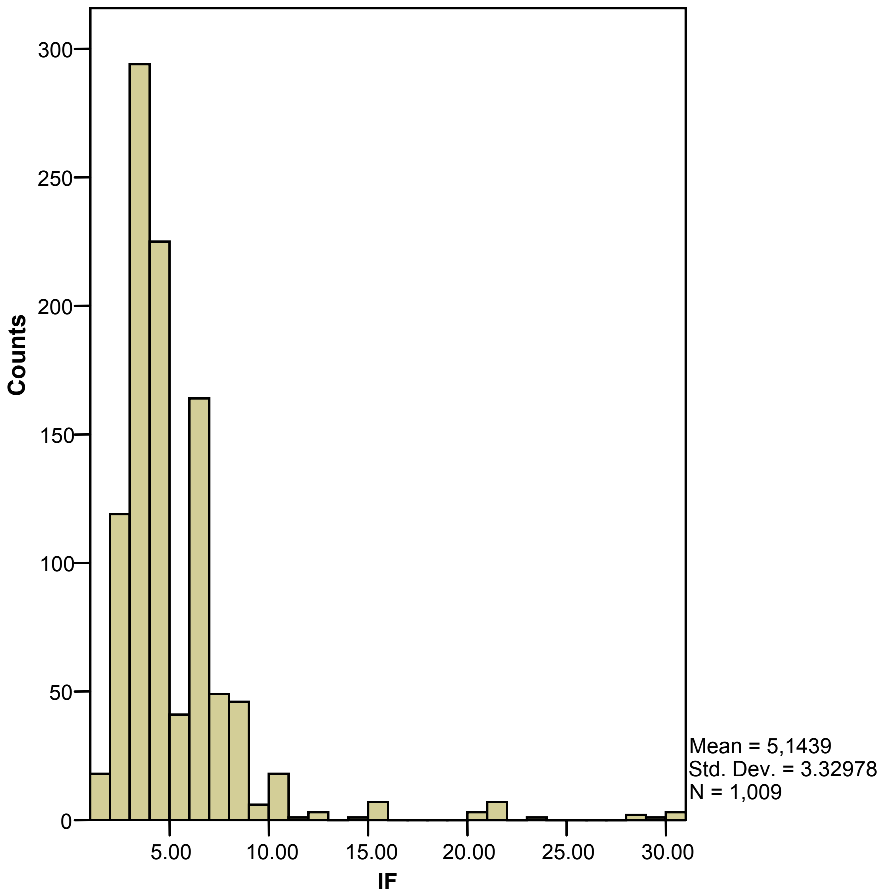
Biology

In area 5 (Graph 2) articles have a mean Impact Factor of 8.48 and the median approximates 6.7, so we may conclude that the submitted articles have been published on journals with considerable IF. The largest IF in biology evaluated articles exceeds 36. The kurtosis is positive, 5.62, but it is lower than the Chemistry IF one, and the peak of the distribution is slightly less distinct. The skewness is 2.3 and it is lower too if compared to Chemistry, so that IF values in Biology area are skewed right but the asymmetry is less emphasized.

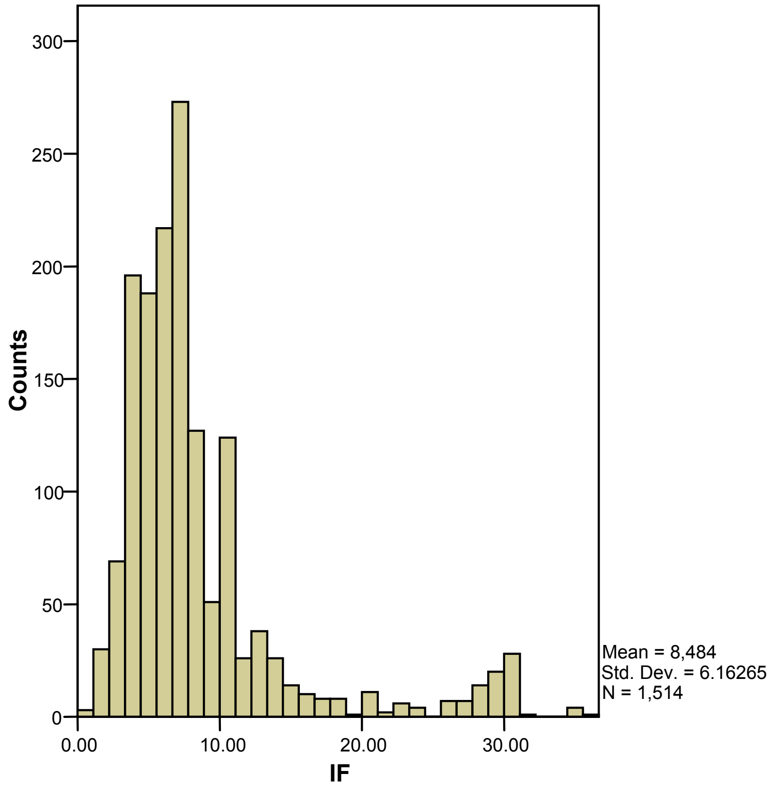
Economics

In Economics (Graph 3) 526 out of 682 articles have been published on journals with Impact Factor. The mean and the median IF are low, respectively 0.87 and 0.675, and the three-fourths of the articles have an IF lower than 1.05, that is the 75th percentile of the distribution. This last is very asymmetric with an high positive skewness (6.8) and no left tail, it presents a very sharp peak close to 0 and an heavy right tail. The kurtosis excess is consistently huge: 83.26.

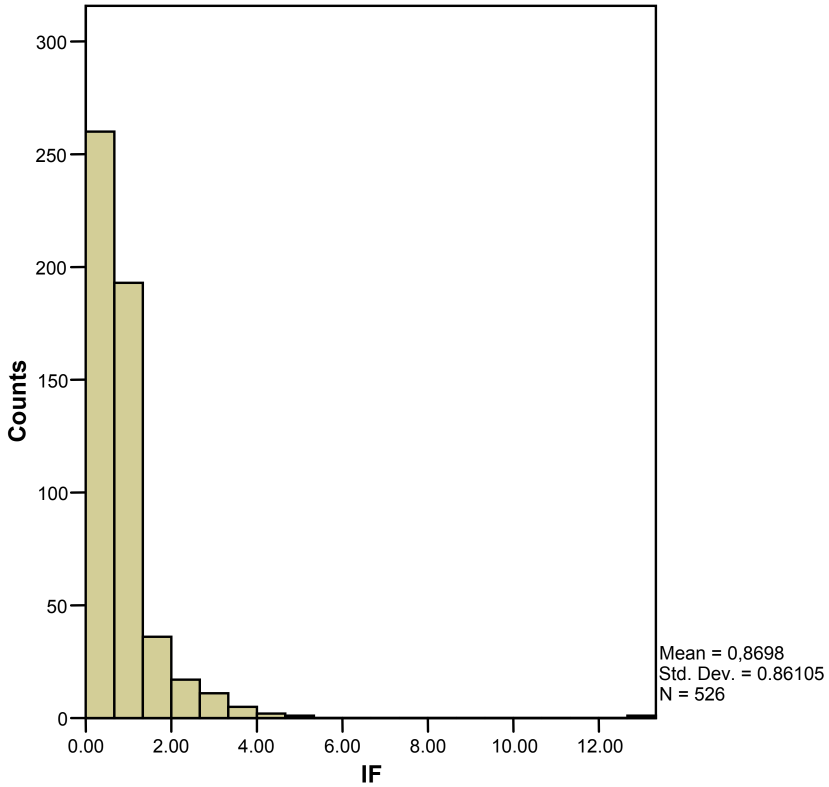
Graph 1: IF distribution for Chemistry



Graph 2: IF distribution for Biology



Graph 3: IF distribution for Economics



Tests between articles final assessment and IF

To compute the correlation between panel judgments, which are expressed on ordinal scale, and Impact Factor of articles published on journals we first converted the qualitative panel judgments to numeric scores by Rating rules. IF scores are continuous real positives and show the distributions described above, so we turned them into discrete values. In doing that, first we determined the percentile ranks corresponding to IF values, and then we split the percentile ranks distribution into quartiles to obtain a four point scale for IF. A Spearman correlation was finally computed between discrete IF values and judgments expressed by the panels. We then conducted an ordinal regression analysis to verify if Impact Factor is a good predictor of products final evaluation.

Two main results can be outlined. First of all the Spearman rho is not so high but it is significant (Table 8): this means that the final judgments are not independent from the IF values. Second, this significance is similar in all the chosen sectors.

Table 8: Correlation (Spearman rho) between Panel judgment and IF

Areas	*Spearman rho*
Chemistry	0.45
Biology	0.48
Humanities	-
Economics	0.44

Source: authors elaboration on CIVR data

A further interest is to estimate the effects of IF on panel final judgments. As panel judgments are the dependent variable and they are an ordinal variable with four categories (1 = ”Limited”, 2 = ”Acceptable”, 3 = “Good”, 4 = “Excellent”) we apply the ordered logit model, which incorporates the ordinal nature of the dependent variable. The independent variable of the model is then given by the IF values, turned into discrete scores following the process already used for the correlation reckoning (see above). The regression performed for Chemistry, Biology and Economics (Table 9) provided the following outcomes.

The regression output is similar among the three areas. The likelihood ratio test is highly significant. It generally makes us reject the null hypothesis that the coefficient for all the independent variable is equal to zero.

The values of goodness-of-fit measures are small, and the observed significance is large enough, so the model fits the data well.

The pseudo R-square (here we report Nagelkerke R-square), that measures the strength of association between the dependent variable and the predictors, suggests that an effect of IF on panel judgments exists even if it is not particularly strong.

Finally, the estimate we are interested in is the *location* parameter (we refer to it as β), that is to say the coefficient for the independent variable Impact Factor. The positive coefficient for Impact Factor indicates that the probability to receive a higher judgment by panels increases if the product has a higher discrete IF (an IF which belongs to a higher IF quartile).[11]

The tests let us reach two conclusions: the former is that there is a positive correlation between the quality of the papers and the quality of the journals where the papers have been published; the latter is that the Impact Factor of a journal does not strictly predict the quality of the articles published in this journal. So the reliability of IF for monitoring the quality of research is higher than as a mean for evaluating the research itself (Amin, Mabe, 2000; De Marchi, Rocchi, 2001). Thus, peer reviewing shows its added value for the purpose of evaluating the quality of research output at both individual and institutional level, while bibliometric indicators should be used carefully (Seglen, 1992; Amin and Mabe, 2000; van Raan, 2004; Weingart, 2005).

[11] An increase in IF quartiles reduces the logit ln[prob(panel judgment ≤ j) / prob(panel judgment > j)] by, respectively, 0.83 in Chemistry area, 0.96 in Biology and 0.82 in Economics. The Wald statistic is the square of the ratio of the coefficient β to its standard error. The observed significance level approximates zero, so we can reject the null hypothesis that the coefficients are zero. If we determine $e^{-\beta}$ we obtain the odds ratio for lower to higher panel judgments for the products having a discrete IF value included in the i-th quartile and products with IF included in the i-1th quartile. The odds ratio is 0.42 for Chemistry, 0.38 for Biology and 0.44 for Economics. In each area the odds ratio remains the same over all the panel judgments.

Table 9: Ordinal regression estimates for the scientific selected areas

Chemistry						
Parameter Estimates						
		Estimate	*Std. Error*	*W ald*	*df*	*Sig.*
Threshold	[Panel Judgment = 1.00]	-1.84	0.22	67.93	1	0.000
	[Panel Judgment = 2.00]	0.44	0.15	8.92	1	0.003
	[Panel Judgment = 3.00]	3.01	0.18	270.34	1	0.000
Location	Impact Factor	0.87	0.06	193.12	1	0.000
Model Fitting Information						
			-2 Log Likelihood	*Chi-Square*	*df*	*Sig.*
			67.74	220.16	1	0.000
Goodness-of-Fit						
				Chi-Square	*df*	*Sig.*
Pearson				11.23	8	0.189
Deviance				12.32	8	0.138
Pseudo R-Square						
Nagelkerke	0.22					
Biology						
Parameter Estimates						
		Estimate	*Std. Error*	*Wald*	*df*	*Sig.*
Threshold	[Panel judgment = 1.00]	-2.31	0.23	101.05	1	0.000
	[Panel Judgment = 2.00]	0.23	0.12	3.55	1	0.059
	[Panel Judgment = 3.00]	3.23	0.16	417.84	1	0.000
Location	Impact Factor	0.96	0.05	328.63	1	0.000
Model Fitting Information						
			-2 Log Likelihood	*Chi-Square*	*df*	*Sig.*
			68.60	384.32	1	0.000
Goodness-of-Fit						
				Chi-Square	*df*	*Sig.*
Pearson				11.21	8	0.190
Deviance				10.75	8	0.216
Pseudo R-Square						
Nagelkerke	0.26					
Economics						
Parameter Estimates						
		Estimate	*Std. Error*	*Wald*	*df*	*Sig.*
Threshold	[Panel judgment = 1.00]	-1.87	0.30	37.71	1	0.000
	[Panel Judgment = 2.00]	0.63	0.20	9.58	1	0.002
	[Panel Judgment = 3.00]	3.09	0.25	149.66	1	0.000
Location	Impact Factor	0.82	0.08	98.18	1	0.000
Model Fitting Information						
			-2 Log Likelihood	*Chi-Square*	*df*	*Sig.*
			61.65	109.09	1	0.000
Goodness-of-Fit						
				Chi-Square	*df*	*Sig.*
Pearson				13.25	8	0.103
Deviance				12.61	8	0.126
Pseudo R-Square						
Nagelkerke	0.21					

Source: authors elaboration on CIVR data

Table 10: Rating and excellence index in Economics

	Rating	*Excellence index*
Articles with IF	0.80	0.29
Articles without IF	0.60	0.05
Books and chapters of books	0.49	0.03

Source: authors elaboration on CIVR data

A further control for Economics was carried out, by comparing the rating and excellence indexes for articles with IF, articles without IF, books and chapters of books (Table 10). The results show higher values of both indices for articles with IF in comparison with other typologies of products. Thus, peers judged articles with IF as higher in quality than the others and there is a visible influence of the journals Impact Factor on the Excellence index too.

This result suggests that the presence of a significant number of products with IF impact the overall evaluation of the interested area, depriving the judgments of the products without IF even if they are published in international journals. The rating and excellence index for products published at international level are, respectively, 0.74 and 0.22, lower than those for articles with IF. Thus bibliometric indicators seem to be a sort of watershed for judging the scientific quality of the research output and this factor explains the lower levels of rating and excellence indexes of Economics in comparison with the other disciplinary areas; moreover it is associated to the higher disagreement of the Panel consensus in this sector with respect to the others (Prospect 1).

CONCLUSIONS

The aim of this paper was to revise the peer review process developed in Italy within the Three-Year Evaluation exercise VTR for controlling what kind of lessons, if any, it provides in terms of transferable approaches. VTR is a retrospective evaluation exercise aimed to assess the quality of the best outputs of the research institutions (Universities and Public research agencies).

The analysis was carried out on the basis of assessment criteria proposed in the literature (rationality, reliability, impartiality, efficiency, effectiveness), controlling the presence and the relevance of some bias (prestigious of institutions, reputation of scientists, interdisciplinary research, agreement among reviewers) affecting the peer reviewing.

Final remarks could be outlined along two issues: the robustness of the peer reviewing process experimented in Italy, and its usefulness for decision-making.

As to the first issue, the outcome analysed reveals many strengths of the process, even if some bias were still present. Factors of success were:

- the high transparency of the VTR and the involvement of external representatives for the setting up of criteria for the panel composition,
- the large use of information and communication technologies and of documents in electronic format,
- training and monitoring activities developed by the CIVR, which assured a high control on the peers for complying with the rules, thus playing a major role for guaranteeing reliability, impartiality and efficiency of the process,
- the continuous supervision of CIVR on the process management, even intervening in the case of conflicts between panellists,
- no influence of prestigious of institutions and reputation of scientists,
- good agreement between peers.

Weak points are:

- difficulties for evaluating interdisciplinary research,
- lack of transparency about the criteria used by Panels for selecting the experts.

The Italian experience confirms the robustness of peer review for the assessment of the quality of research, even if it is necessary to take care of its management, as well as to monitor it.

As to the second issue, the outcome of the exercise supplied the decision makers with information and knowledge on the quality of the research output produced by individuals, groups, institutions in each field and sub-field of science. The positioning of institutions in terms of excellence within the different disciplinary areas is also allowed by the peers outcome. Moreover, comments and recommendations in the Panel Final Reports provide useful information about the patterns of development within the fields, which can help the setting up of strategies and the selection of research priorities.

The tests on the linkage between the score of peer final assessments and IF values revealed an association not strong, that is similar for all the sectors, and confirmed evidences coming from studies on other countries (Aksnes and Taxt, 2004). The results reinforce the idea that IF is a good predictor of the quality of the journals, not for the quality of the articles published in that journals, and its function "as mean to control and strengthen peer review" (Weingart, 2005) is thus reinforced in the case of retrospective evaluation of research institutions.

Another interesting result emerged from Economics, where articles with IF received higher scores from peers than articles without IF or books and chapter of books. This behaviour suggests that bibliometric indicators shape the concept of quality in sectors, as economics, where they are largely used, but do not yet represent the rule for scholars publication, as in chemistry or biology. Bibliometrics seems to act, in this case, as a factor linked to the internationalisation process of the field because it assures that papers are included in journal with a large international circulation.

So the introduction of bibliometric indicators in the peer review process, according to the model of the informed peer review, can produce great effects in some disciplinary fields, impacting the final peer judgments as a watershed for identifying the quality of research. Moreover, it could be a source of disagreement among peers, as the case of Economics outlined. Our analysis does not allow understanding if this disagreement could be considered as "creative" or "rationale".

Summing up, VTR peer reviewing represents a useful experience, which can provide transferable approaches to other national contexts.

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APPENDIX

Annex 1

Measures of skewness and kurtosis

Skewness is a measure of symmetry. For univariate data the formula is:

$$\text{Skewness} = \frac{\sum_{i=1}^{n}(Y_i - \overline{Y})^3}{N\sigma^3}$$

where $\overline{Y}$ is the mean of the distribution, σ is the standard deviation and N is the number of data points. The skewness for normal distribution is zero, and any symmetric data should have a skewness near zero.

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. The formula for kurtosis is:

$$\text{Kurtosis} = \frac{\sum_{i=1}^{n}(Y_i - \overline{Y})^4}{N\sigma^4}$$

where $\overline{Y}$ is the mean of the distribution, σ is the standard deviation and N is the number of data points. The kurtosis for a standard normal distribution is three. For this reason, excess kurtosis is defined as:

$$\text{Excess kurtosis} = \frac{\sum_{i=1}^{n}(Y_i - \overline{Y})^4}{N\sigma^4} - 3$$

so that the standard normal distribution has a kurtosis of zero.

Chi-square test

Let us consider a contingency table with k rows and h columns. Let n_{ij} denote the cross-frequency of generic cell (i,j) and let $\underline{n}_{ij}$ denote the expected frequency of the cell. The deviation between the observed and the expected frequencies (n_{ij} - $\underline{n}_{ij}$) characterizes the disagreement between the observation and the hypothesis of independence. Indeed the expected frequency for any cell may be calculated by the following formula:

$$\hat{n}_{ij} = (RT * CT) / N$$

where $\hat{n}_{ij}$ is the expected frequency in a given cell (i,j), RT is the row total for the row containing that cell, CT is the column total for the column containing that cell and N is the total number of observations. All the deviation can be studied by computing the quantity:

$$\chi^2 = \frac{\sum_i \sum_j (n_{ij} - \hat{n}_{ij})^2}{n_{ij}}$$

The reckoning of the chi-square index does not necessarily demand for the computation of expected frequencies, because an alternative formula, obtainable by the former one, is the following:

$$\chi^2 = n \left(\sum_{i=1}^{k} \sum_{j=1}^{h} \frac{n_{ij}^2}{n_{i.} n_{.j}} - 1 \right)$$

where $n_{i.}$ are the row totals and $n_{.j}$ are the column total.
The chi-square statistic is distributed according to Pearson Chi-square law with (k-1)*(h-1) degrees of freedom. The statistic significance of the relationship between two ordinal variables is tested by using the χ^2 test which essentially finds out whether the observed frequencies in a distribution differ significantly from the frequencies, which might be expected according to a certain hypothesis (say, the hypothesis of independence between the two variables).
The χ^2 test is quite sensitive to the sample size.

In examining the influence of academic standing on peer review we used another measure of association, Phi-square, which is computed as follows:

$$\varphi^2 = \chi^2 / N$$

where N is the total number of observations. φ^2 allows to overcome the sensitiveness of the χ^2 test to the sample size.

Spearman's correlation
Common Pearson correlation, which measures the strength of linear correlation between two variables X and Y, is unduly influenced by outliers, unequal variances, non-normality and nonlinearity. Spearman's rank correlation coefficient is calculated by applying the Pearson correlation formula to the ranks of the data rather than to the actual data values themselves. In so doing, many of the distortions that affect the Pearson correlation are reduced considerably. Spearman's Rho, computed on the ranks of X and Y, it is achieved by the following formula:

$$\rho = \frac{1 - 6\sum (d_i)^2}{n(n^2 - 1)}$$

where d_i is the difference between the ranks of X_i and Y_i.

$\rho = +1$ if there is a perfect agreement between the two sets of ranks

ρ = -1 if there is a complete disagreement between the two sets of ranks

Ordinal regression: a short account on the ordered logit model

The ordinal regression model is an extension of the generalized linear model to ordinal data. SPSS software runs a procedure called PLUM (Polytomous Universal Model). Since we specified a logit link function we estimated an ordered logit model, also known as the cumulative logit model, that estimates the effects of independent variables on the log odds of having lower rather than higher scores on the dependent variable.

Generally, in fitting a logistic model one estimates a set of regression coefficients that predict the probability of the outcome of interest, according to the formula:

$$\ln[\text{Prob(event)} / (1\text{-Prob(event)})] = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

The quantity to the left of the equal sign is called a logit and it is the log of the odds that an event occurs. The odds that an event occurs is the ratio of the number of people who experience the event to the number of people who do not, in other words the ratio of the probability that the event occurs to the probability that the event does not occur. So the independent variables are linear in the logit. The independent variables may be binary, categorical, continuous. The regression coefficients tell how much the logit changes based on the values of the predictor variables.

To incorporate the ordinal nature of a dependent variable the logistic regression model is modifiable by considering the probability of an event and all events that are ordered before it (cumulative probabilities), instead of considering the probability of an individual event. In ordinal logistic regression the event of interest is observing a particular score or less. For the rating of judges from 1 to 4, one models the following odds:

$$\theta_1 = \text{Prob(score} = 1) / \text{Prob(score} > 1)$$
$$\theta_2 = \text{Prob(score} \leq 2) / \text{Prob(score} > 2)$$
$$\theta_3 = \text{Prob(score} \leq 3) / \text{Prob(score} > 3)$$

The last category does not have an odds associated with it since the probability of scoring up to and including the last score is 1.

Generally, the odds have the form:

$$\theta_j = \text{Prob(score} \leq j) / \text{Prob(score} > j) = \text{Prob(score} \leq j) / (1 - \text{Prob(score} \leq j)),$$

since the probability of a score greater than j is 1- probability of a score less than or equal to j.

The ordinal logistic model for a single independent variable is then:

$$\ln(\theta_j) = \alpha_j - \beta X$$

where j goes from 1 to the number of categories minus 1. The effects of the independent variable are subtracted rather than added to the intercepts. This is done so that positive coefficients indicate increased likelihood of higher scores on the dependent variables. A negative coefficient tells that lower scores are more likely.

Each logit has its own α_j term but the same coefficient β. That means that the effect of the independent variable is the same for different logit functions. The α_j terms are called the threshold values and express the categorical nature of the dependent variable. They are like the intercepts in a linear regression model, except that each logit has its own, and they indicate the cumulative logits when the independent variables are zero.

The estimated coefficients are used to calculate cumulative predicted probabilities from the ordered logit model, remembering that events in an ordinal logistic model are not individual scores but cumulative scores:

$$\text{Prob(event j)} = 1 / (1 + e^{-(\alpha_j - \beta_x)})$$

The estimated probabilities allow to determine the number of cases one expects in cells of a two-way cross-tabulation of dependent variable and independent variable. From the observed and the expected frequencies the goodness-of-fit measures can be computed.

Model fitting information
In table 8 we first reported the parameters estimate, then an overall test (model fitting information) of the null hypothesis that the location coefficients for all the variables in the model are 0. It is based on the change in –2log-likelihood when the variables are added to a model that contains only the intercept. The change in likelihood function has a chi-square distribution.

Goodness-of-fit measures
As we mentioned above, from the observed probabilities and the expected probabilities estimated by the model the goodness-of-fit measures are computable. Goodness-of-fit measures are Pearson and Deviance. The Pearson statistic is:

$$\chi^2 = \sum\sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

The deviance measure is

$$D = 2 \sum\sum O_{ij} \ln\left(\frac{O_{ij}}{E_{ij}}\right)$$

where O_{ij} are the observed frequencies and E_{ij} the expected frequencies. If the model fits well, the observed and predicted counts are similar, the value of each statistic is small and the observed significance level is large. In this case we reject the null hypothesis that the model fits if the observed significance level for the goodness-of-fit statistics is small. Good models have large observed significance levels.

Strength of association
There are several R^2-like statistics that can be used to measure the strength of the association between the dependent variable and the predictor variables. The Nagelkerke pseudo r-square is usually the most relevant value to report. It is a modification of another measure of association, the Cox and Snell coefficient, which is based on the likelihood. Nagelkerke pseudo r-square can vary from 0 to 1, differently from Cox and Snell, which its maximum usually is less than 1.0, making it difficult to interpret.

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