Scientometrics (2010) 85:495–507
DOI 10.1007/s11192-010-0266-9

# The impact of the socio-economic crisis of 2001 on the scientific system of Argentina from the scientometric perspective

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Received: 10 December 2009 / Published online: 9 July 2010


**Abstract** In recent years a number of studies have focused on Argentina's 2001 economic crisis and its political, social, and institutional repercussions. To date, however, no studies have analyzed its effects upon the country's scientific system from a scientometric perspective, in terms of resources dedicated to scientific activity and the final output and impact. The present study does so by means of a set of scientometric indicators that reflect economic effort, human resources dedicated to research, publications, collaborative relations, and the international visibility of scientific contributions.

**Keywords** Scientific system · Scientometric indicators · Socio-economic crisis · 2001 · Argentina

## Introduction

The investment in science and technology is on the global rise, to the point where leading countries may report volumes between 2 and 3% of their gross domestic product (GDP).

Argentina, like many other Latin American countries, allocates only a small part of its budget to science-0.5% of GDP. Unlike most developed economies, the greatest proportion of expenditure on R&D in Latin America comes from the public sector (MINCYT 2006).

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This indicator is calculated by the international standard method based on Frascati principles (OECD 2002).

Various authors have explored the reasons for such scarce investment in science by Latin American administrations. It may be attributed to the recent development of scientific activity in the region-after World War II (Vessuri 1987). Though in Brazil, where the processes behind scientific institutionalization took place practically at the same time as in Argentina, investment in R&D amounts to 1% of the GDP.

Other authors link the poor investment between a lack of demand on the part of society, and a certain disassociation between concrete scientific policy (laws, statutes, and plans) and the implicit policy or social demand for national scientific and technological projects (Herrera 1995).

A somewhat different view is held by Vessuri (1995a), who attributes difficulties for the scientific development of Latin American countries to the cyclical processes of advance and retreat resulting from political, social, and economic waves over the past fifty years. The tribulations that Argentina endured from the end of the 1990s to the early years of this century triggered the worst socioeconomic crisis in the country's history.

Despite the universality of the foundations of disciplinary thought and practice, the particular guise of scientific output is conditioned by the social, political, economic, and cultural context of each country (Subramanyam 1983; Vessuri 1995b; Kreimer and Ugartemendía 2007).

## The socio-economic context of Argentina, 1990–2007

Before 1980, a chain of democratic or de facto governments had institutionalized Argentina's scientific and technological activities, and accompanying public policy. The year 1983 marked a new era of institutional reconstruction, with broad social, economic, political, educational, scientific, and cultural implications.

The economic scenario was the least productive perhaps, and towards the end of the decade a hyperinflationary trend was set in motion that rapidly got out of hand, Amid a state of social conflict and discontent, official statements supported by the mass media attributed economic deterioration and budgetary insufficiencies to excessive government spending, and the deficit generated by public accounts (Buchbinder 2005). This precipitated the resignation of the (then) constitutional president, Raúl Alfonsín, and led the president-elect, Carlos Menem, to urge for strict market-oriented structural measures. These characterized socio-economic and political endeavours throughout the 1990s (Benedetti 2003).

Key issues include opening the economy to international trade by reducing the custom tariffs and eliminating tax restrictions; the reopening of foreign credit, which had been highly restricted during the previous decade; the privatization of public enterprises; and the so-called Law of Convertibility—enacted in March 1991—which set an equal parity between the Argentine peso and the U.S. dollar, and validated contracts in foreign currency.

These measures, in the opinion of many analysts, reflect the "Washington Consensus", an economic policy package that the international financial centers rooted in Washington held to be the best economic agenda for ensuring growth and reducing poverty in Latin America. After some short-lived success, their consequences proved to be negative and persistent.

One of the fairly successful features of this decade was a steep rise in the GDP in the first years of implementation of the reforms; reduced inflation; the entry of foreign capital; a substantial increase in imports; and improved purchasing power for Argentinians.

On the downside, meanwhile, there was a deterioration of national businesses; a reduction in exports; an inverse relation between income and the commercial balance (when the Argentine economy expanded, the commercial balance deteriorated); growing unemployment; and more people living in poverty.

After the third quarter of 1998, the economy entered a seemingly endless recessive trend. The bank crash and flight of capital in 2001 left the country in the most severe economic crisis of its history (Coiteux 2003). The regime of convertibility was thus discontinued, leading to external depreciation of the national currency some months later.

A number of studies have analysed the effects of Argentina's 2001 crisis upon the political, economic, social, and even the scientific system (Benedetti 2003; Coiteux 2003; Anlló et al. 2007). Yet we find no studies that show the repercussions of the crisis on the scientific system from a scientometric perspective, and with an integral focus on the resources assigned to this sector as well as the impact of research. Such is the aim of our study.

## Methods

We calculated a set of scientometric indicators related to expenditure and human resources dedicated to R&D, output measured in terms of publications, performance (productivity and efficiency), the relations of scientific cooperation, and the international visibility of results. Overall, the period of study is 1990–2007, but for some variables the time span is shorter. As data sources we used the Indicators of Science and Technology, published by the *Ministerio de Ciencia, Tecnología e Innovación Productiva de la Nación Argentina* (MINCYT), and the Web of Science (WoS) and Journal Citation Report (JCR), both of the Institute for Scientific Information (ISI).

### R&D expenditure and human resources indicators

*GERD* (Gross Domestic Expenditures on Research and Development): the total expenditure on research and development performed on the country during a given period. It is a gauge of governmental and private efforts to generate new knowledge and transfer existing knowledge.

*GERD as a percentage of GDP*: it expresses the intensity of effort on R&D as a percentage of Gross Domestic Product (GDP), and is commonly used for international comparisons and for defining national science and technology policies.

*Res & GrRec FTE:* the total number of researchers and grant recipients in full time equivalence (FTE) devoted to activities of research and development. A researcher is understood as a person working on the creation of new knowledge, products, processes, methods, and systems and the management of the pertaining projects. It includes the senior personnel that develop related planning and management activities. A grant recipient is a young scientist who carries out R&D activities under the supervision of a researcher, usually with training purposes (MINCYT 2006).

*Res & GrRec per thousand of the EAP*: the number of researchers and grant recipients per thousand out of the Economically Active Population (EAP). It therefore stands for the human potential in R&D of a country, and is widely used as an indicator for comparison of countries or regions. The source used to estimate the value of the EAP is the provisional estimate of total occupational variables extended to urban populations produced by the *Dirección Nacional de Programación Macroeconómica, Ministerio de Economía y Producción de la Nación Argentina*, based on OCDE standards.

Output indicators

*Docs in WoS & % Docs in WoS:* number and percentage of documents in a time period. All types of documents included in WoS are considered.
*Articles in WoS journals & % Articles in WoS journals:* number and percentage of scientific articles and reviews included in WoS are considered.
*Articles in domestic and foreign journals:* articles in domestic and foreign journals, whether in WoS or not, reported in the MINCYT *ad hoc* and wide range database of the production of Argentine authors.

Performance indicators

*Prod:* this index measures scientific productivity, the relation between output and the human resources dedicated to R&D activities. Its formula is: IProd = Docs in WoS/Res & GrRec FTE.
*Effic:* it gauges efficiency, calculated as the quotient between expenditure in R&D and output. It is meant to reflect the cost, for the country, of each scientific contribution, through the formula Effic = Docs in WoS/GERD (millions in national currency).

Collaboration indicators

*CoAut:* this indicator, known as the co-authorship index, represents the average number of authors per Docs in WoS. We pay special attention to international collaboration, calculated as documents with at least one Argentine address and at least one non-Argentine address.

Impact indicators

*IFR:* this is a relative measure of the visibility of scientific contributions derived from the ISI impact factor (IF). First we calculate a weighted normalized impact factor (FINP), explained in detail by Moya et al. (2007), to generate IF values that conserve variability, while making the scales of the different categories compatible and comparable. Then, for comparative analysis across countries or regions, the relative impact factor (IFR) is computed as the ratio between the FINP of Argentina (a) in the world (w) using the formula IFR = FINP(a)/FINP(w). The value of reference is 1; hence, if IFR $> 1$, it means that the visibility of the contributions of the given country or region is greater than the world average (ergo, IFR $< 1$ indicates low visibility).

## Results and discussion

### R&D expenditure

Although, there are no data available about expenditure in R&D for all the years covered in this study—only from 1996 to 2007—data suffice to discern three clearly different

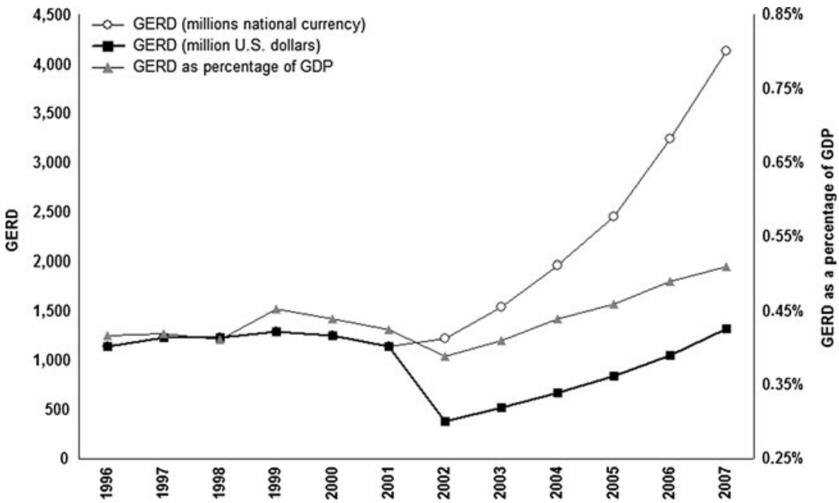


**Fig. 1** Gross domestic expenditure on R&D (GERD) and R&D expenditure as a percentage of GDP, Argentina, 1996–2007

situations. The first, corresponding to the period 1996–1999, shows only a slight increase in economic efforts; the second, from 2000 to 2001, reveals a drop in investment; and the third, from 2002 to 2007, shows rapid recovery and a definite upward trend (Fig. 1).

Such a sharp recovery has two different interpretations, depending on which currency we are looking at (millions of Argentine pesos or millions of U.S. dollars. The Law of Convertibility ruled in Argentina from 1991 to mid 2002, establishing a direct exchange parity of 1 peso = 1 dollar over more than a decade. The end of convertibility was followed by external devaluation of the Argentine currency (from 1:1 it went, in a matter of months, to 3:1). Investment in terms of dollars was therefore greatly reduced, generating a widespread negative impact on the scientific system. Repercussions were immediate: in 2002 overall, investment in dollars was 67% lower than that of the year before. Depreciation also affected subsidies for research projects, and meant the devaluation of scientists' salaries and difficulties obtaining equipment or bibliographic material from abroad.

To compensate for the effects of devaluation, the Argentine government adopted a series of measures that included: an increase in R&D investment, an increase in the budget for external credit to adjust subsidies, and a loan from the Inter-American Development Bank to guarantee access to databases and electronic journals of international prestige (La Nación 2002). Consequently, as of 2003 there was a boost in R&D, with exponential growth that surpassed the increase in GDP. By 2007 Argentina had reached the levels of investment in foreign currency (GERD in millions of dollars) that it had before the devaluation of the Argentine peso.

We should underline that the crisis of 2001 was set off by a recession that began around the third trimester of 1998 (Coiteux, 2003). It is logical, then, that the repercussions of this process, as reflected by the indicators studied, became evident during a later time period.

## Human resources

According to the two variables for human resources of the system, the effects of the recession began to appear in 1999 (Fig. 2).

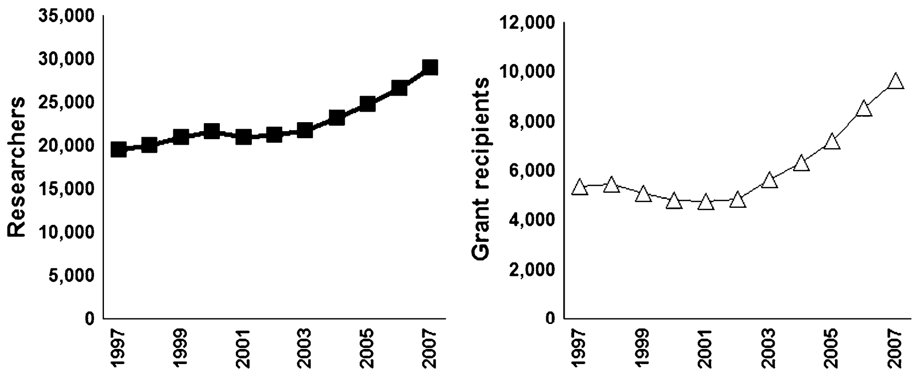


**Fig. 2** Number of researchers and grant recipients in full time equivalent (FTE), Argentina, 1997–2007

Data for the period 1997–2007 show that from 1999 to 2001 there was stagnation in the body of researchers and an actual decrease in the number of grant recipients. The stagnation might have begun in previous years, but there are no official data allowing us to test this premise.

While it is unusual for a scientific system to reduce human resources, this is what happened in Argentina. One reason was the freeze on opening positions, and budgetary restrictions were imposed in the 1990s, hindering the entrance of grant recipients. Moreover, many scientists emigrated, while the natural retirement of older researchers could not be avoided. And aside from the drop in grants, there had been an overall decrease in the number of students and postgraduate offerings in science and technology in the years just previous. Sooner or later, the loss of human capital in the system was bound to make itself manifest as a great handicap.

The diagnosis made by the Government in 1997 is explicit: it was "crucial to modify the generational profile of the scientific and technical personnel of the country, facilitating the incorporation of young graduates, fomenting interest in the sciences and technology in the educational system, strengthening the postgraduate activities in the universities, and promoting grants for education in the country and abroad" (MINCYT 1998).

Finally, in the summer of 2001, after a long period of discontent and claims by the scientific community, the government announced new openings for research personnel and supporting staff of the *Consejo Nacional de Investigaciones Científicas y Técnicas* (CONICET), and the grant program was reinitiated. As the CONICET represents nearly 40% of the grant recipients of the country, this was an important element for the formation of scientists all over the country. A further measure consisted of augmenting the positions for research fellows in institutions of higher education (La Nación 2001).

The impact of these measures materialized as a recovery in human resources. From 2002 to 2007, the number of grant recipients doubled, and researchers increased by 37% (Fig. 2). Growth was also clearly seen in the indicator researchers/grant recipients per thousand of the EAP, which eventually adopted an upward trend lasting to the end of the period analysed here (Fig. 3).

This ignited a process of generational renovation and strengthening of human capital, sustained by the "Bicentennial" National Strategic Plan of Science and Technology (*Plan Estratégico Nacional de Ciencia y Tecnología "Bicentenario"*) of 2006–2010, whose objectives include the qualitative and quantitative enhancement of the system's human resources. The measures are aimed not only to incorporate, promote, and prepare

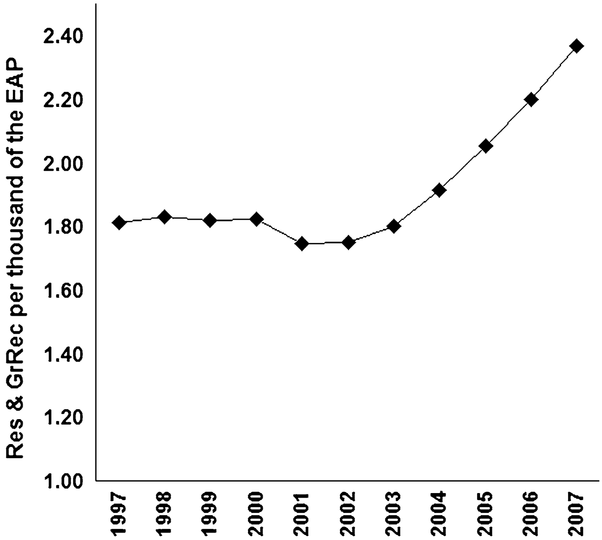


**Fig. 3** Number of researchers and grant recipients per thousand of the Economically Active Population (EAP), Argentina, 1997–2007

researchers and maintain grant offerings, but also to improve salaries, equipment and infrastructure (another cause of the "brain drain" in the past decade).

## Scientific output

The results of this study show the production of publications in the WoS to be the variable that best resisted the crisis. However, as we shall see below, it was affected by the repercussions of the period just after the crisis, due to the devaluation of the currency and the unfavourable economic context.

Firstly, we observe 6% mean annual growth in scientific output for the period 1990–2007. A previous study, but corresponding to the period 1991–2000, gave a rate of 9% (Miguel et al. 2006). Fig. 4 displays the logistic curve reflecting a decrease in growth after a rapid start.

In light of these results, the interruption of growth in output would be one consequence of the economic crisis, directly related to the fall in investment in the early part of the decade (Fig. 1), and tied to the devaluation of the Argentine peso and loss of grant recipients and researchers recorded from 1999 to 2001 (Fig. 2).

Analysis of the evolution of articles published in domestic and foreign journals (based on data from the MINCYT), as compared with the articles in journals included in the WoS, reveals a sharp decline in the percentage of articles published in WoS and foreign journals from 2002 to 2005. The international presence of Argentina declines. Noteworthy is the fact that published output, unlike other variables, was not greatly affected by the years of recession before the 2001 crisis, at least not for papers in WoS and foreign journals; rather, the decline came at the end of the year of convertibility and depreciation of the peso. The relative weight of the volume of articles in domestic journals began to increase after devaluation, however, up to 2005, and then dropped again (Fig. 5).

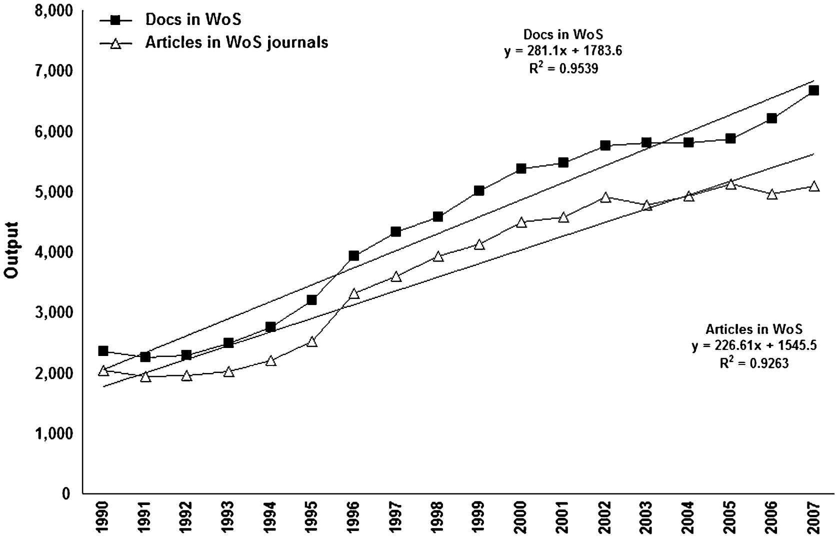


**Fig. 4** Docs in WoS and Articles in WoS journals, Argentina, 1990–2007

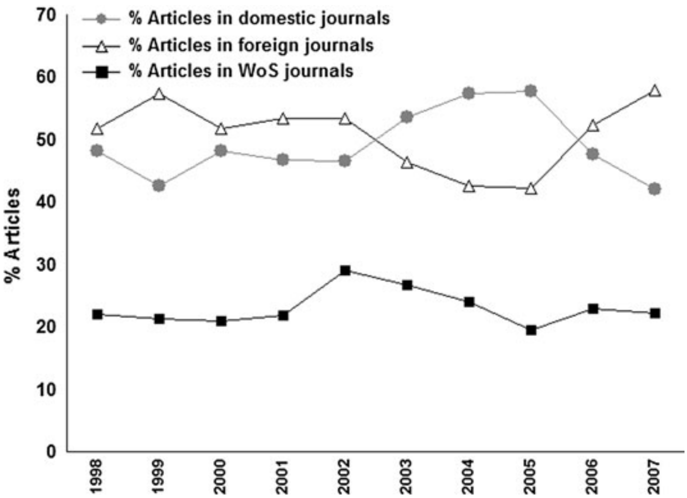


**Fig. 5** Percentage of the scientific output (Articles in WoS, foreign and domestic journals), Argentina, 1998–2007

## Scientific performance

In addition to the above findings, a downward trend is seen in the indexes of productivity (Prod) and efficiency (Effic) from 2002 to the end of the period studied (Fig. 6). This occurred despite renewed investment and additional human resources in the post-crisis period.

These data give rise to certain inferences. For one, a systemic increase in human resources, as in Argentina from 2002–2003 onward, does not necessarily translate into a

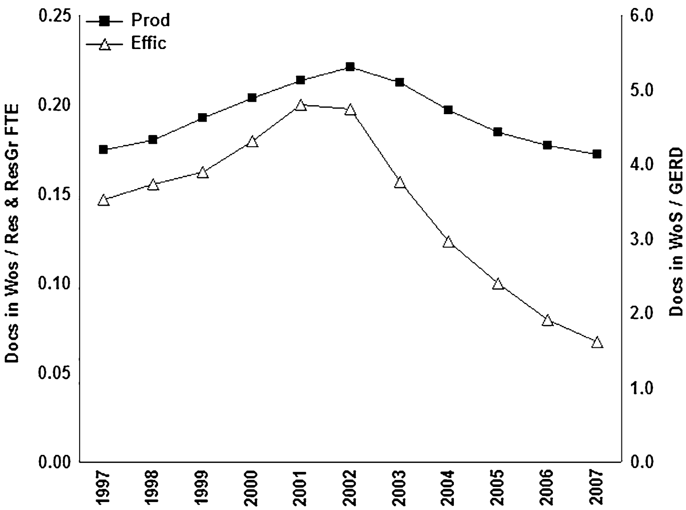


**Fig. 6** Evolution of the productivity and efficiency indicators, Argentina, 1997–2007

rapid increase in scientific productivity. After acquiring new staff and economic resources, work must be effectively carried out before papers can be written. During this time lag, a critical mass of scientists is needed. It may take several years for groups to be strengthened by the incorporation of new researchers, to eventually increase publications and improve productivity.

Meanwhile, the increase in R&D investment from 2003 onward did not manage to reverse the falling trend in financing projects or the depreciation of researchers' salaries caused by devaluation of the national currency. This could also have interfered with output in foreign journals, and may explain the gradual decline in efficiency: each Argentine contribution to international science entailed a cost that grew and grew after the years of convertibility.

## Co-authorship and collaboration

Figure 7 illustrates the evolution over time of two variables: CoAut and Docs in WoS. The relative increase of the co-authorship measure appears somewhat lesser (5%) than the relative increase of the output measure (6%). Nevertheless, if we break down the evolution of these two variables into shorter time spans, the CoAut registered a strong growth from 1990 to 1998 (annual rate of 6.6%), while output grew nearly 9% during the same period. Then, from 1999 to 2003, CoAut showed an annual variation of –4.7%, and output continued to grow, though at a slower pace (around 4%). A change in trend took place in 2004–2005, with a marked rise in co-authorship, while output continued to grow, but only slightly.

As seen in Fig. 8, between 1999 and 2003, the average number of authors in publications resulting from international collaboration indeed decreases. Moreover, we should note that the fall in international co-authorship recorded from 1994 to 1995 coincides with a pause in the economic growth of Argentina related to the Mexican crisis, also known as the 'Tequila Effect' (Benedetti 2003). Furthermore, Argentina was amid a pre-election period which no doubt generated some uncertainty abroad. We surmise that the vulnerability of the internal scientific, political and economic panorama, exacerbated by the

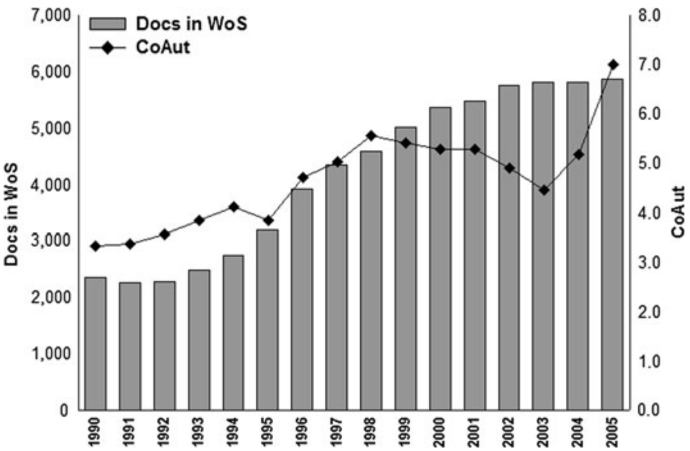


**Fig. 7** Comparative evolution of the coauthorship index and Docs in WoS, Argentina, 1990–2005

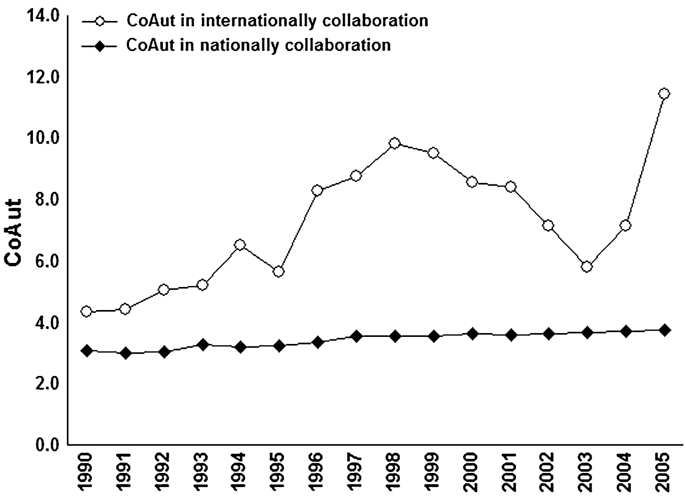


**Fig. 8** Evolution of numbers of the nationally and internationally coauthored documents, Argentina, 1990–2005

external crisis, might have had a negative effect on international co-authorship. But, the (relative) number of publications resulting from international collaboration increases (Fig. 9). Therefore, we no conclusion can be drawn about the effect of the crisis on international collaboration. The data described here do not suffice to draw definite conclusions to this respect, but perhaps future study will shed more light on such points.

## Scientific impact

Figure 10 illustrates the position of Argentina in terms of visibility, well below the world average from 1995 to 2005. The drop in the relative impact factor in 2003 could be due to the declining number of high impact articles in WoS journals over the previous three years (Miguel 2008). It may also reflect the loss of collaboration with foreign authors during the

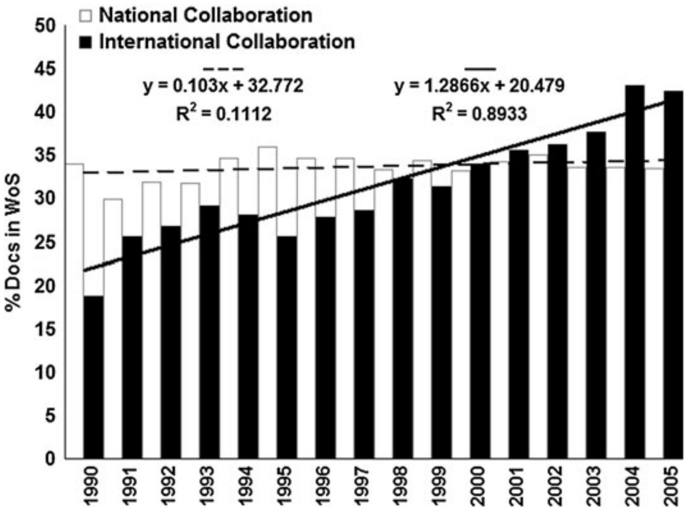


**Fig. 9** Evolution of the national and international collaboration rates, Argentina, 1990–2005

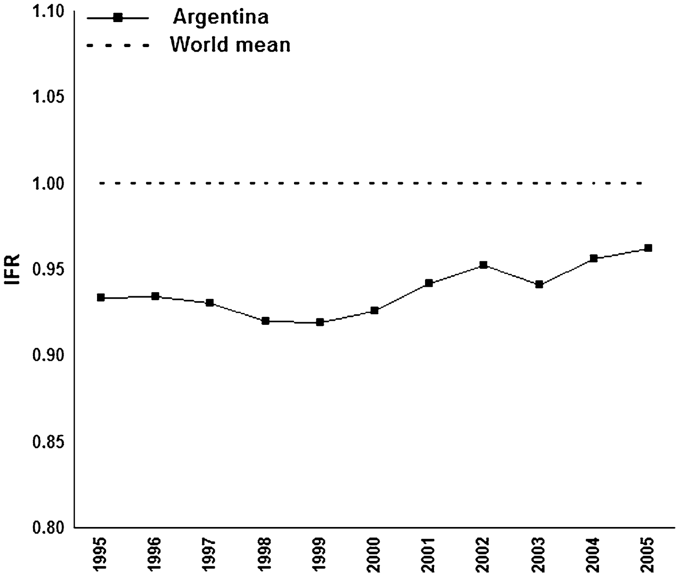


**Fig. 10** Relative impact factor normalized to the world average, Argentina, 1995–2005

period 1999–2002. However, as explained above, the true effects of the crisis on output would not be immediately evident, most likely appearing some years down the road.

## Conclusions

In Table 1 we offer an excerpt about the economic crisis in Argentine science. In view of the three study periods established, arrows indicate the increase (↑) or decrease (↓) of each

**Table 1** Main indicators of the economic crisis in Argentine science

| | 1996–1999 | 2000–2001 | 2002–2007 |
|---|---|---|---|
| GERD U$$ | = | ↓↓ | ↓ |
| GERD pesos | = | ↓ | ↑↑ |
| Researchers | = | ↓ | ↑ |
| Researchers as FAP | ↑ | ↓ | ↑↑ |
| Coauthorship | ↑ | ↓↓ | ↑ |
| Docs in WoS | ↑ | ↑ | = |
| Prod | ↑ | ↑ | ↓ |
| Effoc | ↑ | ↑ | ↓↓ |

variable. Two arrows mean a strong change (up or down), and the equal sign (=) means no significant change.

The period encompassed by this study coincides with a political and economic context of major reforms and many fluctuations, which led Argentina into the worst socio-economic crisis of its history. It also had important repercussions for the development of scientific activity nationwide, as we see from the results put forth.

The first conclusion we can trace is that the development of Argentina's scientific system is strongly conditioned by the socio-economic context. This is evident in the wake of the 2001 crisis, suggesting that cyclical processes of advancement and stagnation or retreat of the country's economy are behind some of the difficulties encountered on the scientific level.

Similarly, we see a paradox of sorts between the political, economic and scientific systems. Whereas during the 1990s science and technology were not considered state priorities, the scientific output of Argentina underwent exponential growth. This was when the economic context and exchange rate were artificially favorable (the parity of 1 peso = 1 dollar). Then, in the midst of the economic recession and the crisis of 2001, just when the Government appeared with policies and measures oriented to reactivate and brace the scientific and technological backbones of the country, the rates of scientific output slowed down and ran into difficulties in sustaining international coauthorship, publishing in foreign journals, and maintaining the levels of production attained in the previous decade. Despite a favourable political context, the economic context was hampered by the external depreciation of the peso. This would explain the relative growth or decline of scientific output in the case of Argentina.

In addition, although the economy of Argentina began to grow at an accelerated rate after 2002, with a mean annual rate of growth near 8%, accompanied by the reactivation of many sectors involving science and technology, the expansion of the economy at the macroeconomic level and an explicitly favorable scientific policy could be one key to the scientific development of a country… but post hoc does not guarantee propter hoc.

The authors show special acknowledge to the referees for their comments after reading the draft of this paper.

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