BRADFORD LAW IN R & D EXPENDING OF FIRMS
AND R & D CONCENTRATION

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The applicability of the Bradford law to the R & D expending of firms is examined and its usefulness is proved. It successfully identifies core firms, peripheral firms and minor firms. It also provides a measure to evaluate the degree of R & D concentration to a small number of firms.

Introduction

The Bradford law subject to which the cumulative number in the decreasing rank order is distributed is empirically known to be valid for the article productivity of scientific journals on a specific theme. Several efforts to give mathematical formulations are giving some, if not fully clear yet, insight into its underlying dynamic mechanism which generates this particular distribution called the Bradford rank distribution. Conceptually, the reason of its validity may be explained as a diffusion of a scientific theme from core journals to peripheral journals. In order to verify and enrich this conceptual interpretation, attempts may be useful to examine whether the Bradford law is still valid in other areas or not. In fact, the report that it is invalid at a microscopic level is quite informative. Among various candidates of its application, R & D expending of firms may be appropriate because it is considered as a diffusion or "epidemic" process in that leading or core firms initiate R & D and other peripheral firms follow them.

This paper reports an experience to apply the Bradford law to R & D expending of firms and to interpret its result.

Method and data

The Bradford rank distribution is composed of two or three sections according as the collection of articles on a specific theme is complete or not: The nucleus section, the logarithmic (or log-linear) section and the droop section where the last section is seen...
only for incomplete cases. The cumulative number is above a logarithmic curve with
appropriate parameter values in the nucleus section, along the logarithmic curve (or a
log-linear line on semi-log paper) in the logarithmic section and below the logarithmic
curve in the droop section. The utility of the Bradford law in bibliography is to judge
the completeness of collection of articles.

The data used herein were the R & D expenditures of the major Japanese firms in
1980\(^7\). Ref. 7 reports the financial data of all the stock-listed firms of Japan for many
of which the data of R & D expenditure is included. The stock-listed firms are classified
into several sectors by the stock-exchange office according to their products. This
classification does not necessarily reflect the present R & D themes because of a time-
lag between R & D and production. This gap is negligible for many sectors but not
negligible for the synthetic fibre firms which are classified in the textile sector by the
stock-exchange office. In our analysis the synthetic fibre firms were classified in the
chemical sector for a better reflection of their present R & D themes. The existing
classification by the stock-exchange office was applied to the rest. The transportation
equipment sector was excluded from our analysis because it is composed of two separate
subsectors (shipbuilding and automobile) and each subsector is too small in number of
firms for our statistical analysis.

Results

The core firms which are defined as the top rank firms corresponding to the nucleus
section were identified for each sector as in the leftest column of Table 1. The sectors
were separately clustered into two: Cluster 1 with a few core firms (steel, non-ferrous,
electrical & electronics, and textile sectors) and cluster 2 with many (about 5) core firms
(pharmaceuticals, machinery and chemicals & synthetic fibre sectors). This identification
and clustering was quite reasonable and was found to reflect well the real situations in
these sectors. In fact it is known that there is no especially leading firm in the sectors in
cluster 2.

The number of core journals is usually not less than three in bibliography\(^4\). But the
number of core firms was only two in a half of sectors in our problem. This will be inter-
preted later.

Different from the collection of articles of a specific theme, the R & D expending
wherein new themes appear one after another is always incomplete. Therefore the droop
section is expected to appear in every case of R & D expending. Actually, the droop
section was very large for every sector: in other words, the logarithmic part was very
short for every sector as is shown by the next left columns in Table 1. Let firms in the
logarithmic section be called peripheral firms.