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RQF Publication Quality Measures: Methodological Issues

John W. Lamp
Deakin University, John.Lamp@deakin.edu.au

Simon K. Milton
University of Melbourne, smilton@unimelb.edu.au

Linda Dawson
Monash University, Linda.Dawson@infotech.monash.edu.au

Julie Fisher
Monash University, Julie.Fisher@infotech.monash.edu.au

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John W. Lamp
School of Information Systems
Deakin University
Geelong, Australia
Email: John.Lamp@deakin.edu.au

Simon K. Milton
Department of Information Systems
University of Melbourne
Melbourne, Australia
Email: smilton@unimelb.edu.au

Linda Dawson, Julie Fisher
Faculty of Information Technology
Monash University
Caulfield, Australia
Email: {Linda.Dawson, Julie.Fisher}@infotech.monash.edu.au

Abstract

The Research Quality Framework uses Thomson-ISI citation benchmarks as its main set of objective measures of research quality. The Thomson-ISI measures rely on identifying a core set of journals in which the major publications for a discipline are to be found. The core for a discipline is determined by applying a non-transparent process that is partly based on Bradford's Law (1934). Yet Bradford was not seeking measures about quality of publications or journals. How valid then is it to base measures of publication quality on Bradford's Law? We explore this by returning to Bradford's Law and subsequent related research asking 'what is Bradford's Law really about?' We go further, and ask 'does Bradford's Law apply in Information Systems?' We use data from John Lamp's internationally respected Index of Information Systems Journals to explore the latter question. We have found that Information Systems may have a core of journals only a subset of which is also in the list of Thomson-ISI journals. There remain many unanswered questions about the RQF metrics based on Thomson-ISI and their applicability to information systems.

Keywords

Research management, Research evaluation, Publication analysis, RQF, Thomson-ISI

Introduction

When announcing the RQF, the Honourable Brendan Nelson, then Minister for Education, Science and Training said "Once implemented, the RQF will provide the Australian Government with the basis for redistributing research funding to ensure that areas of the highest quality of research are rewarded" (Nelson, 2005, 3). The focus for the RQF was to be on the quality of the research and its academic and broader impact. Academic impact was described as how well the research was received by our peers and the broader impact was described as the impact and usefulness of the research outcomes on those the research was designed to assist. In 2006 there was a change in Minister and the new Minister, the Honourable Julie Bishop, reinforced the government's intention of introducing a scheme and argued that the RQF "would measure quality through a combination of metrics and review by domestic and international peers" (Bishop, 2006).

In August 2006, the RQF Departmental Advisory Group released the RQF Guiding Principles (DEST, 2006). The main measure of research quality proposed in this document is as follows:

> "1. Citation measures (where relevant to the discipline) as:
>
> 1.1 Citations per publication listed in the Research Grouping's 'body of work';
>
> 1.2 The proportion of publications in the 'body of work' which have citations that would put them in the top decile for the discipline (to be derived from Thomson Scientific (ISI) citation benchmarks);"

The RQF Quality Metrics Working Group (QMWG) has since confirmed that the impact of research will be judged by the rate of citation of published research. As a default measure, indices devised and calculated by

Thomson-ISI will be used to determine citation measures, unless deemed inappropriate. This decision was a pragmatic one, largely based on cost issues. (QMWG, 2006) There was no examination of the underlying basis for the selection and tracking of journals by Thomson-ISI. At this point it should be noted that while the QMWG document initially talks in terms of a unit of analysis at the individual publication level, the Thomson-ISI measures report at the journal level.

The dominance of the Thomson-ISI indices in the RQF process and generally as an indicator of quality, throws into prominence their rationale for journal selection and exclusion.

In this paper we ask the question "do the Thomson-ISI measures adequately address the RQF needs in the discipline of information systems?" We explore this by examining Bradford's Law, on which the Thomson-ISI measures are based, from its discovery to its development through related research. In so doing we are asking the more fundamental question "what is Bradford's Law really about?" We then go further, and ask "does Bradford's Law apply in Information Systems?"

These questions are very topical not only because of the Australian RQF exercise but also because of the increasingly mature open access journal community in academic publishing. When Bradford devised his law in 1934, there was a single dominant form of academic publishing – the paper journal published by a university or publishing house – estimated by Bradford to number 15,000 journals. The development of technologies to support electronic publishing on the Internet, combined with relatively low overhead costs compared to conventional paper based publishing, has resulted in a large and increasing number of new high quality electronic publications. As a result of this change in economic conditions, many such publications are open access. The emergence of refereed open access journals has resulted in an explosion of new journals and access to papers, which has not been seen since the invention of movable type. The Directory of Open Access Journals (DOAJ, 2007) currently tracks 2,719 journals. The DOAJ has strict criteria for inclusion based on the Budapest Open Access Initiative definition (BOAI, 2007) and on other criteria relating to standards of reviewing, ISSN registration and research reporting. There are also many electronic journals which have business models other than open access or traditional subscription and purchase.

The trend towards open access journals is likely to continue to increase. As discussed in the following section Thomson-ISI have established criteria for the inclusion of electronic publications in their calculations. At this time it is not possible to determine what effect, if any, this might have on citation impact measures. With the application of digital technology to information management and provision, the role of the journal is radically changing. The ability to search journal article databases, either for citations or whole text documents has changed academic reading and publishing habits. This may also affect practices by which articles are selected.

Thomson-ISI

USA academic Dr. Eugene Garfield first mentioned the idea of an impact factor in 1955, and in 1961 published the *Science Citation Index*. Later *Journal Citation Reports* was established, collating and publishing impact factors on journals. In 1992, Dr Garfield founded the Institute for Scientific Information (ISI), now under the umbrella of Thomson Scientific and referred to in this paper as Thomson-ISI. Dr Garfield continues as Chairman Emeritus of ISI.

Thomson-ISI aims "to provide comprehensive coverage of the world's most important and influential research" (Thomson-ISI, 2004). In order to undertake this they are guided by Bradford's Law which they say states:

> "that the core literature for any given scientific discipline was composed of fewer than 1,000 journals. Of this 1,000 journals, there are relatively few with a very strong relevance to the given topic, whereas there are many with a weaker relevance to it. Those with a weak relevance to the given discipline or topic, however, typically have a strong relevance to another discipline. Thus, the core scientific literature can form itself around various topics, with individual journals becoming more or less relevant depending on the topic." (Thomson-ISI, 2004)

Hence Thomson-ISI confine themselves to indexing approximately 8,700 journals from all fields which they believe accounts for 85% of published research and 95% of cited publications.

The criteria demanded of paper publications by Thomson-ISI include:

- Timeliness of publication;
- English language titles, abstracts and keywords; and
- A peer review process.

The criteria for electronic publications are similar, but have additional prescriptions relating to page and article numbering and author identification (Thomson-ISI, 2004). The additional requirements are not unduly onerous

and relate to matters of unique and unambiguous identification and good editorial practice which would be enforced in any traditional publishing house.

The principle measure calculated by Thomson-ISI is the journal impact factor. The impact factor of a journal *J* in year *T* is defined as follows (Moed, 2005):

$$\frac{\text{The number of citations received in year } T \text{ by all documents published in } J \text{ in the years } T\text{-1 and } T\text{-2}}{\text{The number of citable documents published in } J \text{ in the years } T\text{-1 and } T\text{-2}}$$

As an example, the *MISQ* 2005 journal impact factor is calculated as follows in Thomson-ISI's *Journal Citation Reports* (2007):

Cites in 2005 to articles published in:		Number of articles published in:	
2004 =	51	2004 =	24
2003 =	178	2003 =	22
Sum:	229	Sum:	46

$$\textit{MISQ}\ 2005\ \text{impact factor} = \frac{\textit{citations received by articles published in MISQ in } 2004 \textit{ and } 2003}{\textit{articles published in MISQ in } 2004 \textit{ and } 2003}$$

$$= \frac{229}{46}$$

$$= 4.978$$

This measure assumes that a journal article is most heavily cited in the first two years following publication.

At this point it is worth noting that Thomson-ISI make no claims associating quality of research with the calculated impact factor. The question of "Which journals does Thomson-ISI analyse?" raises further issues.

Bradford's Law: Thomson-ISI's Theoretical Underpinning

The rationale for Thomson-ISI's selection of journals, upon which their entire practice of impact factor calculation is based, is Bradford's Law (Bradford, 1934). In this section we examine Bradford's Law and its development and understanding since its discovery. Samuel C. Bradford (1878-1948) was a mathematician and librarian at the Science Museum in London and developed a "law of scattering," which now bears his name, regarding differences in demand for scientific journals. Bradford's original paper was reprinted in 1985 in the *J of Information Science* along with a review of the paper and subsequent developments by that journal's editor, B. C. Brookes (Brookes, 1985).

The Discovery of Bradford's Law

The "core literature" concept which Thomson-ISI proposes, is based on what Bradford calls the nucleus – his $1{:}n{:}n^2$ observation, which lead to his formulation of the law of distribution of papers.

Bradford's motivation was the observation that despite 750,000 articles being abstracted by the various abstracting and indexing journals, owing to duplication only 250,000 unique articles were abstracted. Based on this disquiet, he arranged for an analysis to be undertaken on the sub-disciplines of Applied Geophysics and Lubrication. Bradford does not explain this selection and it is worth noting that in the 1980s these two bibliographies were the only contemporary bibliographies that could be located at the Science Museum Library when Brookes was seeking material for his review (Brookes, 1985). Brookes follows this comment with the statement that "I can only guess that Bradford had already noted what I noted 30 years later – that *some* bibliographies have no nucleus at all."

Bradford's premise was that there would be three broad groupings of journals: a number of journals specially devoted to a subject, some border-line journals and more general journals. His results lead to the articulation of his law of distribution of papers as follows:

> "if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the number of periodicals in the nucleus and succeeding zones will be $1{:}n{:}n^2$ … ." (Bradford, 1934)

Bradford then used this ratio to estimate the number of papers not included in indexing efforts in 1934. Based on his results, he called for a radical change in abstracting and indexing.

> "Periodical literature must be abstracted by source, and not by subject, as hitherto. All the important articles in each periodical should be catalogued, those coming within the scope of a particular bureaux

> should also be indexed, the titles of the remainder being forwarded to the bureaux specially concerned, or to a clearing house."

A number of points are immediately apparent:

- Bradford looked at two small sub-disciplines;
- Bradford was interested in the distribution of publications, not quality; and
- Bradford's motivation was to develop a case for indexing inclusively, not to exclude publications, with an aim of creating a "complete index to scientific literature." (i.e completeness not restriction to outlets more devoted to one discipline than another.)

We will return to these points later in this paper.

Development of Bradford's Law

Leimkuhler (1967) later showed that Bradford's Law could be expressed as

$$G(r) = k \ln(1 + br)$$

where *G(r)* is the cumulated total of papers in the first *r* of ranked journals and where *b* and *k* are parameters to be evaluated from the data.

Chen and Leimkuhler (1986) examined the relationships between Lotka's Law, Bradford's Law and Zipf's Law (see below). In 1926 Lotka published a paper in which he examined patterns of productivity among chemists (Lotka, 1926 *cit* Chen & Leimkuhler 1986). He discovered that if he ranked his population of chemists according to how frequently they published, then the number of chemists publishing *n* papers, *f (n)*, was approximately equal to a/n^2, for some constant *a*, i.e.,

$$f(n) = an^{-2} \qquad n = 1, 2, 3, \ldots$$

Zipf (1949 *cit* Chen & Leimkuhler 1986) stated that "if one takes the words making up an extended body of text and ranks them by frequency of occurrence, then the rank *r* multiplied by its frequency of occurrence, *g(r)* will be approximately constant." In symbolic form:

$$g(r) = br^{-1} \qquad r = 1, 2, 3, \ldots$$

where *b* is a positive constant. Through empirical analysis and mathematical proofs, Chen and Leimkuhler found that there is a common functional relationship in these three laws.

Bookstein (1990a, 1990b) reviewed a number of discovered laws, ranging from Bradford through Zipf even to Pareto's work on businessmen, which demonstrated regularities in counting events or measuring sizes in a variety of areas. He also noted the fact that many of them appeared similar in form to the degree that some were approximations of others. This suggests that these laws are either special cases of some more general law which applies in the area, or the result of very general causes that cut across a range of phenomena. These regularities are often found in a population of discrete entities which is producing something over a time, for example, businessmen making money, scientists producing articles, or journals publishing articles in a given discipline. Bookstein asserts that these laws use different modes of description of the distribution of their yields and once the laws are restated in a form which resolves these different modes, the form of the laws becomes approximately the same.

Bookstein makes the point (1990a) that many of these regularities occur in biological and social sciences where it is often difficult to conceptualise and precisely define the variables in the regularities:

> "For example, the five year time span chosen by Lotka in his study of publication patterns within chemistry was determined by the cumulation period of Chemical Abstracts, a unit chosen for convenience and independent of Lotka's research concerns. Biological classification, on which Willis' law is based, is notorious for the arbitrariness with which genera and species are defined. Even publication counts have an element of ambiguity, most strongly evidenced by the problem of how to count papers with multiple authors, but also, papers of different size and significance."

Bookstein's conclusion is that these laws follow a general distribution, in the same way that other phenomena may follow a normal distribution. This conclusion has been supported by the work of Quentin Burrell. Burrell has published a number of papers (eg 1992) in which he has established that Bradford's Law and other similar laws including those mentioned above are special cases of the Gini index, which has been used by econometricians since the early twentieth century as measures of concentration. Again, the issue of quality does not arise.

Issues in the Application of Bradford's Law to Information Systems

As mentioned in a prior section, Bradford's work is now being applied across whole disciplines, when it was originally an observation of what were arguably two sub-disciplines and that Brookes observed that there are disciplines which have no nucleus, and suggests that Bradford knew that as well.

Since 1934, or even since the 1950s, the world of academia has greatly expanded. How valid now are the assumptions made by Thomson-ISI in the 1950s when adopting it for the ongoing determination of the sample of journals from which they calculate journal impact factors? A key feature of this is growth in the number of cross-disciplinary areas, and the number of young disciplines. IS is both young and a cross-disciplinary area. How applicable is a "law" empirically determined by two observations of mature sub-disciplines to a young discipline such as IS? IS is a young discipline, but is mature enough to have some journals devoted to its core topics of interest. Thus, IS may not be so immature as to warrant the warning by Brookes (1985):

> "If the topic is so widely dispersed or too novel yet to have attracted a journal 'more particularly devoted' to it, we need not expect to find a nucleus in its bibliography."

On the other hand, whether or not IS has a nucleus is completely untested.

In the twenty-first century, the Internet has the potential to provide tools to track and analyse the use of data. The *Index of Information Systems Journals* (Lamp, 2004) is a comprehensive collection of information on IS journals. The *Index* lists journals which publish IS research and provides URLs as hyperlinks to websites run by the journals themselves. It records basic information on the use of these hyperlinks as part of its normal operation. As a convenient test of whether Bradford's Law might apply to the *Index*, twenty-six month's data on use of hyperlinked sites was analysed. Over this time, 44,258 such usages were recorded. A listing of journals ranked by the use of their hyperlinks was separated into three sections at 14,753 usages. This resulted in the following observed distribution:

48 : 138 : 392

This ratio was then scaled to test its adherence to Bradford's $1:n:n^2$ ratio:

1 : 2.9 : 8.2 (observed)

1 : 2.9 : 8.4 (expected)

This would suggest that the usage of the *Index* follows a Bradford distribution. The top 85% of usage was accounted for by 60% of the journals on the *Index*. While this analysis is, to a certain degree, speculative and untested, it is interesting to note that only 36% of journals on the *Index* are tracked by Thomson-ISI. It could therefore be conjectured that the use of the Thomson-ISI indices as a sole measure of IS research would have a major impact on the IS discipline. It should also be noted that no Australian IS journals are presently indexed by Thomson-ISI and neither is the Association for Information Systems (AIS) journal, *Communications of the AIS* (Fisher *et al*, 2007). Thomson-ISI commenced indexing the *Journal of the AIS* mid 2007.

Calculating and Interpreting the Impact Factor

The Thomson-ISI impact factor has also been the subject of criticism, both in the manner in which it is calculated, and in which it is interpreted. A recent detailed UK survey (Shepherd 2007) of authors, publishers, editors and librarians listed 18 disadvantages, including:

- optimized for biomedical sciences, work less well in other fields
- can be manipulated by, e.g., self-citation
- overused, misused and over-interpreted
- is an average for a journal; provides no insight into individual articles
- formula is flawed; two-year time window too short for most fields
- can only be used for comparing journals with in a field
- underrates high-quality niche journals
- does not cover all fields of scholarship
- time-lag before impact factors are calculated and reported; new journals have no impact factor
- reflect only "author" use of journals, not other groups, such as students
- impact factor has a monopoly of comparable, quantitative journal measures
- reinforces the position of existing, dominant journals
- ISI categories are not appropriate and neglect smaller, significant fields.

Recently, Moed (2005) examined several disciplines and specific journals and looked at a number of these issues in more detail. He showed that the age distribution varies significantly among disciplines, resulting in

typical impact factors varying between disciplines. In this context he notes that Eugene Garfield, the developer of the impact factor measures, "was well aware of such differences, and emphasised in many publications that one should not directly compare journals from different disciplines with one another" (Moed, 2005). Given the rate of development of the IS discipline, this could be a major factor affecting IS journal impact factors and requires further investigation. This is compounded by another observation by Moed (2005), that "… 'top' journals in large disciplines tend to have a higher citation impact than top journals in smaller ones." The small size of the IS discipline would suggest that this would also depress IS journal impact factors.

The Thomson-ISI indexed journals, selected on the basis of Bradford's distribution, have somehow become interpreted as a stamp of quality, rather than an artefact of the narrowness of indexing focus. It is being used to justify looking at a subset of journals rather than the whole journal population – the precise opposite of Bradford's intentions. If there was a link between quality and journals with a higher impact factor, then it should be possible to determine two distinct cohorts of authors, based on the impact factor of the journals in which they publish. Some empirical analysis has been done on this and it has been shown to be false in at least one discipline (Moed, 2005).

There is also a degree of circularity in the impact factor/quality equivalence argument: "These are the only journals to publish in because they have an impact factor, we therefore cite ourselves to improve our impact factor in the journals that have an impact factor!" The issue of the impact factor/quality equivalence argument also ignores the issue of the reason for the citation of particular works. Fleischmann's *et al* (1989) paper on "cold fusion" has been cited over 500 times (Garfield, 1996), but rarely in a positive sense.

Mis-citation of journals and articles is another complicating factor. In the literature on ranking and analysis of IS journals, there are three papers which are frequently mis-cited because of their similarity:

> MacMillan, I. C. (1989). "Delineating a Forum for Business Policy Scholars." *Strategic Management Journal* **10**(4): 391-395.
>
> MacMillan, I. C. (1991). "The Emerging Forum for Business Policy Scholars." *Strategic Management Journal* **12**(2): 161-165.
>
> MacMillan, I. C. and I. Stern (1987). "Delineating a Forum for Business Policy Scholars." *Strategic Management Journal* **8**(2): 183-186.

Often it is difficult to accurately determine the name of a particular journal. This is compounded when using listings created by third parties or by persons, including some authors, who are not greatly concerned with the further use of their paper for citation analysis. Data provided by the Computing Research and Education Association of Australasia (CORE, 2007) uses author provided reports with a number of mis-citings, often by including the topic of a special issue as part of the journal title. Moed (2005) reports an analysis of mis-citings in the Thomson-ISI data of the journal *Astronomy and Astrophysics*. Almost 80% of citations to this journal were as *Astron Astrophys*, but most of the remaining references were as *A A*. Overlooking the latter variant reduced the journal impact factor by approximately 20%.

A final issue regarding the question of quality and impact is using the journal impact factors of journals in which a research group publishes as a predictor of the impact of a research group's papers. This issue has been negatively commented on by many authors, including Garfield, Seglen and van Raan (Moed, 2005). Research by Moed (2003 *cit* Moed 2005) on the publications of a number of research departments found that the normalised impact of journals in which papers were published explained between 20 and 40% of the variance in the normalised citation impact of a department's papers.

Eugene Garfield has also expressed concerns with the application of the ISI measurements. In particular he draws a distinction between the validity of journal impact factors and attempts to create individual author impact factors (Garfield, 2000).

> "It is one thing to use impact factors to compare journals and quite another to use them to compare individual authors. Journal impact factors generally involve relatively large populations of articles and citations. Individual authors, on average, produce much smaller numbers of articles."

Other Possible Measures

A number of alternatives measures to the Thomson-ISI journal impact calculation have been suggested over the years. These have ranged from changes to the Thomson-ISI procedures to radical changes of focus.

Moed (2005) suggests the development of a field-normalised journal impact factor. The intention is to develop a measure which is less influenced by the particular discipline or sub-discipline which is being assessed. It would also allow the development of a meaningful measure for multi-disciplinary fields. Moed would prefer a series of

indicators, but feels that this would be difficult, if not impossible because of the dominance of the journal impact factor. This form of measure has also been suggested by others.

Another possibility would be the use of some web based metrics based around databases of articles or indexes of journals, such as the *Index of Information Systems Journals*. One issue of the present approach to tracking citations is that it requires that papers be written, circulated and cited before a measure can be taken. Keeping track of usage via the web would largely eliminate this lag. It would also address one other aspect of the present measures which has been criticised – that they are author focused. This criticism is also implicit in the Australian RQF formulation which talks in terms of research quality and research impact. Research quality refers to "the quality of original research including its intrinsic merit and academic impact" (DEST, 2006). Research impact refers to "the extent to which research in Australian universities has created social, economic, environmental, and/or cultural benefits for the wider community regionally, nationally, and/or internationally" (DEST, 2006). Monitoring web access should include this wider group, whereas using journal impact calculations based on citations to measure research quality only includes use by authors, for the most part academic authors.

Rowlands and Nicholas (2007) have proposed a suite of measures which are wholly reader focused. The measures all assume digital delivery of material. They propose:

- Article download indicator
  an annual count of articles downloaded from journal *J* during year *T*
- Usage impact factor
  following a similar formula to the journal impact factor. The UIF for journal *J* in year *T* is

$$\frac{\text{The number of article downloads in year } T \text{ of all articles published in } J \text{ in the years } T\text{-1 and } T\text{-2}}{\text{The number of articles published in } J \text{ in the years } T\text{-1 and } T\text{-2}}$$

- Usage immediacy index
  a measure of how quickly articles are read after publication. The UII for journal *J* in year *T* is

$$\frac{\text{The number of article downloads in year } T \text{ of all articles published in } J \text{ in the year } T}{\text{The number of articles published in } J \text{ in the year } T}$$

- Usage half life
  a measure of the long term value of an article – the median age of all articles in journal *J* downloaded in year *T*

This is an illustrative selection of examples, rather than an exhaustive list. Our intention in including them is to demonstrate that there is a range of alternatives, and that this area is under active research into measures not previously possible in hard copy publication. The relative novelty of the web based proposals only emphasises the potential of this area and the need for analysis and development of these approaches as new publishing models are implemented and become stable.

Conclusions

As we enter the era of the RQF, Australian IS academics are nervous about how quality measures based on the Thomson-ISI indices will impact them. We have raised fundamental questions about the applicability of the Thomson-ISI indices because of their dependency on Bradford's Law.

The implication of the extrapolation of all this to the RQF is that these measures are not giving a useful or correctly interpreted picture of quality or impact of research especially in small, youthful disciplines like IS. The Thomson-ISI impact factor (for a journal) is being used as an empirical measure of quality in the RQF. Other approaches to the understanding of the quality and impact of research based on a recognition of electronic publishing environments are needed. Also, new ways of analysing bodies of literature that reveal quality, academic impact and social impact need to be explored.

We have argued that there are a large number of unanswered questions raised by this approach to the evaluation of the worth, in terms of quality and impact, of research in Australia. We remain unconvinced that there are presently satisfactory answers to the following questions:

- Do the Thomson-ISI measures adequately address the needs of the RQF?
- Does the Information Systems discipline display a nucleus as predicted by Bradford's law?
- How does the size of the Information Systems discipline affect impact factor calculations?
- How does the youth of the Information Systems discipline affect impact factor calculations?

- How does the multi-disciplinary nature of the Information Systems discipline affect impact factor calculations?
- How does the time over which impact factors are calculated affect the Information Systems discipline?
- Can any relationship be found between the impact factor of Information Systems journals and quality?
- Can any relationship be found between the impact of a research group's output and the impact factor of the journals in which they publish?
- Are there other better measures which can be put in place?

Further research is needed to provide answers to these questions, if the RQF process is to provide credible information.

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