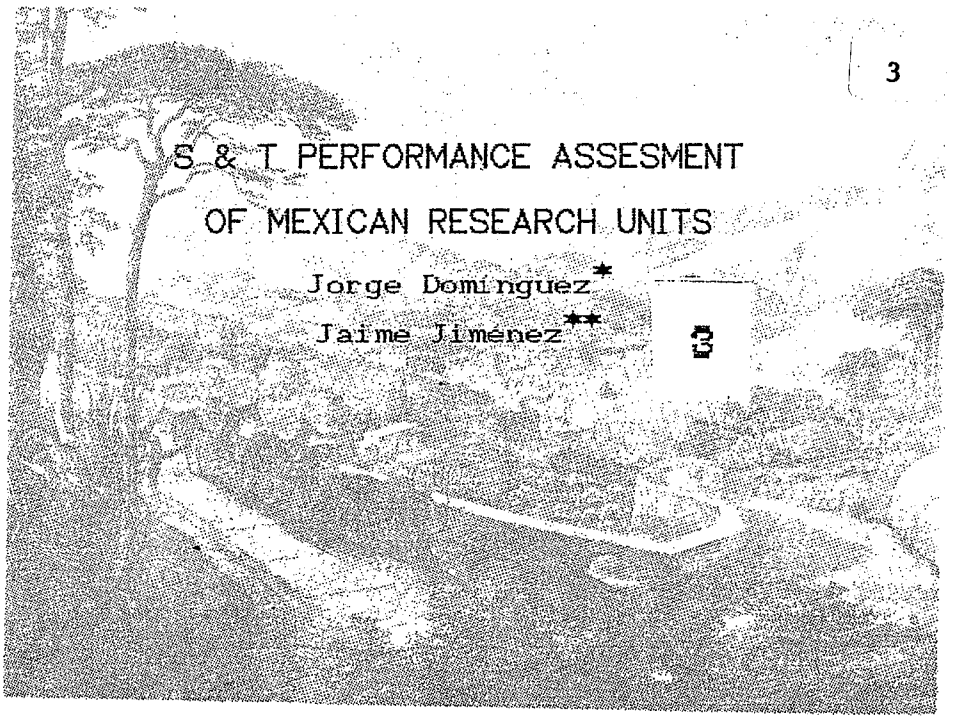
COMUNICACIONES DEL CIMAT



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S&T PERFORMANCE ASSESSMENT OF MEXICAN RESEARCH UNITS

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ABSTRACT

The "International Comparative Study on the Organization and Performance of Research Units (ICSOPRU)", is a study of national S&T systems coordinated by Unesco since 1974. The study is an indirect, a-posteriori, multi-faceted evaluation of the management, productivity and effectiveness of research units. The universe of study in México was made up of "all institutions whose primary activity is scientific or technological research". This universe consists of 251 research institutions. The sample drawn from it is composed by 221 research units belonging to 178 institutions.

We found that units are quite effective in meeting both scientific consultations and technical services. Productivity is analyzed separately as scientific or technological. Both productivity types are arbitrarily defined by the authors. Scientific productivity is higher in central than peripheral units, with the exception of units belonging to institutions of the federal government, where peripheral units produced more scientific output. Units in the social sciences and the humanities are the highest producers of scientific results. Scientific productivity shows some correlation with the unit's age, reaching maximum productivity at the age of 20 years. "Old" units reduce drastically its scientific output.

Thecnological productivity is greater in central than peripheral units, independent of institution type. The highest producers of technological output are units in the natural sciences, engineering and medical sciences. Technological productivity shows a less evident correlation with time, compared to scientific productivity.

Performance distribution over time suggests the existence of life cycle typologies independent of scientific field, however this assertion could only be confirmed with additional analysis of the data.

S&T Performance Assessment of Mexican Research Units

1. Introduction

The performance of research units is one the major and most legitimate concerns of S&T decision-making bodies. Because potential performance is difficult to assess, funding decisions are based primarily on past performance. This paper analyzes data from a national survey of Mexican research units drawn from a universe of all institutions whose primary activity is scientific or technological research (Jiménez et al., 1987). The "International Comparative Study on the Organization and Performance of Research Units (ICSOPRU)" is coordinated by Unesco, having participated so far 17 countries of all latitudes, since 1974. In Mexico this is a project of the federal government sponsored through the National Science and Technology Council (CONACYT).

Two components of performance are studied:

first, the number of services (consultations and technical services) performed by the unit during the 12 months previous to the survey;

second, the number of research products completed during the last 36 months, per scientist or engineer.

We are interested in assessing performance differences among research units by scientific field and type of institution, in addition to the center-periphery classification introduced earlier (Jiménez et al., 1986a). The center-periphery dichotomy refers to the fact that there are significant differences between institutions in the metropolitan area of Mexico City and those outside it, in the provinces. Scientific fields are grouped into five macrofields according to the classification used by CONACYT:

- Natural sciences
- Agricultural sciences and technologies
- Engineering sciences and technologies
- Medical sciences and technologies
- Social sciences and the humanities

The research units belong to the following institution types:

- Federal government
- Public academic
- Private academic
- Other (private businesses, non-profit organizations, institutions belonging to international organizations, etc.)

Productivity, that is the number of R&D products per scientist or engineer, is separated into scientific and technological products.

Scientific productivity is arbitrarily defined as the production of books, scientific or technical papers published in the country or abroad, critical reviews and bibliographies, and original unpublished R&D reports.

Technological productivity is defined as the production of patents, algorithms, computer programs, blueprints, flowcharts, drawings, experimental prototypes, instruments, experimental materials, and collections of research materials. Depending on the nature of the work done in the research unit, it will produce more of one or the other types.

No attempt has been made to assess the quality of R&D products, since ICSOPRU does not directly address such performance charasteristic. Performance is assessed by graphical methods (Chambers et al., 1983; Chambers & Kleiner, 1982), indexes (Alestalo, 1979; Knorr et al., 1979), and clustering techniques (Guanadeskian, 1979; Hayashi, 1980; Shye, 1978).

We found that performance varies with age of the unit, type of institution and geographic location (center-periphery). Units producing thecnological products are fewer than those producing scientific products. Units in the social sciences and the humanities stand out as high producers of scientific papers.

2. The data

The data used in this study were obtained from the answers given by the heads of 221 research units. The units are classified as central or peripheral, by

institution type, and scientific field, as explained above.

Table 1 shows the number of units per institution type and geographic location (center-periphery). Table 2 shows the distribution of units per scientific field and institution type.

3. Performance assessment

3.1 Scientific consultations and technical services

Although Mexican science is young compared to other countries (Jiménez et al., 1986b), some segments are very dynamic in terms of consultations and technical services. A rough visual measure of the effectiveness of these S&T products is obtained by plotting the number of requests received on the y-axis versus the number of requests satisfied on the x-axis (see Figure 1). Units that are 100% effective in meeting requests are plotted along a straight line at 45 degrees, whereas units that do not meet all requests are plotted above this line. All plots shown are scaled to 100 to be able to make simple visual comparisons.

Figures 1 and 2 show the number of consultation requests received by the units within the country versus the number met. Figure 1 indicates the geographic location and institution type of the unit, and Figure 2 the unit's scientific field. These figures show that the number of units receiving requests is large (184 out of 221 units). The concentration in the lower left side of the figure indicates that most units get a low number of requests (1-5 per year). Since most of the units are plotted close to the diagonal, we may assert that effectiveness is fairly high. However, there is one unit that gets many requests and meets only one out of five. It is a periphery-private academic in the social sciences. There are two more units with low affectiveness, one center-public academic in engineering, and one center-other in the social sciences.

Figures 3 and 4 show the number of scientific consultations received from abroad versus the number satisfied. Fewer Mexican units get requests from abroad

(86 out of 221). The distribution of units looks about the same as in the previous case: many units concentrate in the lower-left side of the figure, however the number of requests is smaller. Again, effectiveness in general is acceptable, except for one periphery-private academic unit in the social sciences which satisfies only one out of three requests from abroad.

Regarding requests for and satisfaction of technical services in the country, the picture is similar to the one depicted by scientific consultations, although the number of units involved is smaller. Only 116 units received requests for technical services. Figures 5 and 6 display the effectiveness of these. Most units fall on or very close to the diagonal, with the exception of two center-federal government units in agriculture that have only a 50% effectiveness.

Figures 7 and 8 show that only 36 units get requests for technical services from abroad. Most units show an acceptable degree of effectiveness, but one periphery-public academic unit in the social sciences does not satisfy any requests.

3.2 Scientific productivity versus age of the research units

Scientific productivity is defined as the number of books, papers published in the country or abroad, reviews and bibliographies, and original unpublished R&D reports produced in the 36 months previous to the survey, per scientist or engineer. We arbitrarily define 10 or more products as "high" productivity, between 5 and 10 products as "intermediate" productivity, and below 5 products as "low" productivity . Similarly, we consider units to be "young" when they are 10 or less years old, of "intermediate" age between 10 and 20 years old, and "old" when they are older than 20 years.

Figures 9 and 10 show the age of the unit (x-axis) versus its scientific productivity (y-axis). Figure 9 displays the geographic location (center-periphery) and institution type, and Figure 10 shows the scientific field of the unit. Both figures show that 29 units (13%) reported not having produced any printed output in the last 36 months previous to the survey. Most of the units (190 out of 221, 86%) are between 1 and 20 years old, and have produced between zero and 10 printed products in the

last three years. All institution types and scientific fields are represented in these intervals.

It is interesting to note that, in general, units are distributed along a line going from the lower left side of the figure (see Figure 9), upwards to approximately 20 years, suggesting a positive correlation between age and printed productivity. There can also be observed a negative correlation between "old" age and productivity: most units older than 20 years display "low" productivity. Specifically, 12 out of 16 units over 20 years old are in the "low" productivity interval, and none of the remaining 4 units fall in the "high" productivity interval.

This performance distribution over time suggests the existence of a unit typology independent of scientific field, like the one proposed by Aimeti et al.(1979). In essence, Aimeti's typology could be interpreted as two different life cycle paths to which all units belong. Further analysis will show the validity of this assertion.

Finally, more than half of the units in the "high" productivity class are in the social sciences and the humanities.

A discussion of scientific productivity versus age of the unit, per institution type and geographic location follows:

Federal government

Peripheral units are younger and produce more than central units. Figure 12 shows that 78% of the peripheral units are in the "young" interval and none fall in the "old" interval, contrasted with only 69% of the central units in the "young" interval (see Figure 11). In terms of productivity, 39% of the peripheral units are from the "intermediate" level up, with two units standing out for very high productivity in the social sciences. In contrast, only 33% of the central units are in the "intermediate" and "high" productivity intervals, and none stand out as a very high producer of printed output.

Public academic

Peripheral units are much younger and produce fewer scientific writings than central units. As can be seen in Figure 13, central units are represented in the three age intervals, whereas peripheral units are mostly represented in the first one (see Figure 14). Contrary to the previous case, central units produce more than peripheral units. In fact, 37% of the central units are from the "intermediate" productivity level up, contrasting with only 17% of the peripheral units in the same levels. One central unit in engineering stands out as a very high producer of printed material.

Private academic

Peripheral units are much younger and produce a little less than central units. Figure 15 shows how central units are represented in the three time intervals, whereas peripheral units are mostly in the "young" interval (see Figure 16). Productivity of central units is somewhat better than peripheral units. In contrast, one peripheral unit in medicine has a remarkably high productivity in printed material.

Other

Peripheral units are younger and produce less written output than central units. Figure 18 shows that all peripheral units are in the "young" age interval and have "low" productivity. Figure 17 shows that two central units are in the "intermediate" age interval, and have "intermediate" productivity of printed material.

3.3 Technological productivity versus age of the research units

Technological productivity is defined as the production of patents, blueprints, flowcharts, drawings, experimental prototypes, instruments, experimental materials, and collections of research materials performed in the 36 months previous to the survey, per scientist or engineer. The same productivity intervals ("high", "intermediate", "low") and age intervals ("young", "intermediate", "old") are used as in the case of scientific productivity. Figures 19 and 20 show the age of the unit (x-axis) versus its technological productivity (y-axis). Figure 19 displays the geographic location (center-periphery) and institution type, and Figure 20 shows the scientific field of the unit. The number of units producing technological output is much less than the units producing scientific output, only 93 of 221 units (42%) produce technological results, compared to 192 units (87%) producing scientific results. Most of the units (195 of 221, 88%) fall between one and 20 years old, and between zero and ten technological products. As with the scientific productivity case, all institution types and scientific fields are represented within these intervals.

The correlation between age and productivity is less evident here than in the scientific productivity case, and the maximum productivity is reached earlier, perhaps at 10 or 12 years of age. Also, the correlation between "old" age and productivity is less apparent: 9 out of 16 units over 20 years old are in the "low" productivity interval, although 4 of the remaining 7 units are in the "high" productivity interval.

Finally, units in the natural sciences, engineering and medical sciences are equally represented in the "high" productivity interval. Units in agriculture are not represented in that interval.

A discussion of technological productivity versus age of the unit, per institution type and geographic location follows. Since age distribution is similar to the case of the scientific productivity analysis, the observations with respect to time are the same, therefore no emphasis will be made in that respect.

Federal government

Central units are older and produce more than peripheral units. Figure 21 shows that 30% of the central units are in the "intermediate" and "high" productivity intervals, while only one peripheral unit in engineering (4%) is in the "high" productivity interval, and no one falls in the "intermediate" productivity interval (see Figure 22). Six central units stand out in the "high" productivity level: four in medicine, one in the natural sciences, and one in engineering.

Public academic

Peripheral units are much younger and produce about the same as central units (see figures 23 and 24). However, in the "high" productivity level more central units are represented: 11% central versus 6% peripheral. The central units which are "high" producers are three in the natural sciences, two in engineering, and two in the social sciences.

Private academic

Peripheral units are younger and produce less than central units. Figures 25 and 26 show that more peripheral units (78% vs. 56%) have zero productivity, and only two central units reported "high" productivity, one in the social sciences and one in the natural sciences.

Other

Peripheral units are younger than central units and do not produce any technological products (see figures 27 and 28). Two central units do have technological output, one in the "low" productivity interval, and one in the

"intermediate" productivity interval. Both units are in the social sciences.

4. Conclusions.

Effectiveness in meeting both scientific consultations and technological services is satisfactory in general. Fewer units receive requests for scientific consultations from abroad than from within the country. Similarly, fewer units receive requests for technical services that for scientific consultations both within the country an abroad.

In terms of age, as reported in earlier works (Jiménez et al., 1986a) peripheral units are younger in general than central units.

Scientific productivity, as defined in this paper, is higher in peripheral units of the federal government than the corresponding central units. Central units are more productive in all other institution types than peripheral units. Units in the social sciences and the humanities stand out as "high" producers of scientific output.

A positive correlation between the unit's age and scientific productivity is apparent, reaching maximum productivity at about 20 years. A negative correlation is observed for units in the "old" age interval.

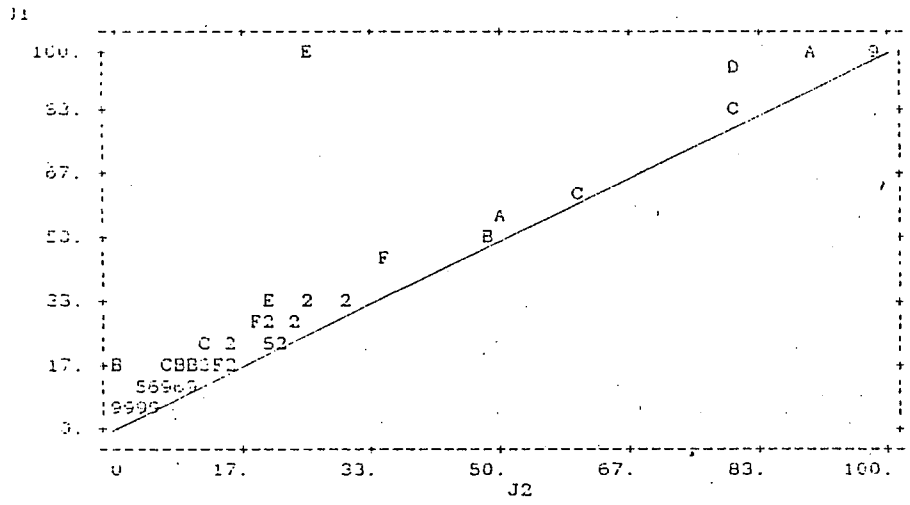
Fewer units are engaged in the production of technological output than in scientific output. This is a confirmation of the reduced potential for technological research of the Mexican S&T system. Technological productivity, as defined in this work, is greater in central units than in peripheral units, with the exception of public academic institutions, whose central and peripheral units produce about the same. Units in the natural sciences, engineering and medical sciences are equally represented in the "high" productivity interval. Units in agriculture are not represented in that interval at all.

Positive and negative correlations between the unit's age and technological productivity are less apparent than in the scientific productivity case.

Finally, further research will make evident whether it is possible to classify units within life cycles independent of scientific field.

TABLES AND FIGURES

FIGURE 1. SCIENTIFIC CONSULTATIONS REQUESTED TO AND SATISFIED BY THE UNITS IN THE COUNTRY, BY GEOGRAPHIC LOCATION AND INSTITUTION TYPE.



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G: PERIPHERY-FEDERAL GOVERNMENT
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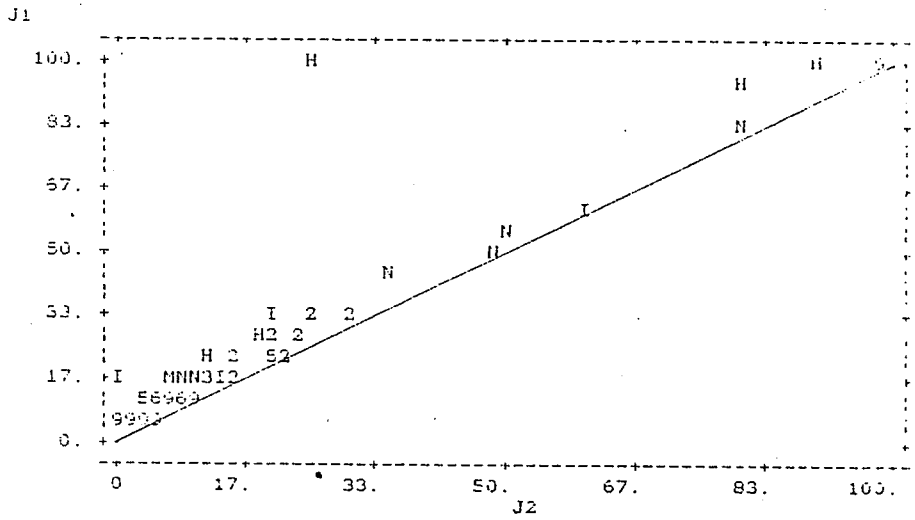
D: CENTER-OTHER
H: PERIPHERY-OTHER

FIGURE 2. SCIENTIFIC CONSULTATIONS REQUESTED TO AND SATISFIED BY THE UNITS IN THE COUNTRY, BY SCIENTIFIC FIELD.



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NOTE: WHEN MORE THAN ONE UNIT FALLS INTO THE SAME POSITION ON THE GRAPH, A NUMBER INDICATING HOW MANY ARE THERE IS PRINTED.

FIGURE 3. SCIENTIFIC CONSULTATIONS REQUESTED TO AND SATISFIED BY THE UNITS FROM ABROAD, BY GEOGRAPHIC LOCATION AND INSTITUTION TYPE.

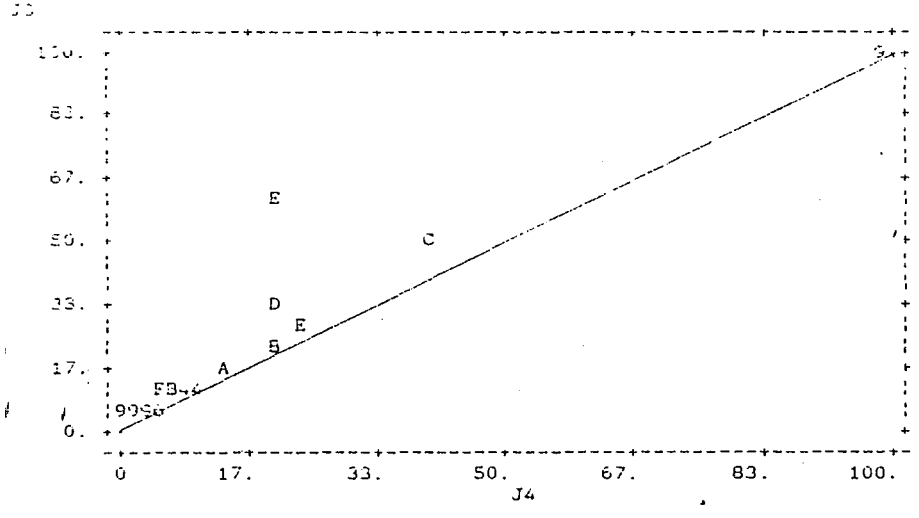

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FIGURE 4. SCIENTIFIC CONSULTATIONS REQUESTED TO AND SATISFIED BY THE UNITS FROM ABROAD, BY SCIENTIFIC FIELD.

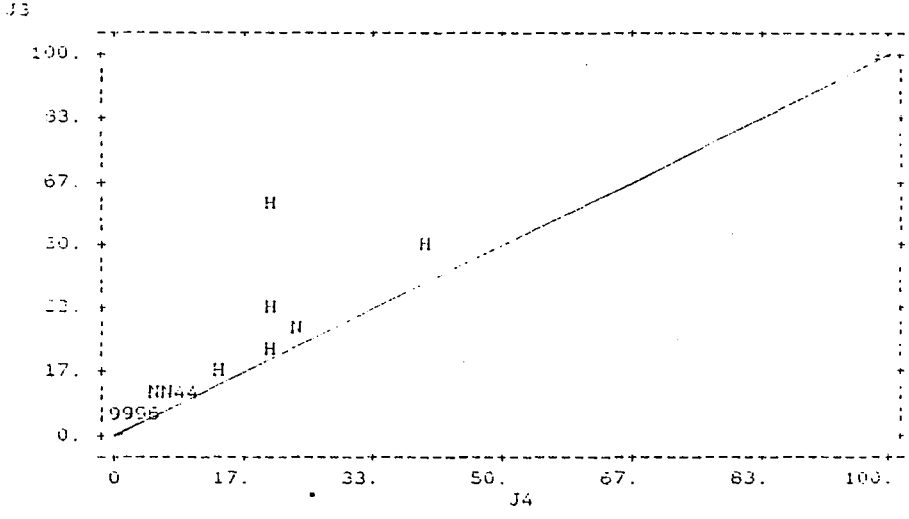

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FIGURE 5. TECHNICAL SERVICES REQUESTED TO AND SATISFIED BY THE UNITS, BY GEOGRAPHIC LOCATION AND INSTITUTION TYPE.

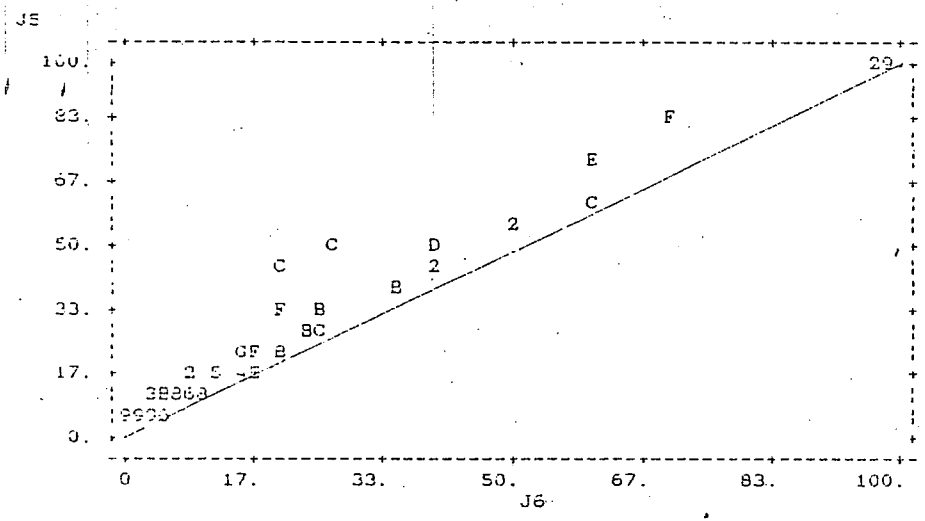

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FIGURE 6. TECHNICAL SERVICES REQUESTED TO AND SATISFIED BY THE UNITS IN THE COUNTRY, BY SCIENTIFIC FIELD.

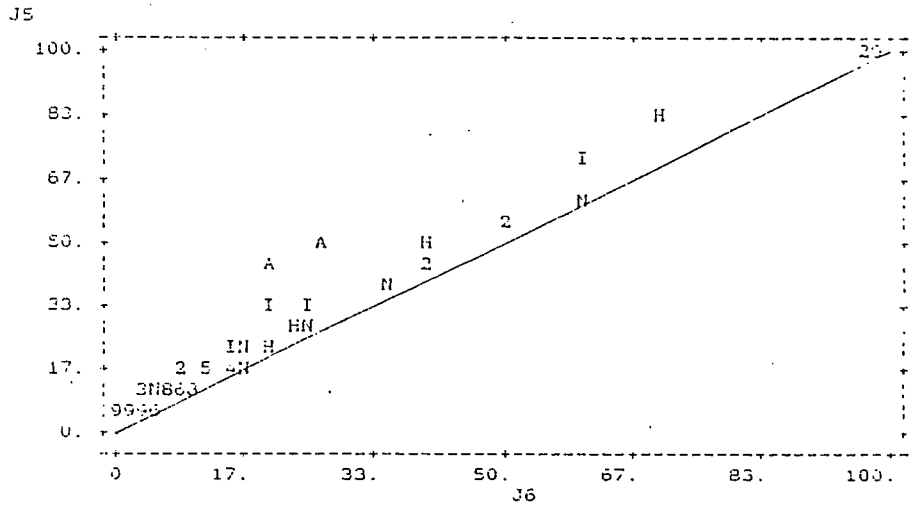

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FIGURE 7. TECHNICAL SERVICES REQUESTED TO AND SATISFIED BY THE UNIT FROM ABROAD, BY GEOGRAPHIC - LOCATION AND INSTITUTION TYPE.

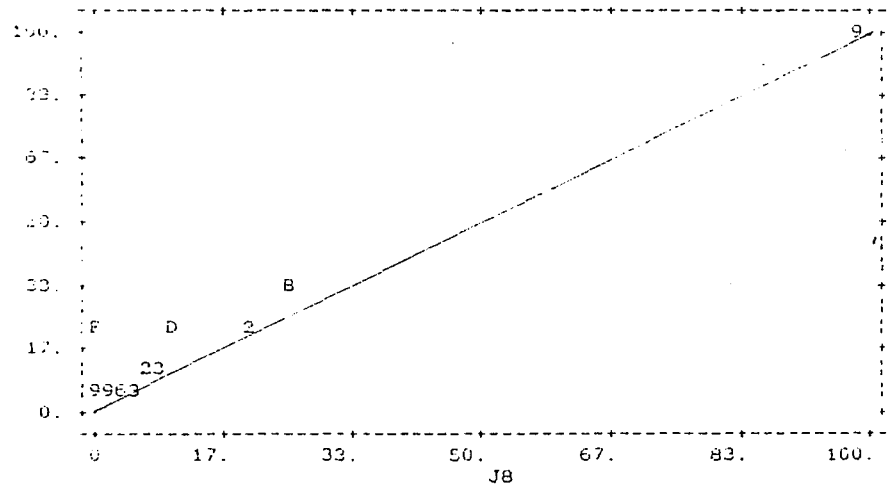

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FIGURE 8. TECHNICAL SERVICES REQUESTED TO AND SATISFIED BY THE UNITS FROM ABROAD, BY SCIENTIFIC FIELD.

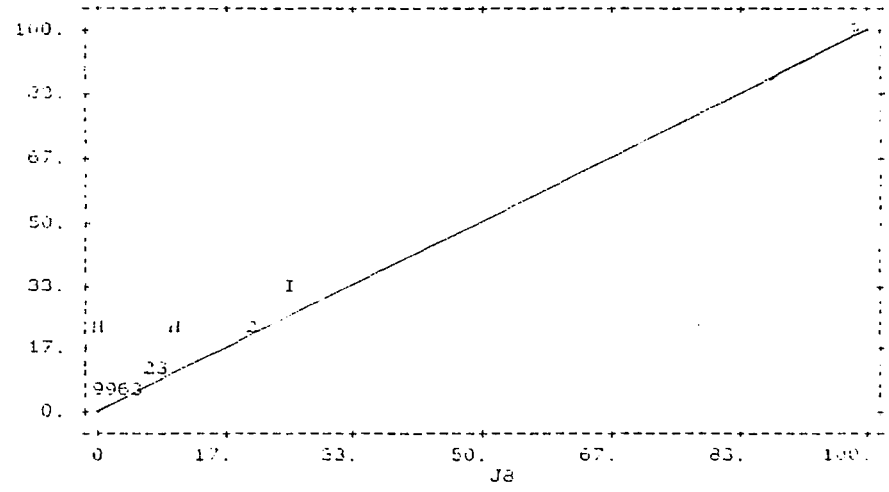

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FIGURE 9. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY GEOGRAPHIC LOCATION AND INSTITUTION TYPE.

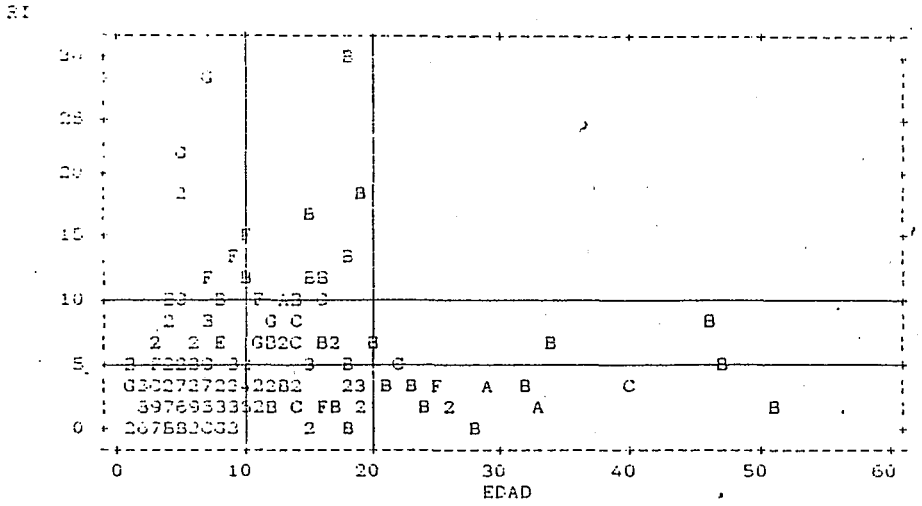

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FIGURE 10. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

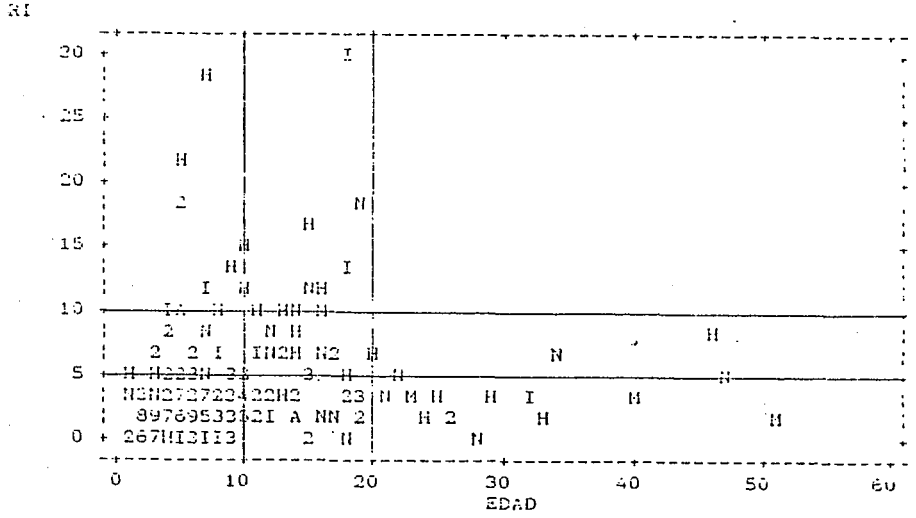

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FIGURE 11. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

CENTER-FEDERAL GOVERNMENT

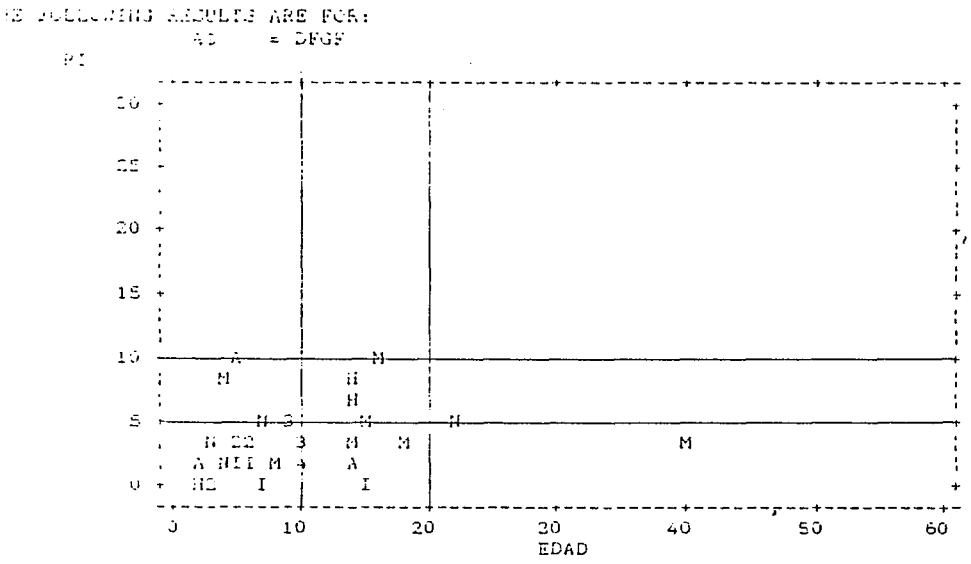

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FIGURE 12. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-FEDERAL GOVERNMENT

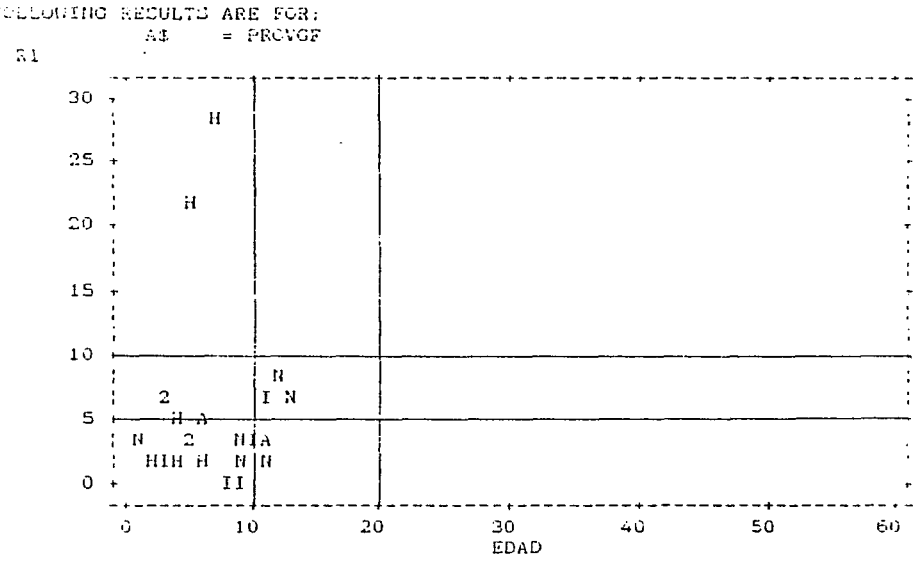

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FIGURE 13. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

CENTER-PUBLIC ACADEMIC

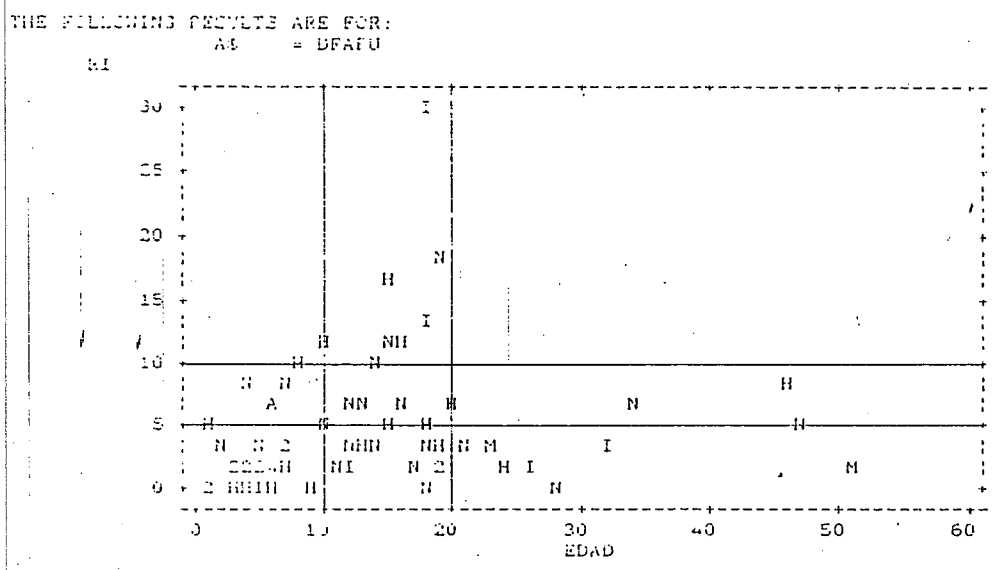

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FIGURE 14. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-PUBLIC ACADEMIC

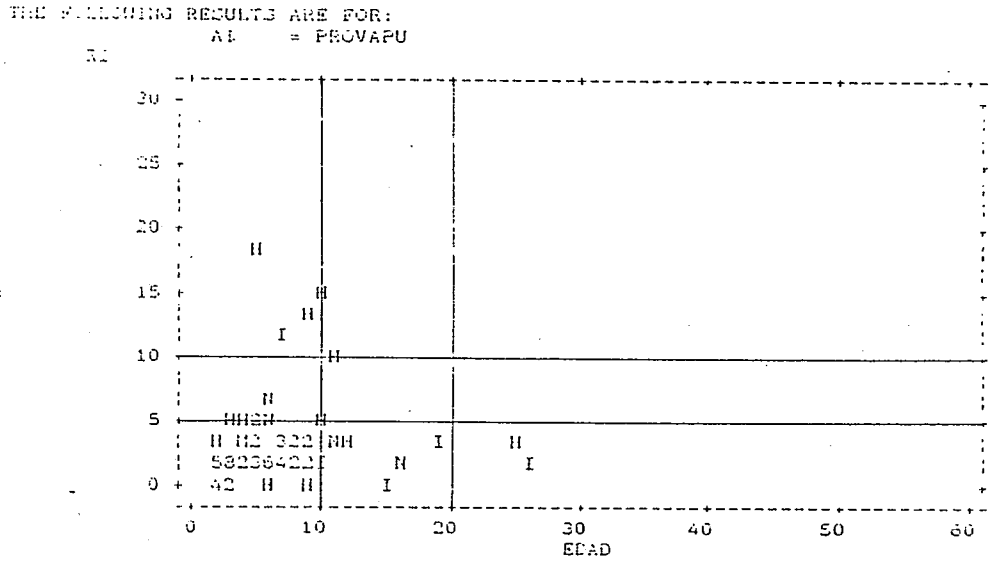

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FIGURE 15. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

CENTER-PRIVATE ACADEMIC

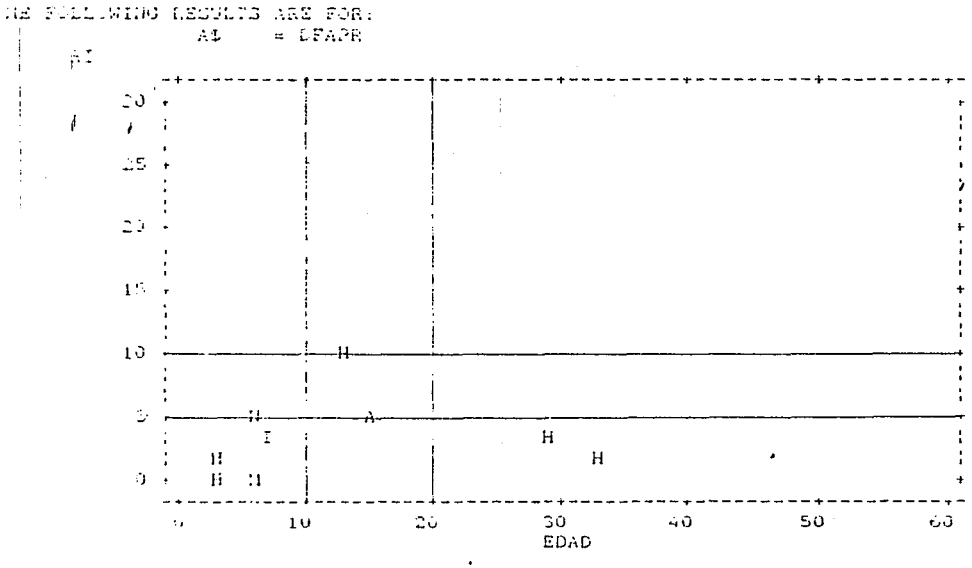

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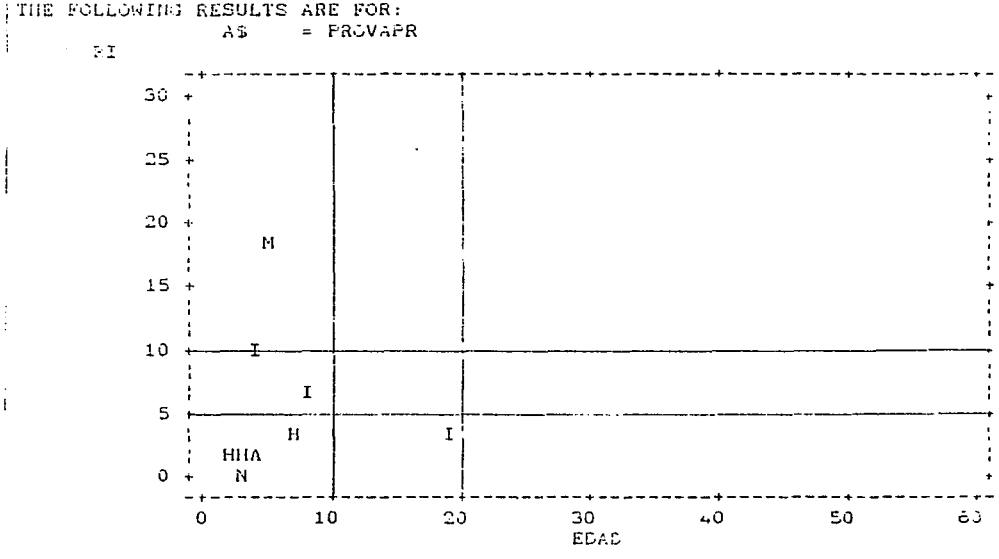
FIGURE 16. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-PRIVATE ACADEMIC



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M: MEDICAL SCIENCES AND TECHNOLOGIES
H: SOCIAL SCIENCES AND THE HUMANITIES

FIGURE 17. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

CENTER-OTHER

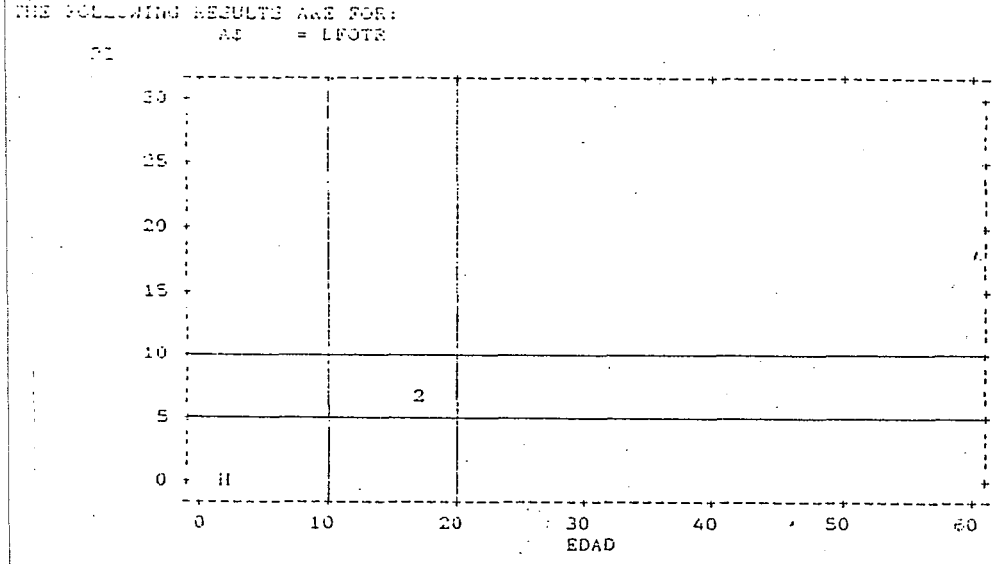

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FIGURE 18. SCIENTIFIC PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-OTHER

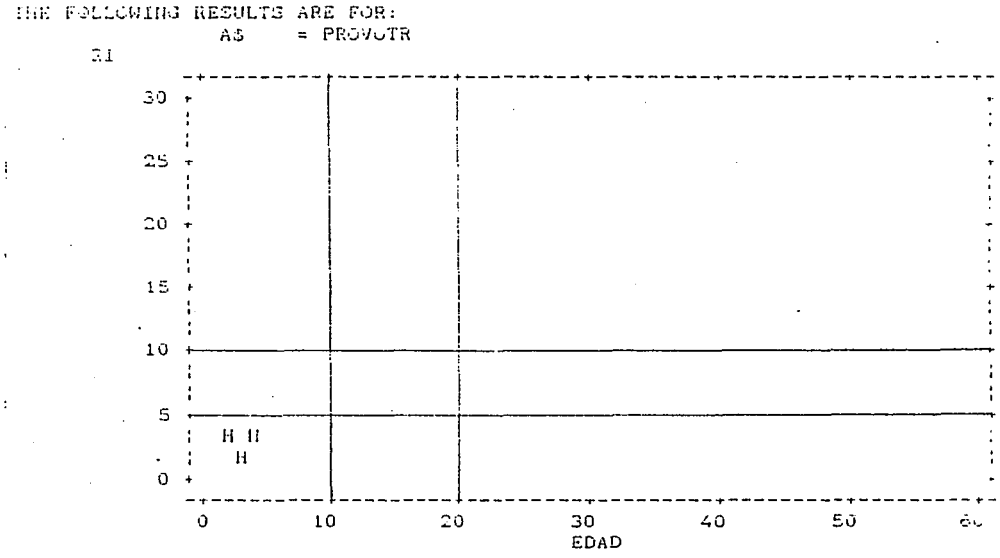

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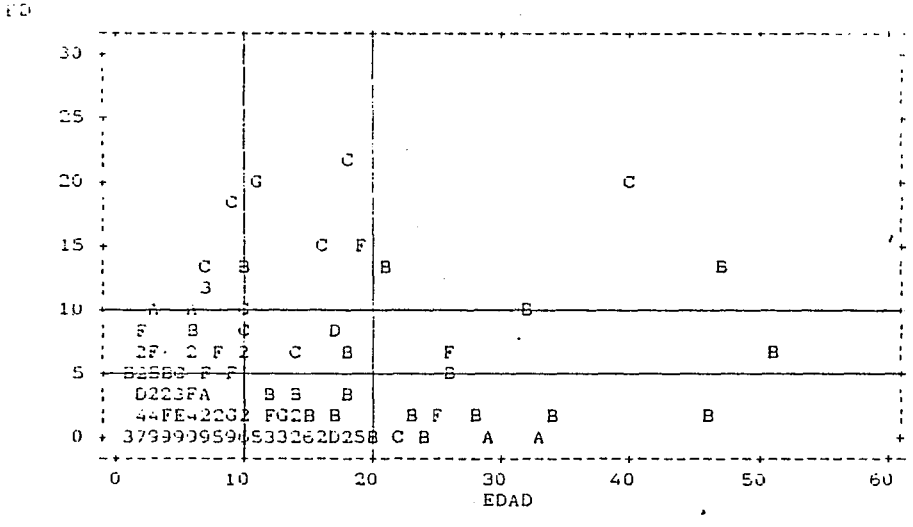
FIGURE 19. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY GEOGRAPHIC LOCATION AND INSTITUTION TYPE.



KEY:

C: CENTER-FEDERAL GOVERNMENT
G: PERIPHERY-FEDERAL GOVERNMENT
B: CENTER-PUBLIC ACADEMIC
F: PERIPHERY-PUBLIC ACADEMIC
A: CENTER-PRIVATE ACADEMIC
E: PERIPHERY-PRIVATE ACADEMIC
D: CENTER-OTHER
H: PERIPHERY-OTHER

FIGURE 20. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

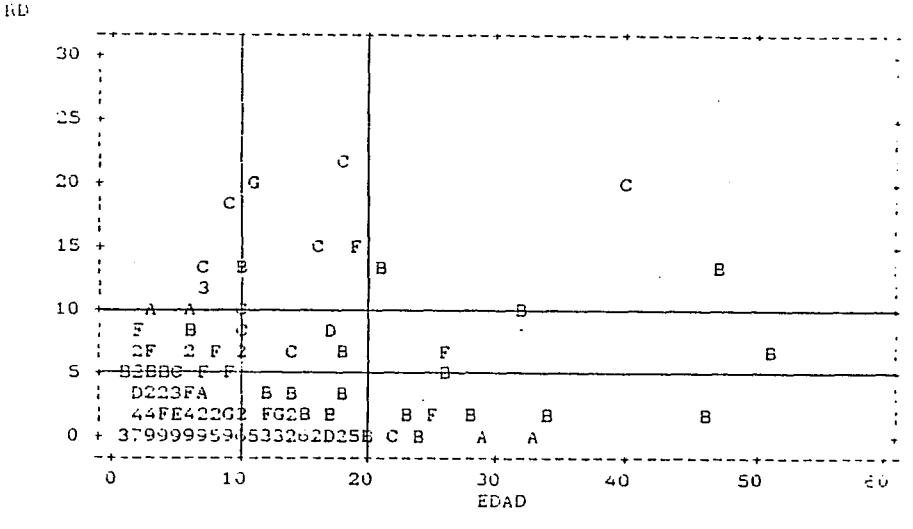


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FIGURE 21. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD

CENTER-FEDERAL GOVERNMENT

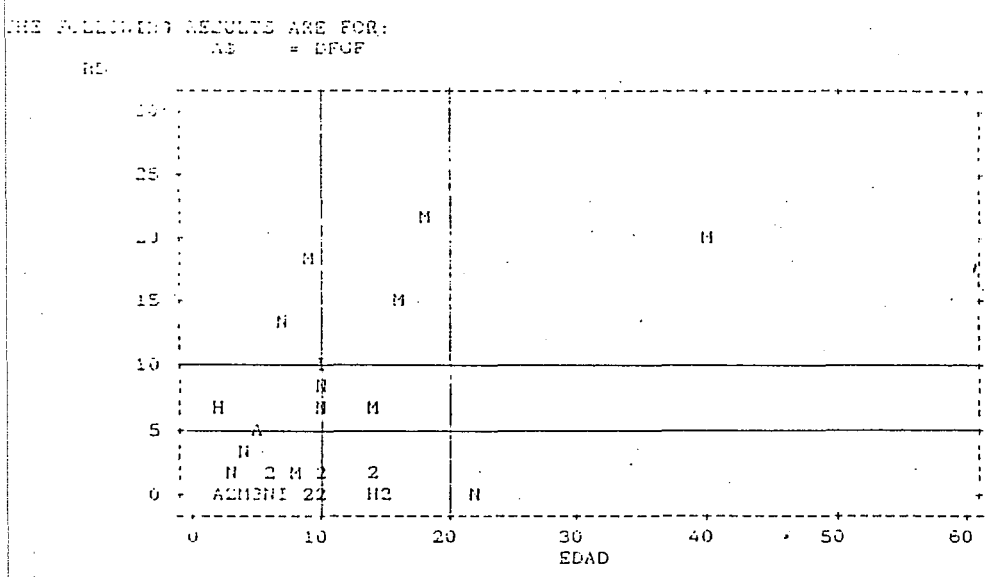

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FIGURE 22. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-FEDERAL GOVERNMENT

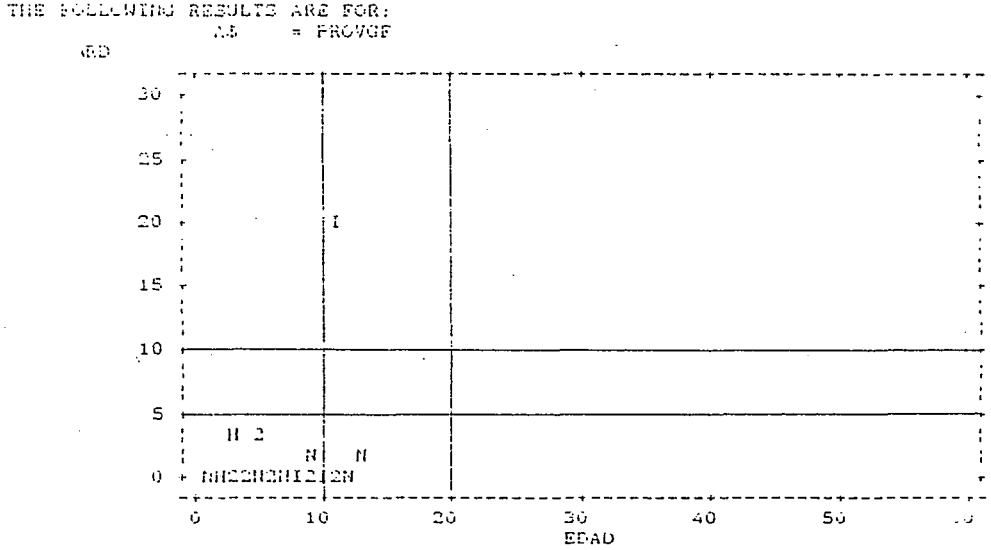

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FIGURE 23. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

CENTER-PUBLIC ACADEMIC

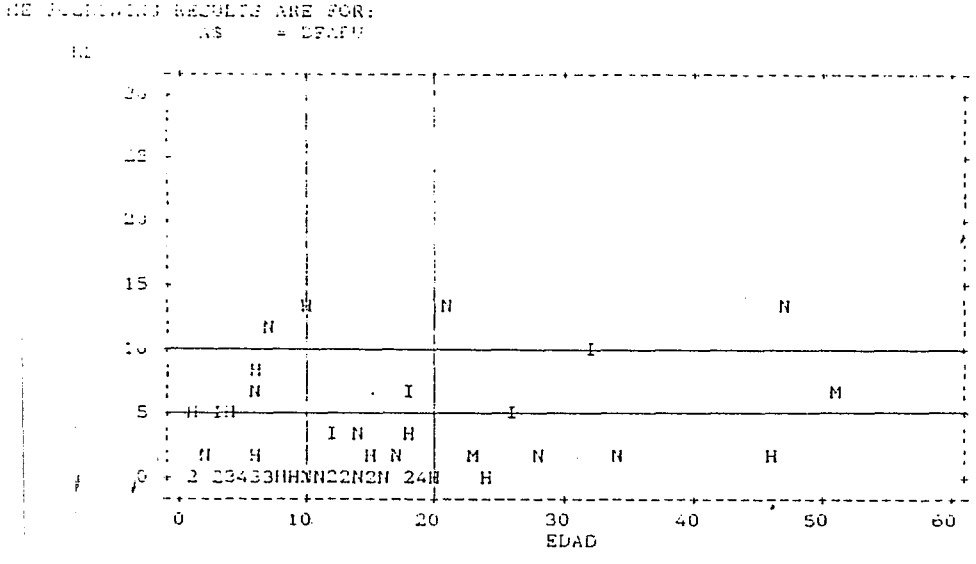

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FIGURE 24. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-PUBLIC ACADEMIC

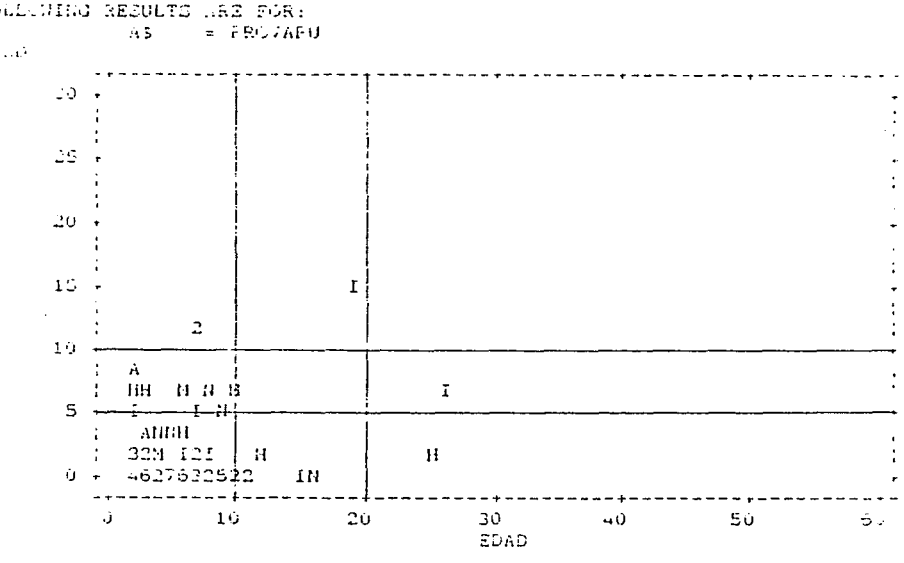

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FIGURE 25. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS. BY SCIENTIFIC FIELD.

CENTER-PRIVATE ACADEMIC

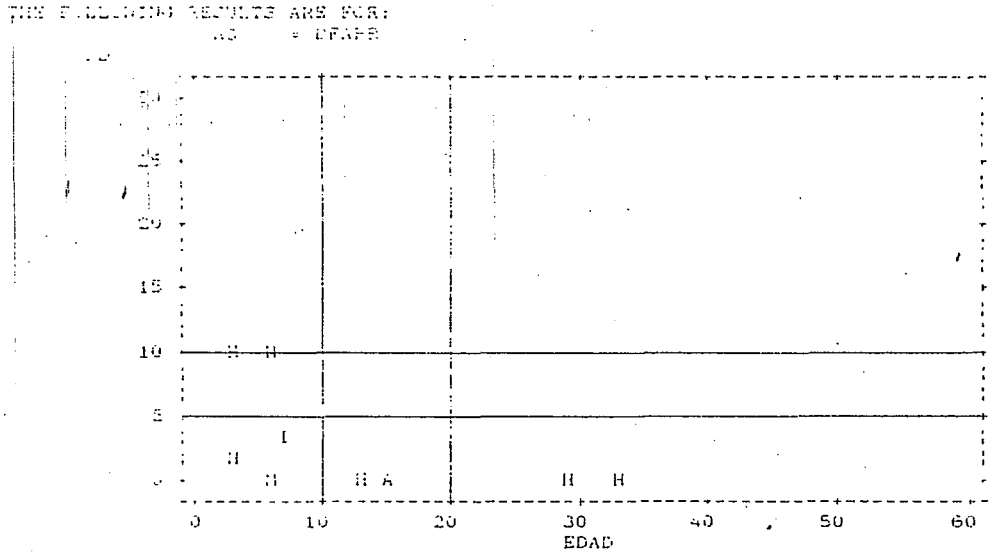

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FIGURE 26. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-PRIVATE ACADEMIC

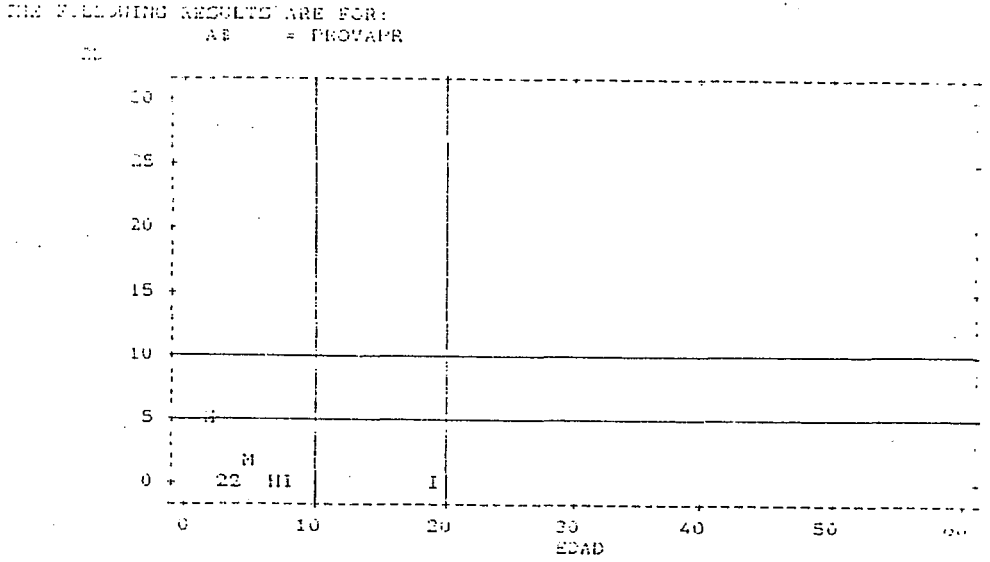

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FIGURE 27. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

CENTER-OTHER

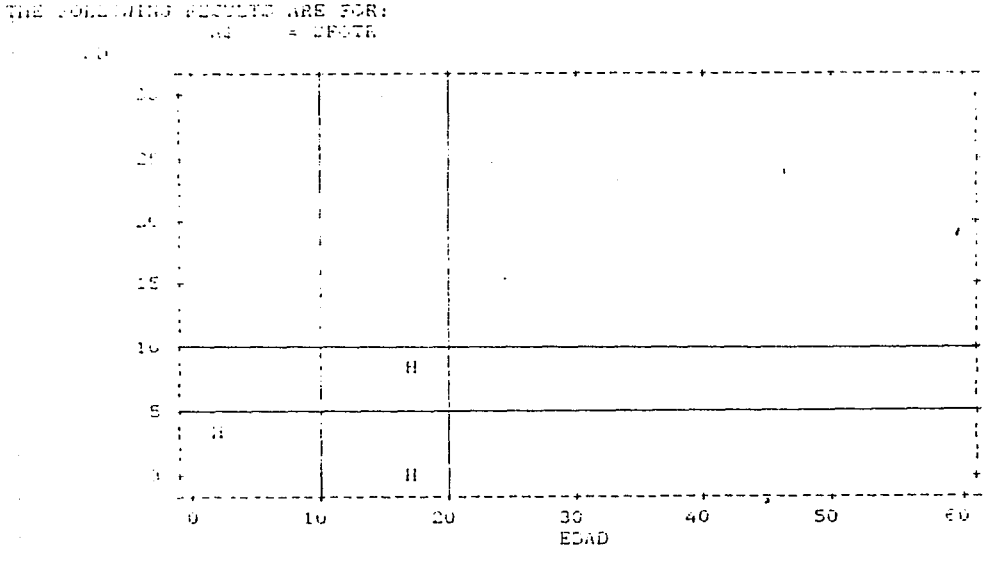

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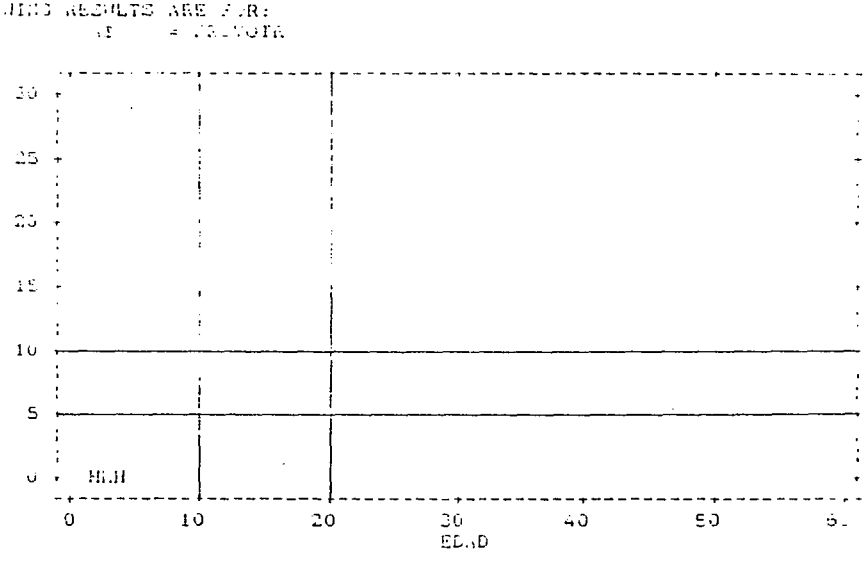
FIGURE 28. TECHNOLOGICAL PRODUCTIVITY VERSUS AGE OF THE UNITS, BY SCIENTIFIC FIELD.

PERIPHERY-OTHER



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