Emergence and convergence of scientific communication in a developing country: Mexico 1900-1979].

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Abstract

As part of the project to develop the Atlas of Mexican Science we analyzed the scientific production of the country from 1900-1979 with a view to completing the set of historical bibliometrical indicators for the entire 20th century. Procedures and database sources centred on publications in the mainstream literature proved insufficient for the development and interpretation of indicators for this period in time. To accomplish this we needed to establish the coexistence of two modes of scientific communication: (1) the traditional, endogenous mode based on production in local journals and (2) the emerging mode of publication in international journals. The emerging mode achieved higher growth dynamics and positioned itself as alternative and complementary to endogenous publication within an environment where endogenous practices prevailed as the more frequent form of communication. The increasing consolidation of the emerging communication system in developing countries did not signify the replacement of the local mode, at least in the case of Mexican science.

Keywords**:** Scientific Communication; Mexican Science; Historic Bibliometrics Indicators

Introduction

For any country the generation and validation of global scientometric indicators for the 20th century unavoidably involves a painstaking labour of historical bibliographical research for the years from 1900 to 1979, the period less studied up to the present. On the one hand, the ISI-Thomson *Century of Science* initiative covering scientific production during the entire 20th century has served to evidence a scarce presence of research literature from the great majority of developing countries in international journals and indexes principally during the first six decades of the century (Luna-Morales, Collazo-Reyes, Russell and Pérez-Angón, 2009; Collazo-Reyes, Luna-Morales and Vélez-Cuartas, 2010). On the other, it has given testimony to the lack of data on the institutional affiliation of authors in the period from 1900-1972 in the bibliographical records of the *Science Citation Index Expanded* (SCIE). These shortcomings complicate the construction of historical bibliometrical indicators by country when applying the same methodology used to develop production and impact indicators from 1980 onwards.

Data from the Atlas of Mexican Science project (*Atlas de la Ciencia Mexicana) (http://www.atlasdelacienciamexicana.org/)* suggest that papers published in journals represented in SCIE constitute a scant 1% of all knowledge production in the sciences, social

sciences and humanities in local journals from 1900-1950. It is clear not only that few publications were covered by the SCI during this period but also that the communication structure most representative of Mexican scientific production complied with research practices associated with distinct literary, scientific, technical and communication styles (Bazerman, 1988; Pontille, 2003) whose subject matter, orientation, publication language and dissemination channels, bear the imprint prescribed by prevailing local circumstances.

In the light of this situation dictated by the communication practices representative of the national context, we look at the introduction of modern scientific communication patterns as an emerging occurrence. We assume that these patterns were acquired through a long process of adoption of conventions and features of the writing styles characteristic of international academic and research environments. Pontille (2003) categorised this style as the IMRAD format (Introduction, Methods, Results and Discussion) which became the code of practice for the reproduction and publication of knowledge internationally (Day, 1998; Thompson and Tribble, 2001). The IMRAD format was adopted by international science during the 20th century as the core structure for the reporting of original experimental research and was established as the standard for international scientific publication.

It is within this framework we employ the concept of the emerging phenomenon (Deguet, Demazeau, and Magnin, 2006) as a qualitative novelty (Bunge, 2004). Scientific communication systems develop structurally by means of long historical processes where each level of complexity supposes the presence of emerging signals that announce the existence of new qualities (Marchione, Salgado and Gilbert, 2010). Each innovation or marker functions as a distinctive characteristic not found within the precursor components of the object in question but not forgetting that there is no emergence that springs from nothing nor entirely separate from the emerging components (Bunge, 2004).

Our main objective therefore is to analyse the evolution of knowledge production in Mexico both by means of the endogenous publication system (national journals) and through international publications (foreign journals). We assume that each publication incorporates the hallmark characteristic of the system from which it derives by way of features that define its identity. Independently of the level of development each system employs procedures for content revision, standards for structuring scientific texts and expert panels via editorial review practices. In our case the greater growth dynamic achieved by production in foreign journals is witness to the process of adoption by our country of styles and attributes of international communication systems. As is inherent in emerging phenomena these qualitative traits are distinct from those of locally edited publications taking into consideration the criteria established by international journals and indexes. In addition to the papers identified in the SCIE we also looked at the coverage of Mexican science in five other international indexes, namely Chemical Abstract, BIOSIS, GeoRef, PsycINFO and MathSciNet.

We found that theoretical and methodological assumptions that underlie mainstream indicators based on the prestige of authors, journals, subjects, institutions and country are insufficient for the development and interpretation of the historical bibliometrical indicators for Mexican science 1900-1979. It was necessary to employ a methodology that also included criteria relevant to knowledge production/publication in the local context. The results allowed us to interpret the process by which Mexican scientists gain access to international scientific communication as a clearly emergent event occurring in parallel with traditional publication. The international model does not emerge as continuation of the local model nor-does does it replace it.

Materials and Methods

Knowledge production published locally: 1900-1950

Due to the difficulties associated with tracing and consulting local publications from a historical perspective so far we have identified local production from 1900 to 1950 only. In this period we identified 166 journal titles edited locally with distinct periods of coverage. The production in each one of these was determined by direct consultation of printed archives in libraries within the metropolitan area of Mexico City. A total of 33,582 articles of diverse content were identified in the natural and social sciences, and in the humanities. The articles were classified according to subject area and type of research. In order to compare the growth of local production with international publication during the same period, the growth of local production for the period between 1951 and 1979 was estimated using two different linear regression techniques: exponential and second degree polynomial.

International coverage of locally published work: 1900-1950

Searches were carried out on papers from Mexican institutions published in local journals from 1900 to 1950 in the following specialized indexes: Chemical Abstracts, BIOSIS, GeoRef, PsycINFO and MathSciNet. The majority of the studies retrieved were from the 1940s.

Knowledge production in international journals: 1900-1979

Given the problem of retrieving information from the SCIE for the period 1900-1972 we used three distinct search strategies covering different time spans: (1) 1900-1950. We used the 392 papers identified in earlier studies (Luna-Morales, Collazo-Reyes, Russell and Pérez-Angón, 2009); (2) 1951-1972. A catalogue was developed consisting of the names of scientists known to have published during this period based on previous bibliographical research carried out in publications on the history of Mexican science (Collazo-Reyes, Luna-Morales and Vélez-Cuartas, 2010; Carrasco-Martínez[15] and Collazo-Reyes, 2010; Robles-Glenn, 1971). This last exercise was supplemented by checking the institutional affiliations of the authors, absent in the SCI, but taken directly from the publications themselves present in print and electronic archives of the National Autonomous University of Mexico (Universidad Nacional Autónoma de México, UNAM) and the Research and Advanced Studies Center (Centro de Investigación y de Estudios Avanzados, Cinvestav). (3) 1973-1979. The production in the period was taken directly from the SCIE using the search strategy: *Mexico not New Mexico* in the address field. All retrieved records fulfilled the criterion of publication in SCIE journals.

Statistical analysis

We compared the growth patterns of local and international production using time series analysis, correlations and adjustments to different growth tendencies. Dynamic growths were determined dividing each of the values of the annual series by the arithmetic average (taken as a constant value) of the papers from 1900-1950 or 1900-1979 to local or international production, respectively.

Results

A total of 33,582 studies from 166 local sources were identified for the period 1900-1950, as well as 10,289 papers published in 1,155 international journals from 1900-1979. Figure 1

[15] Carrasco-Martínez, M. and Collazo-Reyes, F. (2010). Producción de conocimientos y fuentes de publicación en México: 1900-1950. *En Seminario de Estudios Cienciométricos Sobre la Ciencia Mexicana* (junio 23, 2010, México, DF, México).

shows the growth (in absolute numbers) of local and international publications and the exponential and polynomial projections of the local production to cover the same period as the data for the international publication.
When we consider that the first Mexican research publication dates back to 1859 (Collazo-Reyes and Collazo-Rodríguez, 2009) it required a long process of almost one hundred years to the middle of the 20th century, for local research to continually transcend the endogenous publication system (Figure 2).

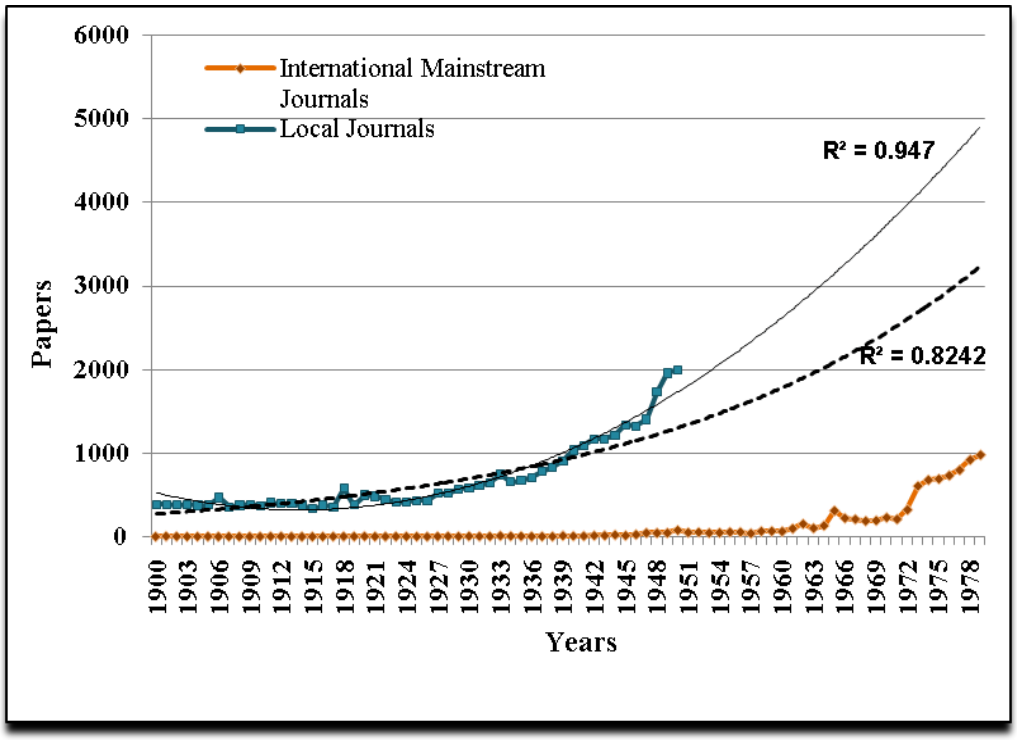

Figure 1. Local and international production: 1900-1979].

The quantitative differences found between the production in local and external media demonstrate that endogenous publication practices predominated as the most common form of knowledge dissemination in the period from 1900 to 1979. During the first half of the 20th century local publication made up 99% of total production. The projections for local production up to 1979 suggest that if growth is maintained according to the polynomial model then the proportion of local to external studies would be 5 to l at the end of the period or 3 to 1 using the exponential projection (Figure 1).
On the other hand, only 2% of local publications are covered in the specialized indexes of Chemical Abstracts, BIOSIS, GeoRef, PsycINFO and MathSciNet, the remaining 98% being excluded from coverage by international indexing services.
All the papers in foreign journals, are covered by the SCI (therefore classified as mainstream in Figure 2) and barely represent 1% of total production as can be seen in Figure 2. Moreover local journals publish a wide range of content types and writing styles. Two-fifths correspond to research articles in the natural and exact sciences; one fifth to articles for a non specialist audience and 8% to book reviews in the sciences, social sciences and humanities. Other titles engaged in the dissemination of industrial and commercial information for specific sectors or focussed on specific research objectives, principally the publication of data from observatories or clinical case studies from social security hospitals.

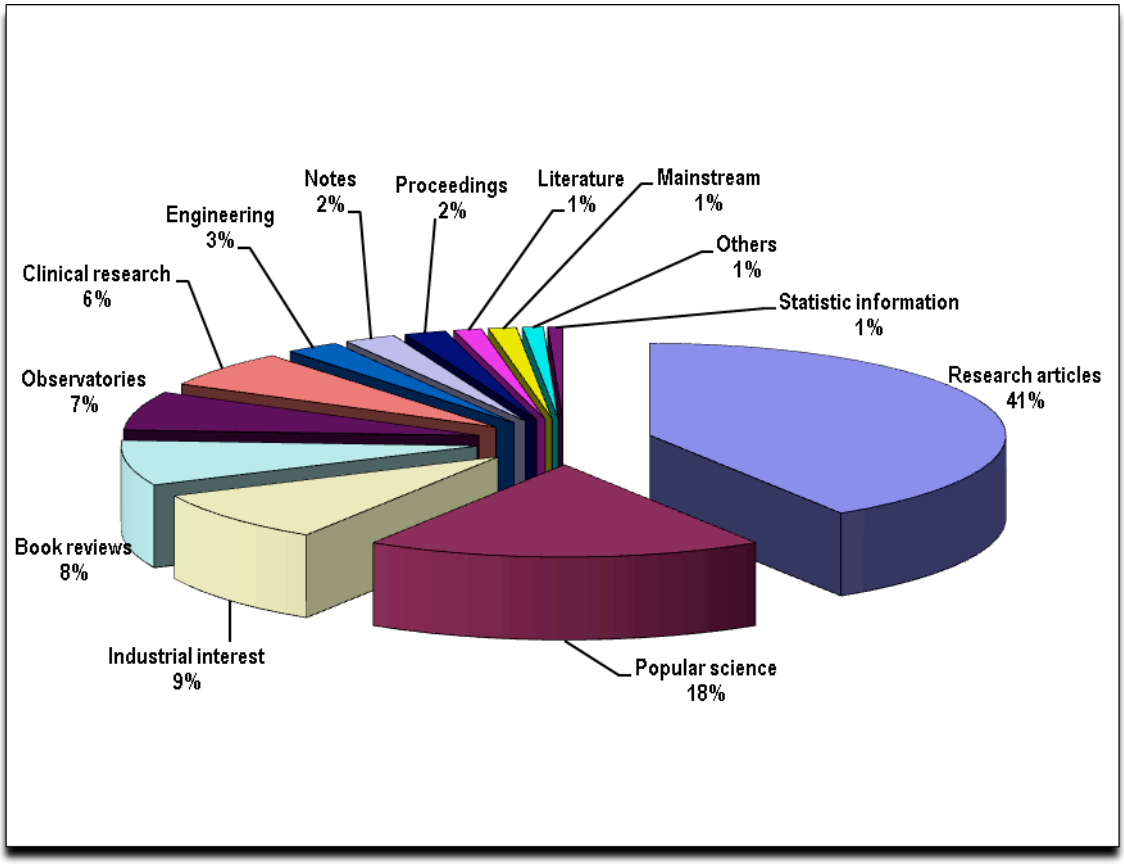

Figure 2. México 1900-1950: document types].

Figure 3 indicates that local sources of knowledge distribution built up an endogenous publication culture which clearly dictated the ways of communicating research results between 1900 and 1950. By employing these publication practices local production showed a tendency for continuous growth without significant changes throughout the period. Practices were strongly characterised by local editorial criteria with respect to language and origin of the studies as well as by a lack of subject reference links to and collaboration with external communities.

The first studies to transcend local channels which were written in English, reviewed and approved by external peer review and published in external sources, led to visibility in international indexes for the first time. These characteristics mark the distinction between local and international publication and refer to elements that confer identity to the international scientific communication model. Even so these studies were carried out by transnational companies from the mining and metallurgy sectors as well as government bodies. The first publications were centred on the identification, extraction and exploitation of mineral resources and subsequently on the completion of the mapping of national geographic and geodetic measurements and as an aid in the search for solutions to local health and public hygiene problems.

Figure 3 compares the growth dynamics of production in local and international publications according to the procedure described in the methodology section. Unlike the exponential growth showed by the former, the latter exhibit a trend showing distinct growth dynamics throughout the period. The periods of greatest growth coincide with the appearance of the ISI-Thomson citations indexes (SCI, SSCI y A&HCI) and the incorporation of the production in local journals into these services.

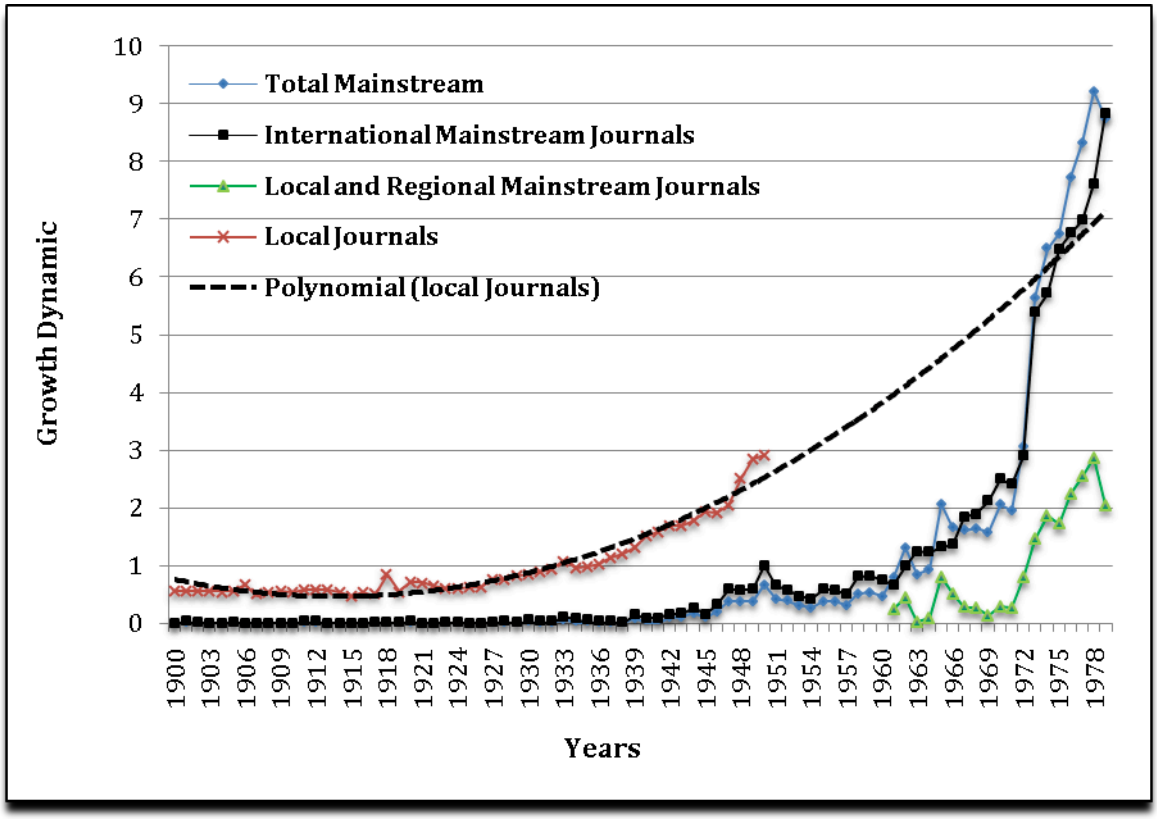

Figure 3. Mexican knowledge production (1900-1979): growth dynamics].

In general terms and over time the production in foreign journals developed an important growth dynamic independent of and greater than local publication. After showing stable production during the decade of the 50s, the beginning of the 60s marked the start of a period of greater growth for Mexican science in foreign journals. This stage corresponds to the creation of the SCI, with the division of scientific journals into two types: mainstream journals and others, not recognised by the SCI, as well as the integration by this service of the first Mexican and regional journals considered mainstream and include papers published in journals edited in other Latin American countries**.** The initial inconsistency in the production shown by local and regional journals, as part of mainstream science, did not affect the overall dynamics of publication in external journals, which served to reach and overtake the exponential trend projected for local production.

The other important growth identified at the start of the 70s coincides with the first publication of the SSCI and the A&HCI which also includes the production of Mexican journals covered by these services (Luna-Morales and Collazo-Reyes, 2007). The sum of the production in the three citation indexes influenced the growth dynamics of the final decade while not modifying the general trend of sustained growth achieved by publication in international journals.

Despite this clear process of emergence and trend in the consolidation of publication practices in external sources, the appearance of international publication does not act in detriment to the endogenous publication mode nor does it act as a substitute. Rather it seems to strengthen it although this has to be substantiated by completion of the process of data retrieval for local production for the period from 1951 to 1979 and the characterisation of the formation of its communication structures.

When looking at the coverage of each one of the indexes we find that the research article is the most frequent type of document published, varying from 68% of total production in the sciences, to 56% in the social sciences and 44% in the humanities. Other important document types in the sciences were: conference proceedings (20%), notes and letters to the editor (9%); in the social sciences, books reviews (29%) and editorials (10%) while in the humanities we find book reviews (23%), poetry and fiction (20%). English is the preferred language more so in the sciences (85%) than in the social sciences (56%) and in the humanities (63%).

Discussion

In Mexico as in the majority of countries, the National Science Indicators (NSI) from ISI-Thomson have been used from the 80s onwards to construct the official national inventory of knowledge generated in the country, leaving aside up to the present time the development of more comprehensive information systems which include knowledge production of a more endogenous nature published in local journals and languages. As we have seen in the present study these are more representative of the production/publication patterns in the period between 1900 –1979.

The widespread use of the NSI to make international comparisons, to establish science policy and to aid local evaluation exercises, confirms in its daily practice, the generalised idea that the international model of production/publication arose in the less developed parts of the world, as a continuation of the system based on local publication which with time became inoperable and consequently was replaced.

The development of historical bibliometrical indicators for Mexico previous to 1980 has drawn our attention to the fact that the opportunity to publish internationally is clearly an emerging event which transpired over a long period of almost 100 years. Foreign publication developed its own growth dynamics which allowed it to position itself as an alternative system complementary to the traditional one. But it emerged neither as continuation of the endogenous system nor as a means to replace it but rather it seems to have strengthened the existing system. However, this last assumption requires the continuation of our work to identify and organise local production not only for the period from 1951-1979, a task pending from the present work, but also in its entirety. Consequently the results of the present study also underline the importance of developing historical bibliometrical indicators especially for countries with scant scientific production. The project to construct the Atlas of Mexican Science includes among its objectives the continuation of research into the characterization of the communication structures that have accompanied the practices associated with the endogenous production and publication of scientific knowledge, including the identification of the varying levels of dependence or independence exhibited by the Mexican research community on endogenous and international communication systems.

Our results add argument to the discussion of other initiatives which have promoted the creation of databases to act as indigenous knowledge repositories (Nwagwu, 2005) more akin to understanding the nature, structure, use, production and flow of scientific communication than databases containing only mainstream literature (Nwagwu, 2010).

The notion of emerging does not imply that production in external sources is an event alien to the local environment. The subject matter of studies arise from the same research concerns and are likewise geared towards finding solutions to problems traditionally seen as local and which stem from local situations. However, external publications incorporate basic markers that clearly differentiate them from local publications, such as a different author set, publication in distinct languages and styles and validation using much stricter review systems than local publications. These traits are replicated by researchers as part of their daily routine (Bourdieu, 2003), a skill acquired through academic training abroad and involvement in

publication practices inherent in the international system of scientific communication, experiences often lacking in local authors.
In keeping with the notion of emerging, the local and international production-publication modes are not mutually exclusive. The dual system of scientific communication continues until the present time, the two systems developing in parallel with each other.

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